ABET
Self-Study Report

for the

Plastics and Composites Engineering

at

Western Washington University

Bellingham, Washington

June 17, 2022

CONFIDENTIAL

CRITERION 1. STUDENTS

A. Student Admissions

Admission to the Plastics & Composites Engineering (PCE) major is a two-phase process. After acceptance to WWU, students first declare as a PCE Pre-major at the time they register for classes at WWU. PCE pre-majors take the foundational courses in math, physics, chemistry, and engineering principles listed below. Depending on when students are able to begin calculus, these foundational courses take up to 5 quarters to complete at WWU. Foundational coursework may also be taken at community colleges or other institutions. Information on the acceptance of transfer courses is outlined in Section 1.C. These foundational courses are the minimum required courses (see below) to apply to the PCE major. The PCE program accepts major applications during winter quarter, and students begin taking major courses in the spring. Upper-division coursework is restricted to students who have been accepted into the full major.

Required courses to apply:

- MATH 124 - Calculus and Analytic Geometry I
- MATH 125 – Calculus and Analytic Geometry II
- CHEM 161 - General Chemistry I
- CHEM 162 - General Chemistry II
- PHYS 161 - Physics w/ Calculus I
- ENGR 115 or 104 or 197D- Intro to Engineering & Design
- ENGR 170 - Intro to Materials Science & Engineering
- ENGR 214 - Statics

Recommended courses, but not required for application:

- MATH 345 or 341 – Statistics for Engineering
- PHYS 162 - Physics w/ Calculus II
- PHYS 163 - Physics w/ Calculus III
- ENGR 225 - Mechanics of Materials
- CSCI 140 or 141 – Computer Programming I

Students may be currently enrolled in no more than two of the required courses when they apply for major admission. A final decision on a student's application may be delayed until receipt of final grades for in-progress courses. Students must obtain at least a C- in the above courses and an overall GPA in them of 2.0 or higher to be considered. AP scores are converted to GPA as follows: 5 = A; 4 = B; 3 = C. If a course is retaken, the PCE program uses the most recent grade in the class to calculate their GPA. While admission decisions are based primarily on cumulative GPA in the foundational courses, a required essay, successful completion of other required major courses, GPA in the major courses, and overall GPA are also considerations. Admissions information is also available on the <u>PCE Admissions</u> web page.

Applications are reviewed by all tenured and tenure-track PCE faculty members, and selections are made based on the above criteria. Students are notified of acceptance via email and are required to complete the major declaration process. Twenty-four students are typically accepted into the program each year, and they begin major courses spring quarter.

B. Evaluating Student Performance

Student performance in all courses is evaluated and graded on an A through F scale or as Satisfactory/Unsatisfactory (S/U) or Pass/No Pass (P/NP). Under normal circumstances, all courses that are required for the PCE program are graded on the A through F scale, and a student must receive a grade of C- or better to receive credit for having completed that course requirement for the major. A student who gets a grade lower than C- in a course required for the major must repeat that course unless he or she is granted an exception. The exception request process is described later in this section, after the discussion of pre-requisite enforcement. Due to the COVID-19 pandemic, from spring quarter 2020 through spring quarter 2021, students were allowed to take any course Pass/No Pass. The Pass level was set at D+ by the University. If a student elected to take a class Pass/No Pass due to the pandemic, a course successfully completed shows up as an EP (Exceptional circumstances Pass) on the student's transcript. EP grades were accepted as meeting program requirements for graduation.

Monitoring of student progress is done at all levels of a student's education but is done differently for pre-majors than it is for majors. Pre-majors' progress is monitored by the Department Program Coordinator & Pre-major Advisor. All students are contacted and encouraged to get advising each quarter before registration but advising is not mandatory. However, if a student is struggling academically, an extra effort is made to get the student to come for advising. WWU has multiple advising tools, including Navigate, which provides an academic tracking tool that will flag a student who is having academic problems so that the Program Coordinator is aware of them quickly and can reach out to the student, and Degree Works, which maintains a record of students' progress towards their declared majors.

Once a student has been accepted to the PCE major, academic advising is conducted by PCE faculty members. All newly accepted students are assigned a PCE program faculty member that will advise them throughout their time in the program. Students have a minimum of two meetings with their advisors, the first at the time of acceptance to the major, and the second to review and approve students' plans to complete program requirements and graduate. The latter meeting is conducted two quarters before students are due to graduate, so it usually occurs during the fall quarter of students' senior year. Students are encouraged to seek advising quarterly to ensure their progress toward the degree, and many do, but since all students take classes from all program faculty members over the course of their degree, much advising is informal and takes place on an ad hoc rather than planned schedule. Advising tools can be found in Appendix F.

The PCE program has a strong prerequisite structure. If a student does not pass a prerequisite course with a C- or better, the registration system will not allow that student to register for the next course. However, if the student is taking a pre-requisite course at the time of registration, that student will be allowed to register for the next course, and then the Engineering & Design (ENGD) Department office staff must confirm that the student received an appropriate grade of C- or better in the pre-requisite class. Every quarter after grades have been submitted, the ENGD office staff runs grade reports and identifies any and all students who did not attain a grade of C- or better in a pre-requisite course. The ENGD Program Coordinator then sends notices to those students who have not met prerequisites, notifying them that they must drop the course that requires the pre-requisite that was not successfully met and seek advisement. If the student does not drop the class voluntarily the Program Coordinator contacts the faculty member teaching the course so that she or he knows to make the student drop on the first day the class meets. The only reason that a student would be allowed to stay in a class without the appropriate pre-requisites being completed with a grade of C- or better is if he or she has an exception request approved to take the courses out of order or concurrently.

Students who believe that they have a legitimate reason for being allowed to stay in a class without having passed the pre-requisite course(s) with a C- or better must file an exception request. The student must submit the request for the exception and the reason for the exception in writing using the ENGD Department exception request form, which is available on the Department's Policies, Procedures, and Student Forms web page. For a PCE major or PCE pre-major, the PCE program faculty then review the student's request and submit a recommendation for or against the exception in writing to the ENGD Curriculum Committee. The Curriculum Committee then discusses the merits and drawbacks of the student's request and makes a decision for or against the exception. The ENGD Department Chair then informs the student of the decision. Records of all exception requests are maintained in the ENGD Department office and entered into students' University records in Degree Works.

The progress of students in the major is discussed during program meetings. If a student is identified as potentially failing a course or courses, then someone, typically the student's advisor, will reach out to talk with the student about the situation and possibly develop a new plan for the student to graduate in a timely manner. If a student does fall into academic difficulties, the University has an Insufficient Progress Policy. If a student fails one or more courses, withdraws from multiple courses during the same academic term, or gets a term GPA below 2.0, that student is notified that they are in potential violation of the Insufficient Progress Policy. If a student violates the Insufficient Progress Policy again, such as by failing a course for a second time, the program faculty will discuss the student's academic progress and any circumstances that may have led to the student's academic difficulties. If there is not an assignable cause, such as illness or injury, then the student will be removed from the major.

C. Transfer Students and Transfer Courses

Transfer students are accepted to WWU according to WWU admission policies. If a student has been admitted to WWU and is interested in the PCE program, that student applies for the program following the procedure described above. A transfer student may only be accepted into the PCE major by successfully completing, with a grade of C- or better, the same or equivalent courses to all of the courses a native student must complete before applying to the PCE program.

The process for the validation and acceptance of credits from other institutions is handled in one of two ways. Institutions in the state of Washington have developed a thorough list of standard course transfers, including universal course numbers for certain classes, while courses that are not on that list and course transfers from out-of-state universities and community colleges are all reviewed before being accepted.

If a class at another Washington university or community college uses a common course number, then that course gets entered into the WWU system as a course that can be transferred to WWU, but may or may not count for a specific course in the PCE program. Such a course will be listed on a student's transfer report as a 1TT or 2TT equivalent, meaning that the course is at the 100 or 200 level (as indicated by the first number) and the credits count at WWU, but not towards the major without Department approval. In this case students must provide a course syllabus and possibly additional course material for PCE program review. Once a transfer course from a specific Washington university or community college has been reviewed, generally through direct communication with the faculty at that Washington university or community college, the course is entered into the WWU system as an exact transfer, and that course will show up on a student's transfer report as an equivalent of the WWU class without further action on the part of the PCE program. Once a course is in the WWU system as an equivalent transfer course, the course will transfer smoothly for all students who have that course from that institution.

WWU Admissions will only change a course from another Washington university or community college to being equivalent to a WWU course at the direction of the department that owns that area, so only the Engineering and Design Department can designate transfer of engineering courses as true equivalents. A department may, however, elect to accept a course from another area as an equivalent transfer as well as courses in its own area. This is often done for Math classes, primarily differential equations classes, that are deemed insufficient for Math majors, but can be verified as being sufficient for engineering majors. Students and faculty members from any institution can review course equivalencies on the WWU Admissions website.

Courses from out-of-state universities and community colleges must be evaluated on a case-by-case basis by the PCE program, which is generally done by the PCE Program Director for major courses or the Department Chair for pre-major courses, unless they need the input of other members of the ENGD or PCE faculty. Review of a course from an out-of-state university or community college starts with review of the course syllabus. If the syllabus is sufficiently detailed, no other information is required, but if it is not then the student is required to provide more information from the course, which might include assignments and labs. Once a course has been accepted as a transfer course for a student, it is indicated in the student's file in Degree Works.

In addition to accepting transfer courses, WWU grants credit for certain AP, IB, and Cambridge International Examinations. WWU generally grants credit for College Board Advanced Placement (AP) exams completed with a score of three (3) or higher, according to the posted equivalency chart. Credits are granted upon receipt of official scores (AP Transcript) from the College Board. WWU will grant up to 15 credits for each approved standard level and higher-level International Baccalaureate (IB) subject examination passed. WWU will generally grant 15 credits for approved A-level Cambridge International examinations and 7.5 credits for approved AS-level examinations with passing grades of A-E, subject to the 45 credit maximum. Approved exams will be given a Satisfactory, "S", grade. Credit will not be granted for both an A-level and an AS-level exam in the same subject area. Some exams may also apply to GURs. Students may receive credit for Math, Computer Science, and Science classes in these manners, but there are no approved equivalencies for required engineering courses.

D. Advising and Career Guidance

As mentioned in Section 1.B, students are advised by the PCE program faculty, the Department's Program Coordinator & Pre-major Advisor, and possibly the University's Academic Advising Center at different stages of their academic career, and students get career guidance from the PCE program faculty and through the University's Career Services Center.

Students who have an interest in the PCE major can get advising from the Department's Program Coordinator & Pre-major Advisor and the University's Academic Advising Center. Once students declare their pre-major the Department's Program Coordinator & Pre-major Advisor serves as the students' advisor until they are accepted into the PCE program. As mentioned in Section 1.B, advising is not mandatory, but the Department's Program Coordinator contacts all pre-majors each quarter to encourage them to get advising and also tracks their progress toward the major using the Navigate software. If a student is struggling in required classes, an extra effort is made to get that student to come in for advising. Once students have been accepted into the PCE major, they are assigned a PCE faculty member as their primary academic advisor. If a student is struggling academically, they are advised more frequently and provided additional advising guidance. Students are encouraged to seek advising each quarter prior to registration but advising is not mandatory.

The two primary advising tools are the PCE Program Planning Guide, shown in Appendix F, and the online tool Degree Works.
All of the fundamental advising information is also available on the PCE Advising web page.

Career Guidance starts in the ENGR 101 – Engineering, Design, & Society course and continues throughout the program. Career guidance is accomplished through program faculty, student club organized company tours and guest speakers, and the University's Career Services Center. Additional resume and career guidance is given in the first course in the capstone series, PCE 491.

Career advising through Western's Career Services Center includes career counseling, job search guidance, workshops to help prepare students and alumni, on-campus recruiting opportunities, and special events such as career, internship, and graduate school fairs. They also maintain an on-line job database called Handshake.

E. Work in Lieu of Courses

The PCE program does not allow majors to substitute work experiences, acquired either before being admitted, or while completing their program, for academic credit. The process for awarding AP, IB, and Cambridge International Examination credit is outlined in Section 1.C.

F. Graduation Requirements

The degree awarded is a Bachelor of Science in Plastics and Composites Engineering.

The graduation requirements for the program are documented in the Western Catalog. The program Degree Works is used to both document the requirements and track students' progress towards meeting those requirements. Students can access their own file on Degree Works and department advisors can access any students' file on Degree Works. In addition, the program advisors maintain a degree planning sheet for each advisee.

The degree evaluation is completed in four steps: 1) students fill out a graduation application at least two quarters prior to graduation and set up a meeting with their faculty advisor to complete a graduation assessment. Students' plans indicate the courses they plan on taking during their remaining quarters. 2) A faculty advisor completes the degree evaluation using Degree Works. The program advisor confirms that all transfer classes and any exceptions that were granted are properly entered into Degree Works. The faculty advisor then adds a note that lists the students' remaining courses, including the plan to complete any outstanding technical elective requirements, and verifies that with the completion of these courses, students meet all graduation requirements. 3) The Department Chair verifies that the student and advisor's plan satisfies the program requirements and adds a note to Degree Works verifying that the student will have met graduation requirements with the completion of the listed courses. 4) The Registrar's office credit evaluators verify that the students have met all University requirements for graduation.

A student cannot graduate without meeting the program requirements unless they appeal to the departmental exceptions committee as was outlined in Section 1.B.

G. Transcripts of Recent Graduates

The PCE program will provide transcripts from some of the most recent graduates to the visiting team along with copies of the same students' files from Degree Works, along with any needed explanation of how the transcripts are to be interpreted.

The program is designated on the transcript as: PCE-Plastics and Composites Engineering: WB35

CRITERION 2. PROGRAM EDUCATIONAL OBJECTIVES

Mission Statement

Western Washington University Mission and Values:

Western Washington University is a public comprehensive institution dedicated to serving the people of the state of Washington. Together our students, staff, and faculty are committed to making a positive impact in the state and the world with a shared focus on academic excellence and inclusive achievement.

As a community, we uphold certain basic values. These include:

- Commitment to student success, critical thought, creativity, and sustainability
- Commitment to equity and justice, and respect for the rights and dignity of others
- Pursuit of excellence, in an environment characterized by principles of shared governance, academic freedom and effective engagement
- Integrity, responsibility and accountability in all our work

Engineering & Design Department Mission:

The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience that we provide emphasizes critical thinking and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context. We value and foster teamwork, communication, and a commitment to equity, justice, and the respect for the rights and dignity of others.

Program Educational Objectives

The objective of the Plastics and Composites Engineering Program is to prepare graduates who will be successful in their chosen career paths. Specifically, within five years of graduation, graduates of this program will be capable of achieving:

Success in their chosen profession as evidenced by:

- career satisfaction
- career advancement (e.g. promotion/raises, new jobs/positions, leadership roles, professional license)
- life-long learning (e.g. continued education, technical training, professional development)
- professional visibility (e.g. publications, presentations, patents, inventions, awards, involvement in professional societies and standards bodies)
- entrepreneurial activities.

Or

Success in continued studies as evidenced by:

- satisfaction with the decision to further their education
- graduate and professional degrees earned
- teaching and/or research experiences, and/or
- grant activities and academic publications

The Plastics and Composites Engineering Program PEOs are available to the public on the Engineering & Design Department website.

Consistency of the Program Educational Objectives with the Mission of the Institution

All of the Plastics and Composites Engineering Program Educational Objectives are "student-centered" and about developing the potential of the students in the program so that they will be strong contributors in their careers and communities after graduation. These are consistent with the "serves the people of the State of Washington" and "making a positive impact in the state and the world" portions of the University mission. Furthermore, a focus on "academic excellence and inclusive achievement" is a key component of preparing students for long-term success.

Program Constituencies

The PCE Program constituencies are:

1. *Employers* – Who depend on the value of our graduates as employees to achieve company goals.
2. *Alumni* – Who are forever tied to the program and its reputation through the success of its graduates.
3. *Faculty* – Who are committed to developing the appropriate outcomes and curriculum that leads to students achieving the educational objectives and who, themselves, rely on the success of the program to achieve their career goals.

Note: Employers and Alumni are a part of the PCE Industrial Advisory Committee – see Table 2.1

Process for Review of the Program Educational Objectives

To improve effectiveness and efficiency, the PCE Program's Continuous Improvement Process is similar in process and timing to the Electrical & Computer Engineering and Manufacturing Engineering Programs.

The Process: Figure 2.1 shows the process for revision of the program educational objectives. Figure 2.1 is a flow diagram that outlines the steps taken for revisions to the program objectives, program outcomes, and also changes to this continuous improvement process itself. This process is initiated annually.

The first process is the "Program Evaluation (summer/fall)." Information that is used during this evaluation includes: the existing Program objectives, program outcomes, and continuous improvement plan, administrative issues (such as support programs, ABET-EAC requirements,

General University Requirements (GUR) changes), budget restrictions,
assessment data collected during the previous academic year (alumni/employer surveys, course evaluations, outcomes assessment, faculty input, etc), Industrial Advisory Committee (IAC) feedback (meeting minutes can be found in Appendix E.5), and changes to the WWU Mission. If changes are needed, the program faculty proposes changes to the Engineering & Design Department Curriculum Committee for
review. If the changes are rejected, the program faculty returns to the step of "Program Evaluation" If the proposed changes are approved by the Curriculum Committee, these changes are presented to the department faculty as a whole for approval. Approved changes are reflected in a new version of the Program Objectives, Program Outcomes, and/or Continuous Improvement Plan that will be used for the next academic year.

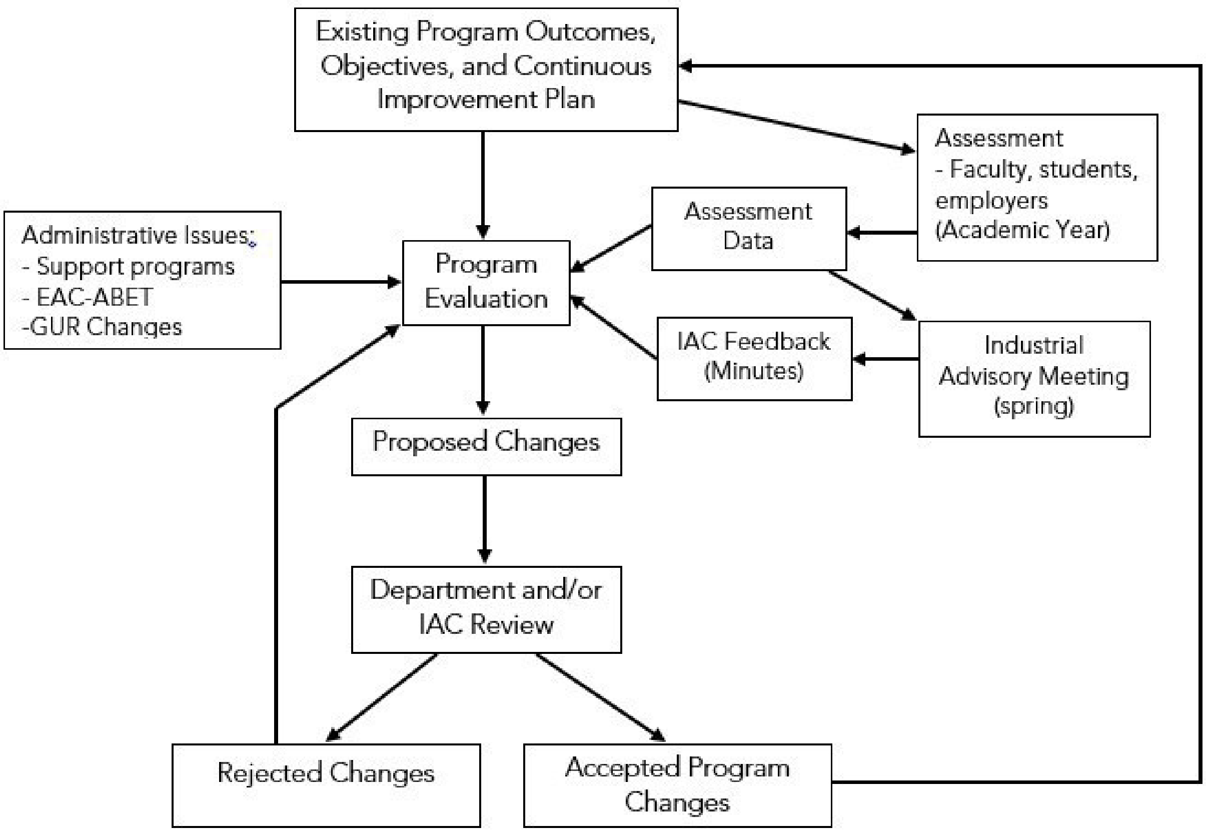


Figure 2.1 – Revision process for Program

Table 2.1 Educational Objectives Industrial Advisory Committee Members

IAC Member

Member Name	Member Company	Alumni? (Y/N)
Bryan Kraft	Nike	Y
Elliot Banko	Hexcel	Y
Michael Hinkley	Archer Aviation	Y
Nathan Slesinger	Janicki Industries	Y
John James	Pacific-Research Laboratories	Y
Eben Sarver	Fluke	Y
Scott McLean	HP	Y
Peter Quinn	HP	N
Jordan Kiesser	Paccar	Y
Damon Call	Toray	Y
Sarah Cornwell	R&D Plastics	Y
Marcin Rabiega	Boeing	N
Surendra Rajpal	Boeing	N
Kacey Loyd	IDEX	Y
Bill Karman	Airtech International	N
Charlie O'Bosky	Cascadia Molding	N
Jordan Birkland	Boeing	Y
Todd Jones	Boeing	N
Robert Kearney	Boeing	Y

CRITERION 3. STUDENT OUTCOMES

Student Outcomes

The current Student Outcomes for the Plastics and Composites Engineering Program are:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

These outcomes were adopted in spring 2018 and took effect in fall 2018. Up through spring 2018, the Student Outcomes were:

a. an ability to apply knowledge of mathematics, science, and engineering.
b. an ability to design and conduct experiments, as well as to analyze and interpret data;
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d. an ability to function on multidisciplinary teams;
e. an ability to identify, formulate, and solve engineering problems;
f. an understanding of professional and ethical responsibility;
g. an ability to communicate effectively;
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i. a recognition of the need for, and an ability to engage in life-long learning;
j. a knowledge of contemporary issues; and
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Relationship of Student Outcomes to Program Educational Objectives

The career success requires all student outcomes as they require technical, business, communication, professionalism, and individual outcome categories. The success in continued studies focuses on technical, communication, and individual outcome categories.

Objective and Evidence	**Student Outcomes**
Success in their chosen profession as evidenced by:	
career satisfaction	1-7 (a-k)
career advancement	1-7 (a-k)
life-long learning	6, 7 (e, h-k)
professional visibility	1-6 (b, c, g-j)
entrepreneurial activities	2-5, 7 (d, f-i)
Success in continued studies as evidenced by:	
satisfaction with the decision to further their education	1, 2, 4, 6, 7 (a-c, e, g, i)
graduate and professional degrees earned,	1-7 (a-c, e, g, i)
teaching and/or research experiences, and/or	1-3, 6, 7 (a-c, e, g, I, k)
grant activities and academic publications.	1-3, 6, 7 (a-c, e, g, I, k)

Table 3.B.1 Outcomes Support of PEOs

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Student Outcomes

1. <u>Description of Assessment Processes</u>

For each course review a PowerPoint template (example in Appendix E.4) is used to determine where deficiencies in both the student learning outcomes and the course as a whole are present. The professor in charge of the course (typically the one who taught it last) leads the discussion. At the conclusion of that discussion the changes to the course are documented using a summary document (Appendix E.3).

Since the last ABET accreditation visit in 2016, assessment was continued to assess a-k Students' Learning Outcomes (SLOs) as previously scheduled (Refer to Appendix E.1 for the a-k rubrics). When ABET approved the transition to 1-7 SLOs, the Faculty mapped the two outcomes and created a new set of rubrics for assessment (see Appendix E.1 for the 1-7 rubrics). For each SLO rubric, three to six performance indicators (*PIs*) are used to rate students at one of four levels of proficiency: *Exemplary*, *Satisfactory*, *Developing* and *Unsatisfactory*. Below is a description of the assessment and evaluation process for the SLOs:

- *Assessment Methodology:* For each *PI* in any of the rubrics, the type of data collected e.g., exam questions, student project work, laboratory work, homework assignments, in-class activities etc., is described.
- *Assessment Target:* In most cases, 80% of students receiving a *Satisfactory* or *Exemplary* rating on a performance indicator is the target.
- *Continuous Improvement Actions:* For each *PI* in any of the rubrics, the evaluator records any actions proposed to address developing or unsatisfactory performance for any of the *PIs*. These actions are then discussed and determined at program and curriculum committee meetings for which minutes are available.
- *Re-evaluation Plan:* This identifies when the results of the improvement action(s) will be re-evaluated. In most cases actions would be executed so that a re-evaluation can be performed at the time of the next scheduled review.

Formal assessment of SLOs occurs every year.

Section 4 below provides an example of the yearly summaries that are created each year (see Appendix E.3 for additional years). It should be noted that the information captured in these tables show student performance at summative levels of assessment and evaluation obtained towards the end of the program (senior year courses).

Although SLOs are evaluated on the summative level of upper-level courses (PCE 4xx), lower-level courses "prerequisite structure" are essential blocks that ensures that the foundations of these SLOs are built during the second- and third-year courses (2xx & 3xx). This process is examined through a cyclic review of each course in the course review cycle schedule**,** refer to Table 4.1 below for the full course review schedule. All the courses in the curriculum will be reviewed by the program faculty (and the curriculum committee for ENGRxxx courses) once every three year**s** (see Appendix E.3 for an example of the format). During these course reviews the faculty responsible will give a detailed presentation answering the following questions:

1. Did students entering the class meet the pre-requisite outcomes, and what is the evidence?
2. Are students meeting the course learning outcomes, and what is(are) the evidence?
3. If not, what changes would you recommend improving students' learning?
4. Are there other changes that you would recommend be made to the course and/or its learning outcomes, and if so, why?
5. What changes have been made to address recommendations made at the last review and what has been their effect?

This helps the program modify/improve any unmet SLOs through providing the appropriate support structure in that class or the prerequisites.

2. <u>Frequency of Assessment Processes</u>

Formal assessment of the mastery of student learning outcomes (1-7) occurs each year. The only exception to this occurred during the 19/20 school year due to COVID where only a portion of the outcomes were assessed. Formal assessment of course outcomes occurs on a 3-year cycle. Table 4.1 documents the current formal course assessment schedule.

Course		Title	3 Year Assessment Cycle								
		Courses required for MFGE and PCE	**F1**	**W1**	**S1**	**F2**	**W2**	**S2**	**F3**	**W3**	**S3**
ENGR	101	Engineering Design and Society								X	
ENGR	115	Innovation in Design									X
ENGR	170	Introduction to Materials Science and Engineering		X							
ENGR	214	Statics							X		
ENGR	225	Mechanics of Materials									X
MFGE	231	Introduction to Manufacturing Processes						X			
MFGE	250	Introduction to Manufacturing Automation	X								
MFGE	261	Introduction to Computer-Aided Design							X		
MFGE	332	Introduction to CAM and CNC	X								
MFGE	362/ 462	CAD Modeling and Analysis Using Surfaces		X							
PCE	371	Introduction to Plastics Materials and Processes	X								
PCE	372	Introduction to Composites Materials and Processes								X	
MFGE	341	Quality Assurance		X							
PCE	342	Data Analysis and Design of Experiments			X						
ENGR	351	Electronics for Engineering							X		
MFGE/PCE	491	Project Research, Planning and Ethics				X					
		Courses required for PCE Majors only									
PCE	331	Injection Molding									X
PCE	431	Advanced Materials and Processing						X			
PCE	461	Tooling for Plastics Processes				X					
PCE	471	Advanced Materials & Characterization					X				
PCE	472	Advanced Composites					X				
PCE	492	Plastics Project Definition						X			
PCE	493	Plastics Project Implementation							X		

Table 4.1 PCE Major Course Formal Review Schedule

3. Expected Level of Attainment

For each of the student outcomes (1-7) it is expected that 80% of students will either perform satisfactorily or exemplarity in each performance indicator category within each outcome.

4. Summaries of Evaluation and Analysis of Attainment of Outcomes

The following are brief written summaries of the tabulated information in Table 5.2 and Appendix E.3, for each 1-7 outcome for the 20/21 academic year.

an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	**1**	All 4 of the PI's for this outcome were met this year as we were able to have some lab work completed (unlike last year with COVID not allowing for any lab work). Assessment is taken from the final paper and presentation in PCE 493.
an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	**2**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for 5 of the 6 performance indicators. For the PI where the threshold was not met the PI should be changed. The majority of students were able to identify most of the important considerations and incorporate some of these into the final solution. This is not an option for this rubric so these students were scored at Developing. Often, incorporating these considerations into their project is outside of the project scope. Data is taken from the final paper in PCE 492.
an ability to communicate effectively with a range of audiences	**3**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all 4 performance indicators. Data is taken from the final paper and presentation in PCE 493.
an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	**4**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all 4 performance indicators. Data is taken from the ethics assignments/presentations in PCE 491.

an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	**5**	All of the PI were met with 80% or more of students scoring in the satisfactory or exemplary categories for this outcome. Assessment is taken from the Tooling course in their teammate evaluations.
an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	**6**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for 2 of the 4 PI's which were assessed in PCE 431. PI's that were missed were due to changes made due to COVID restrictions. PI's, select and operate appropriate process equipment and instruments to perform necessary experiments. (lab-based classes only), and form conclusions based on empirical evidence and to compare these with researched information or theoretical models missed the mark because, due to COVID, lab access was restricted and students were not able to make decisions on their own.
Student have an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	**7**	The first PI is assessed in PCE 492 from the background assignment. The other 2 PI are assessed in PCE 493. All students were able to meet the threshold of at least 80% of students in either the satisfactory or exemplary category for PI 1. For the other 2 PI's assessed in PCE 493, both were met with an 80% or more students able to achieve a satisfactory or exemplary rating. Data for PI 2 & 3 was taken from the students' final reports, final presentations, and reflective statements.

5. Documentation and Maintenance of Results

The following mechanisms are used for documenting and maintaining the results of the outcomes assessment and evaluation process:

a) *Outcomes Assessment Worksheets* (Appendix E.2)
These are the primary mechanisms used for recording the results from assessment and evaluation. An Excel workbook is maintained for each outcome. Within each workbook a worksheet is created for every course identified in the mapping for collecting data. Worksheets are designed around the rubrics and performance indicators that have been developed. These are distributed by the program at the start of the term to each of the instructors teaching a course for which assessment is being conducted. Instructors are required to document the assessment process used and to indicate the number of students attaining each level of achievement.

b) *Program Outcomes Assessment Results* (Appendix E.3)
A listing and description of the assessment processes used to gather the data upon which the evaluation of each student outcome is based.

c) *Course Outcomes Formal 3-Year Reviews* (Appendix E.4)
These record attainment of course level outcomes and are performed by the instructor every three years. The instructor is required to report to the ENGD curriculum committee or program on the following questions:

- Is the course meeting its learning objectives, and what is the evidence?
- If learning objectives are not being met, what changes are recommended to improve student learning?
- Are there other changes that are recommended be made to the course and/or its learning outcomes, and if so, why?

d) *End of Year Summary* (Appendix E.3)
These forms (a consolidation of each outcome results spreadsheet) are the result of the review of each outcome as a whole. This is the documentation that denotes if 80% of students have performed satisfactorily or exemplarity in each performance indicator category within each outcome. If this threshold is not reached a rationale for the deficiency is noted with a suggested remedy. If the recommended changes are significant enough (i.e. large changes to content/delivery/etc.) then this form would be the starting point for more curricular discussions at the IAC level.

B. Continuous Improvement

The continuous improvement process used to regularly assess student outcomes is shown in Figure 4.1. The numbers on Figure 4.1 correspond to the numbered paragraphs that follow. The inputs to the process (top of figure) are the published student learning outcomes, program education objectives and course specifications (defining the course content and course learning outcomes). A mapping matrix relates the program level student outcomes to each of the courses (see Table 5.2). This matrix also stipulates which courses are used for assessing attainment of student outcomes. This matrix is presented and discussed under Criterion 5.

1. *Course Level Evaluation:* Instructors are responsible for ensuring that course outcomes, as defined in the course specifications, are being met. They are able to improve the course as they see fit in a manner that is consistent with the published course specification using their own observations, student evaluations and program feedback. Coordination of evaluation is completed by the program coordinator (for PCE-specific courses) or the ENGD curriculum committee chair for shared courses. The evaluation itself is typically completed by the last tenured/tenure-track faculty that taught it.

For courses used to assess the student outcomes defined by the program, the instructor states which assignments, exams, homeworks, etc. will be used to gather data. These data target the performance indicators (PI's) used in rubrics developed for each outcome (see Appendix E.1). The instructor collects the data using these methods and assesses if the performance indicator for each student outcome has been met by the threshold that the program has previously determined. This information is then passed on to the program director for consolidation with the other outcomes for analysis by the program.

Instructors provide informal course updates to the program faculty at end-of-term meetings (ongoing). Changes to courses taken only by majors of the PCE program may be approved at this time. Changes for courses that are required by other programs are passed forward to the ENGD Curriculum Committee for further deliberation.

In addition to the informal course updates, each course is on a three-year formal review cycle (see Table 4.1). The instructor at the time of the review must give a presentation to the ENGD Curriculum Committee or Program, depending on the student make-up of the course, describing how the course is meeting the published outcomes and providing recommendations for improvement.

The extent to which the outcomes are being obtained can be seen in Appendix E.3.

Documentation:

- Course Syllabi — Appendix A
- Outcome Rubrics — Appendix E.1
- Outcome Assessment Worksheets (Sample) — Appendix E.2
- Program Outcome Assessment — Appendix E.3
- Course Outcomes 3-Year Reviews (Sample) — Appendix E.4

2. *Program Level Evaluation:* Assessment data is evaluated by the program each year for each course in the program used to measure attainment of student outcomes. If targets set by the program are not achieved, course modifications are proposed to address the deficiency. There are no instances of final mastery assessment data taken from courses outside of the major. For interim (non-mastery) assessment of outcomes data is taken on a 3-year cycle. Evaluation data and recommended changes to courses that are also required by non-PCE majors are passed on for consideration to the ENGD Curriculum Committee (Department Level Evaluation) before final approval. As mentioned previously, instructors give informal updates of the student learning in the courses they teach at the end-of-term program meetings. This provides a mechanism to address a problem that might arise within the formal, 3-year cycle for non-mastery assessment of outcomes. This is particularly useful in guiding the development of new courses where the content and outcomes are evolving.

The program is also responsible for defining and modifying, as needed, the student outcomes, program educational objectives, mappings and assessment methods and targets.

Documentation:

- Course to Outcome Mapping Table 5.2
- Outcome Rubrics Appendix E.1
- Outcome Assessment Worksheets (Sample) Appendix E.2

3. *IAC Review*: The program uses its Industrial Advisory Committee to provide feedback on all major curriculum changes. In cases where assessment driven changes require significant modifications to a course's content and outcomes, the guidance of the IAC is sought to maximize harmonization with regional industrial practice. The IAC also provides guidance on the introduction of new material to the curriculum and in helping the program set its educational objectives. Until Fall of 2021, the IAC has been meeting once per year in the spring. In the fall of 2021 the PCE program added an additional IAC meeting to be able to gain more support and advice from them specifically in regards to changing the program name and the potential of adding a concentration in sustainable materials and processes. An example of how the PCE IAC influences curriculum and aids in our continuous improvement is that the program added a course, MFGE 250, Introduction to Manufacturing Automation, to the major. As can be seen in the last couple of years of meeting minutes, the PCE IAC has stated that PCE majors were lacking these skills. After careful thought, deliberations, and planning the PCE program was able to make this curricular change.

Documentation:

- IAC Meeting Minutes Appendix. E.5

4. *Department Level Review*: The ENGD Curriculum Committee is responsible for curriculum oversight at the department level. Evaluation of assessment data for all courses with the ENGR designation (mostly pre-major classes) is the responsibility of this committee with input from the programs. Evaluation results and recommended changes for PCE courses, particularly those that are required by other programs, are also reviewed by this committee. This is done on a 3-year cycle, though the program is free to bring forward an issue that arises from evaluation at any time for consideration. Any curriculum changes that result in modifications to the published program and course descriptions in the WWU annual catalogue must be reviewed and approved by the curriculum committee. Examples of these include changes to course prerequisites, credit hours, descriptions and course requirements for the major. In order to track these changes the University uses a software package called Curriculog.

Documentation:

- Course Outcomes 3-Year Reviews (Sample) Appendix E.4
- WWU Course Change Form (Sample) Appendix E.6

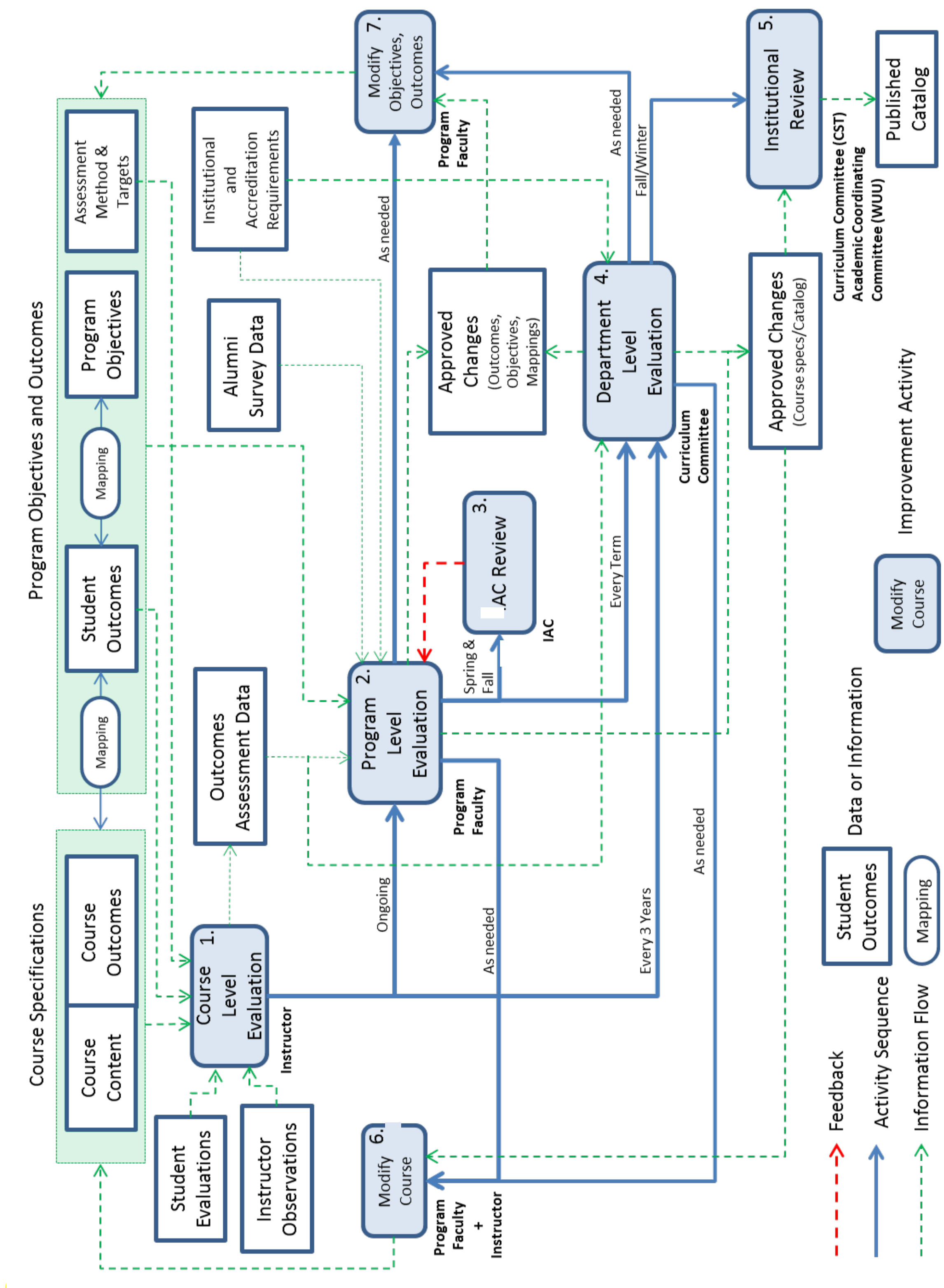


Figure 4.1: Continuous Improvement Process

5. *Institutional Review*: This occurs at two levels; the first is by the curriculum committee of the College of Science and Engineering. All program and course changes that impact information published in the university catalog must be reviewed and approved by this committee. A similar review is conducted at the university level by the Academic Coordinating Committee (ACC). Proposals travel from the program originator to the Engineering and Design Curriculum Committee for review and approval, then to the College Curriculum Committee for review and approval, and finally to the ACC within the Curriculog system.

Documentation:

- WWU Course Change Form (Sample) Appendix E.6

Example of Continuous Improvement Process

An example of how the process is used is described below.

PCE 491 – Project Research, Planning, and Ethics, & PCE 492 – Plastics Capstone Project Proposal

When the program initially offered the capstone series the credits were distributed as follows: PCE 491 – 4 credits, PCE 492 – 2 credits, PCE 493 (Plastics Capstone Implementation) – 4 credits. After offering the course sequence a number of times it was determined that the information should be split up and disseminated differently than faculty had initially thought. In the '20/'21 catalog the PCE made that change and reduced PCE 491 by one credit and added a credit to PCE 492. This change was one initiated by the course instructor (Course Level Evaluation) and brought to the attention of the program on 10/2/19 (Program Level Evaluation) as can be seen in the meeting agenda from that day in Appendix E6. Also included in Appendix E.6 are the meeting minutes from the department's curriculum committee meeting on 10/14/19 (Department Level Evaluation) and the log in the curriculum system showing approval for the change in the College and the University (Institutional Review).

Problem. Although the student learning outcomes were being met in both version of the series, students and faculty both agreed that having them learn the project management software and how to create a detailed project plan would be better served at the time when they are actually planning their project in PCE 492.

Solution.

A credit's worth of project management and planning, including learning project management software, was removed from PCE 491 and added to PCE 492.

A summary of the major changes in the curriculum over the last 3 years is tabulated below:

Effective Year	Adding	Removing	Modifying	Description	Credit Impact
21-22	ENGR 101 ENGR 115	ENGR 104		Enhancements of the pre-major curriculum by expanding ENGR 104 Introduction to Engineering and Design (3 credits) into ENGR 101 Engineering, Design and Society (2 credits), and ENGR 115 Innovation and Design (4 credits).	+3
			ENGR 225	Reduced from 5 to 4 credits with the credit saved used to support the change of ENGR 104 to ENGR 101 and 115.	-1
	MFGE 250			Made MFGE 250 Introduction to automation a required class for all majors to ensure exposure to this subject for all graduates as requested by our IAC.	+4
	MFGE 462	MFGE 362	MFGE Program	Renumbered MFGE 362 Advanced CAD Modeling and Analysis. Although this class is still required in the junior year for PCE majors, the MFGE majors will now take it in their senior year.	0
			PCE Program	Decreased technical electives from 13 to 7 to account for the addition of MFGE 250 and ENGR 101 courses.	-4
			PCE Program/EECE 351	Moved EECE 351, Electronics for Engineers, to the junior year from the senior year and revised the curriculum. The course was not providing any information that was used in follow on courses. With the addition of MFGE 250 this course can add additional valuable information on PLC's and automation	0
20-21			PCE 491 & 492	Rebalanced content between the first and second classes in the Capstone Senior Project sequence moving content on Project planning from 491 (4 to 3 credits) to 492 (2 to 3 credits)	0
19-20			PCE 331	Removed PHYS 163 prerequisite from the course as it is not needed until PCE 471	

				the following fall and added PCE 342 (then MFGE 342) as a corequisite so that students could use DOE to identify important injection molding processing parameters	0

C. Additional Information

Copies of the assessment rubrics are available in Appendix E.1.

CRITERION 5. CURRICULUM

A. Program Curriculum

The Plastics and Composites Engineering Program curriculum is focused on the structure-property-processing-performance relationships of polymer and polymer-composite materials with an emphasis on applied material science and manufacturing engineering. The curriculum has been developed over the past 30 years with significant input from the program's constituency, especially the Industrial Advisory Committee (IAC).

The curriculum is designed to prepare students to be successful in their chosen profession or continued education (PEO's). The IAC feedback informs the curriculum change decisions that will prepare students for success in their career and/or further education. The strategy to meet this objective is to prepare the student to be immediately of value to the company and to have an appreciation for lifelong learning to contribute to the company long-term.

Another strategy for student success in their careers is to cover topics important to the employers that hire our students. This includes a strong topic thread in relating how the structure, properties, processing and performance impact thermoplastic and composite materials and manufacturing.

All students are given several opportunities to take part in research-based learning, most with corporate sponsors. This provides another avenue for education outside of the prescribed curriculum and promotes the synthesis of several courses (basic math/science/engineering and advanced PCE courses) into one real-world problem. Many students produce scholarly work (peer-reviewed conference papers and posters) from these additional opportunities.

The Plastics and Composites Engineering program is a single-path, large program with at least 154 quarter credit hours of Math, Science, and Engineering coursework. This allows for the successful attainment of the program outcomes while emphasizing strong laboratory components in both coursework and projects for design, testing, and practice. The advising sheet for the major that lists out each course specifically is included in Appendix F.

Table 5-1. Curriculum

Course (Department, Number, Title) List all courses in the program by term starting with the first term of the first year and ending with the last term of the final year.	Indicate Whether Course is Required, Elective or a Selected Elective by an R, an E or an SE.[1]	*Subject Area (Credit Hours)* Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other	Last Two Terms the Course was Offered: Year and, Semester, or Quarter	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
FIRST YEAR							
CHEM 161 General Chemistry 1	R	5				2022 Spring 2022 Winter	24 24
Math 124 Calculus & Analytic Geometry I	R	5				2022 Spring 2022 Winter	35 35
PHYS 161 Physics with Calculus 1	R	5				2022 Winter 2021 Fall	20 20
ENGR 101 Engineering, Design, and Society	R		2			2022 Winter 2021 Fall	36 36
ENGR 115 Innovation in Design	R		4√			2022 Winter 2022 Spring	36 36
CHEM 162 General Chemistry II	R	5				2022 Spring 2022 Winter	24 24
MATH 125 Calculus & Analytic Geometry II	R	5				2022 Spring 2022 Winter	35 35
PHYS 162 Physics with Calculus II	R	5				2022 Spring 2022 Winter	20 20
SECOND YEAR							
ENGR 170 Introduction to Materials Science & Engineering	R		4			2022 Winter 2021 Fall	40 40
ENGR 214 Statics	R		4			2022 Winter 2021 Fall	45 45
PHYS 163 Physics with Calculus III	R	5				2022 Winter	24

						2021 Fall	24
ENGR 225 Mechanics of Materials	R		4			2022 Spring 2022 Winter	36 36
CSCI 140 Programming Fundamentals	R		4			2022 Spring 2021 Spring	25 25
PCE 371 Introduction to Plastics Materials & Processes	R		5			2022 Spring 2021 Fall	36 36
MFGE 250 Introduction to Automation	R		4			2022 Spring	12
MFGE 261 Introduction to Computer Aided Design	R		4√			2022 Spring 2021 Spring	24 24
MATH 345 Engineering Statistics	R	4				2022 Spring 2021 Fall	35 35
THIRD YEAR							
CHEM 251 Elementary Organic Chemistry	R	5				2021 Fall 2020 Fall	24 24
MFGE 231 Introduction to Manufacturing Processes	R		4			2022 Spring 2021 Fall	12 12
EECE 351 Electronics for Engineers	R		4			2022 Winter 2021 Fall	30 30
PCE 331 Injection Molding	R		4			2022 Winter 2021 Winter	6 6
PCE 372 Introduction to Composite Materials & Processes	R		5√			2022 Spring 2022 Winter	36 36
MFGE 341 Quality Assurance	R		4			2022 Winter 2021 Fall	30 30
PCE 342 Data Analysis/Design of Experiments	R		4			2022 Spring 2022 Winter	24 24
MFGE 462 CAD & Analysis Using Surfaces	R		4√			2022 Spring 2021 Spring	24 24
CHEM 308 Polymer Chemistry	R	3				2022 Spring 2021 Spring	24 24
FOURTH YEAR							
PCE 491 Project Research, Planning & Ethics	R		3√			2021 Fall 2020 Fall	24 24
PCE 471 Advanced Materials& Characterization	R		4√			2021 Fall	24

MFGE 332 Introduction to CAM & CNC	R		4			2022 Winter 2021 Fall	10 10
PCE 472 Advance Composite Materials and Processing	R		4√			2021 Fall 2020 Fall	24 24
PCE 461 Tooling for Plastics Processing	R		4√			2022 Spring 2021 Spring	12 12
PCE 492 Plastics Capstone Project Proposal	R		3√			2022 Winter 2021 Winter	24 24
PCE 431 Advanced Materials & Processes	R		4√			2022 Winter 2021 Winter	24 24
PCE 493 Plastics Capstone Project Implementation	R		4√			Spring 2022 Spring 2021	24 24
Technical Electives (distributed over several quarters)	SE		9				
GURs not in the major (distributed over several quarters)	SE			38			
Totals (in terms of semester credit hours)		47	103	38			

Table 5.2 shows the mapping of program courses to student outcomes. Table 3.b.1 in criterion 3 explains how the objectives of the program map to the student outcomes.

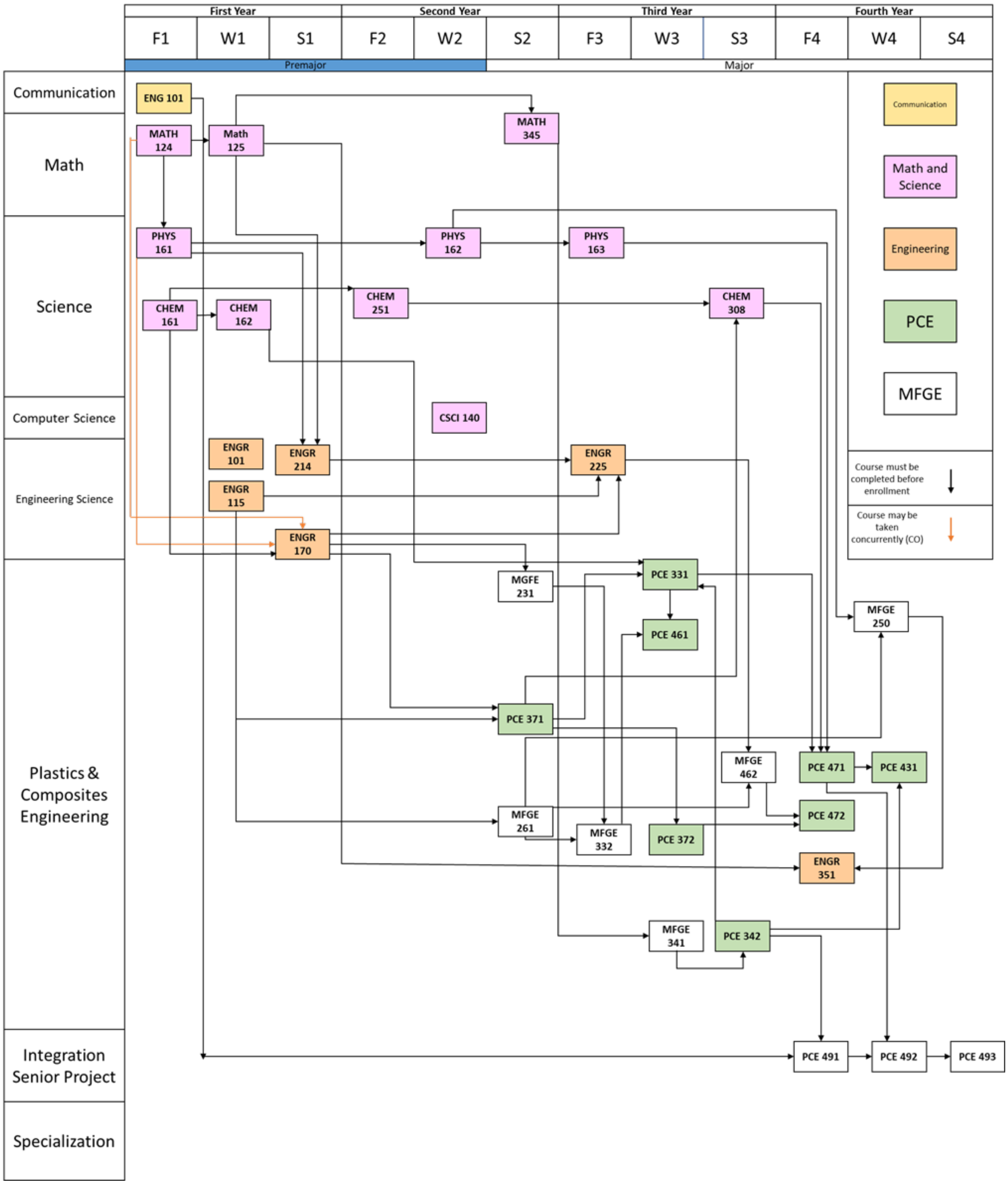
Table 5.2 Course to Student Outcome Map

Course	Title	1	2	3	4	5	6	7
EE 351	Electronics for Engineering	2	1	1	1	1	2	1
ENGR 101	Engineering, Design, and Society	1	2	2	3	2	1	2
ENGR 115	Innovation in Design	2	3	3	3	3	1	2
ENGR 170	Introduction to Materials Science and Engineering	3	2	1	1	3	2	1
ENGR 214	Statics	2	1	1	1	1	1	1
ENGR 225	Mechanics of Materials	3	2	1	3	1	1	1
MFGE 231	Intro. to Manufacturing Processes	2	3	1	3	1	1	1
MFGE 261	Intro. to Computer- Aided Design	3	2	2	2	2	1	1
MFGE 332	Intro. to CAM & CNC	2	3	3	3	1	1	1
MFGE 250	Intro. to Manufacturing Automation	3	3	1	1	1	1	1
MFGE 341	Quality Assurance	2	3	3	3	3	2	1
PCE 342	Data Analysis & Design of Experiments	2	3	3	3	3	2	1
MFGE 462	CAD & Analysis Using Surfaces	3	2	3	1	3	3	1
PCE 331	Injection Molding	3	1	2	1	2	2	3
PCE 371	Intro. to Plastics Materials & Processes	2	1	2	1	2	2	1
PCE 372	Intro. to Composites Materials & Processing	2	2	2	1	2	2	2
PCE 431	Advanced Materials & Processing	3	2	2	1	3	3	3
PCE 461	Tooling for Plastics Processing	2	2	2	1	3	2	3
PCE 471	Advanced Materials & Characterization	2	2	2	1	3	3	3
PCE 472	Advanced Composites	2	2	2	1	3	3	3
PCE 491	Project Research, Planning, & Ethics	2	2	3	3	1	1	2
PCE 492	Plastics Capstone Project Proposal	3	3	3	2	1	3	3 (PI 1)
PCE 493	Plastics Capstone Project Implementation	3	3	3	2	1	3	3 (PI 2/3)

(shaded)	Assessed

1	Little to No Course Focus
2	Minor Course Focus
3	Major Course Focus

Figure 5.1 PCE Program Map with Prerequisite Paths



As can be seen in Table 5.1 and Figure 5.1 above, the program has a strong prerequisite structure and meets all credit hour requirements for Math and Basic Sciences, Engineering Topics, and General Education.

The math courses include two quarters of calculus and an engineering statistics course (MATH 124, 125, and 345) as required by the general criteria. These topics are used in the appropriate courses throughout the engineering topics.

The basic sciences include the engineering physics series that includes mechanics, electromagnetism, waves, and geometric optics (PHYS 161, 162, 163) and two general Chemistry courses, one organic chemistry course, and a polymer chemistry course (CHEM161, CHEM 162, CHEM 251, CHEM 308). Basic math and science credits total 48 credits, or 25% of the overall credits in the degree.

The program requires a computer science introduction to programming (CSCI 140 or CSCI 141 - 4 credits) as required by the general criteria.

The core curriculum is made up of several courses that are taken by the PCE students as well as the Manufacturing Engineering students. Courses include: Engineering, Design, and Society (ENGR 101), Innovation in Design (ENGR 115), Introduction to Materials Science and Engineering (ENGR 170), Introduction to Computer-Aided Design (MFGE 261), Statics (ENGR 214), Mechanics of Materials (ENGR 225), Introduction to Manufacturing Processes (ENGR 231), Introduction to CAM & CNC (MFGE 332), Introduction to Polymer Materials & Processes (PCE 371), Introduction to Composite Materials and Processes (PCE 372), Quality Assurance (MFGE 341), Data Analysis/Design of Experiments (PCE 342), Introduction to Automation (MFGE 250), Advanced CAD Modeling and Analysis (MFGE 462), and Electronics for Engineering (EECE 351). These courses provide the robust foundation that the more specialty courses rely on.

Specialty courses for the program include Injection Molding (PCE 331), Advanced Materials and Processes (PCE 431), Tooling for Plastics Processing (PCE 461), Advanced Materials and Characterization (PCE 471), and Advanced Composite Materials and Processes (PCE 472). Students are also required to complete a minimum of 9 credits of technical electives. The core specialty topics provide most of the depth and breadth in the program and continually reinforce the relationships between structure, properties, processing, and performance of polymeric materials that are introduced in the earlier classes. An example of this is in the Advanced Materials and Characterization (PCE 471) course. Students perform a wide range of advanced characterization experiments and interpret data from a wide variety of polymeric materials. Specifically, students use TGA (thermogravimetric analysis) and identify upper processing temperatures for various materials, a concept discussed in PCE 371 and PCE 331. They use DSC (differential scanning calorimetry) to trace thermal histories of materials and to intentionally quench and slow-cool materials to alter the amorphous and crystalline content and material thermal stability, as a follow-up to material covered in PCE 371 (Introduction to Polymer Materials & Processes) and PCE 331 (Injection Molding). Students also analyze DSC data from thermoset curing experiments to examine cure cycles needed to achieve thermal and mechanical requirements of composites made from these resins; this content is initially covered in PCE 372 (Introduction to Composite Materials and Processes). Students extrude or press specimens for DMA (dynamic mechanical analysis) to examine how the modulus of elasticity and viscoelasticity change with temperature, as introduced in PCE 371 (Introduction to Polymer Materials & Processes) and other classes. Finally, students use IR (infrared) spectroscopy to identify vibrational features of materials, content that was introduced and applied in the foundational CHEM 251 & CHEM 308 (Introduction to Organic Chemistry and Polymer Chemistry) courses.

Finally, the PCE program includes a three-quarter sequence during the last year for the culminating major design experience as required by the general criteria (PCE 491, 492, 493). Overall the Engineering Topics account for 106 credits, or 55% of the degree's credits.

The general education component is primarily made up of the General University Requirements (GURs). The GURs include six areas – *Natural Sciences*, *Comparative, Gender, and Multicultural Studies*, *Social Sciences*, *Humanities*, *Quantitative and Symbolic Reasoning*, and *Communication*. The program courses satisfy the *Natural Sciences* and *Quantitative and Symbolic Reasoning* areas. Students must complete the requirements in the other four areas. This requires at least 38 additional credits, or 20% of the total credits for the degree program.

GUR's provide critical content to the PCE degree and ensure the students are well-rounded global citizens. In a national survey of businesses and non-profits in 2013 conducted by the American Association of Colleges and Universities, 93% of the companies listed the candidate's ability to think critically, communicate clearly, and solve problems are the most important attributes. They also stated that intercultural skills, ethical judgement, and integrity is of the upmost importance. These skills are largely gathered through the GUR courses and highly complement the technical components of the major.

The GUR component of the curriculum also ties back into WWU's University Mission by the emphasis in the GUR's on solving complex problems. This directly speaks to the mission of "developing the potential of learners and the well-being of communities."

Major Design Experience. The culminating major design experience is contained in the three-quarter senior project sequence (PCE 491, 492, and 493). By design, these courses are modeled after a typical development process found in industry. The students fill out a ballot stating their top choices with justifications as to why the projects would be a good fit for them. Program faculty then review the ballots and assign students to the various projects. Students can be placed on teams or they may work individually. More information on what happens in each course can be found in the following sections.

As required, Table 5-1 uses a check mark to indicate courses where students were exposed to engineering design. Within the discipline, students can have these design experiences within the context of developing products, processes, tooling, experiments, testing methods, equipment, and production systems. These experiences culminate in the capstone design experience which will be discussed in the next section.

<u>Capstone Design Experience:</u>

Figure 5.2 shows an overview of the capstone senior project that all majors are required to take. It is a three course, 10 credit sequence that covers the entire senior year. The administration of this project starts during a lead-in period prior to the beginning of the academic year.

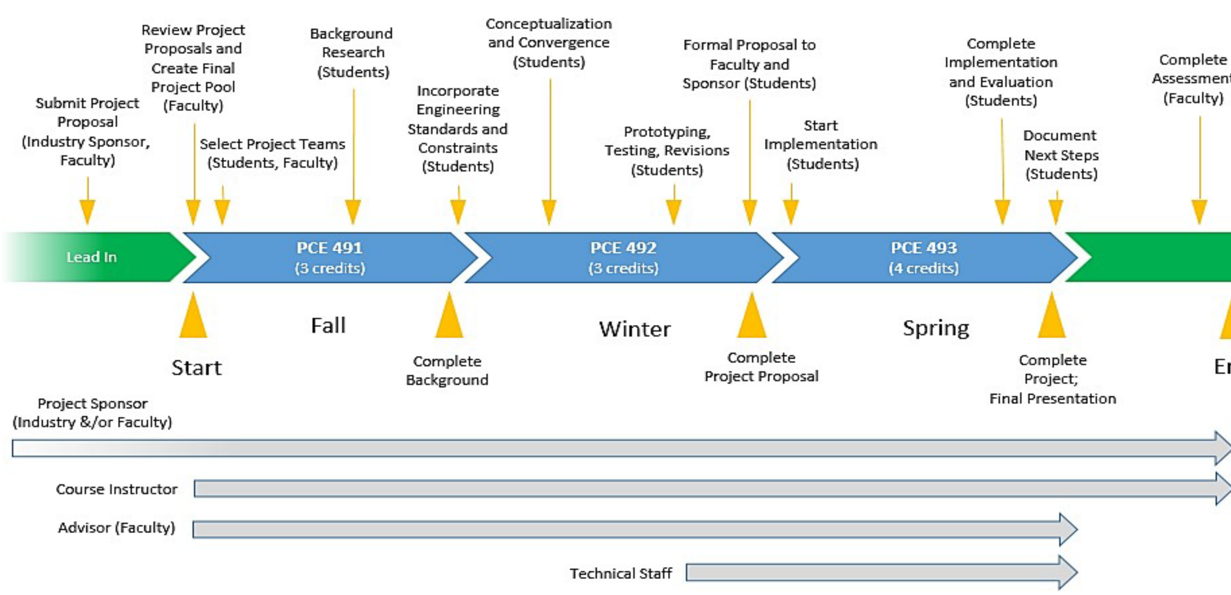


Figure 5.2 Capstone Senior Project

- *Project Lead-In:* During this period, projects from faculty and potential industrial sponsors are submitted and solicited. Before the start of the Fall term, all submitted project proposals from individual PCE faculty and industrial sponsors are reviewed by all of the faculty for appropriateness. This involves a number of criteria. First and foremost is to determine if the project meets a suitable threshold in design content for the Plastics and Composites Engineering discipline to provide an appropriate capstone experience for a major. Since project proposals can vary significantly in scope and content, there is also a determination of whether it should be tackled by an individual versus a group. The program's preference is to provide capstone experiences that require teamwork. The program is engaged in educating industrial sponsors to modify their proposals to meet a more team- based model for the PCE program. Having projects sponsored by industry partners remains a very high priority.

- *PCE 491 (3 credits):* The first course in the capstone sequence integrates key topics such as ethics and communication skills with problem definition, research, and key requirements planning needed in the early stages of a design project. Students are given ballots at the beginning of the term to indicate their preference for projects. Students also indicate how each preferred project aligns with their career goals. Key deliverables in this course focus around defining the problem, performing a thorough literature review, and determining the real-world constraints and key requirements necessary to successfully solve their problem. Students are also required to review all standards and best-practices for the problem at hand. The incorporation of realistic constraints is identified through dialogs with the project sponsor, faculty members, and the literature review. This leads to a set of key requirements at the end of the course that are used in the follow-on two courses (PCE 492/493). The assignments for this course can be found in the display materials for the course.

- *PCE 492 (3 credits):* The second course in the sequence requires students to complete a proposal that documents the work completed in arriving at a solution to the problem. Proposals need to clearly show consideration of alternative solutions and justify choices that are made using information found in the literature and appropriate engineering analyses. Design reviews during the term are used to advise students and to ensure ongoing engagement with their sponsor. Students in this course are also expected to give several presentations to their sponsors, faculty members, and their peers to gather input into their plan. Student deliverables not only focus on having a solid plan for implementing their chosen solution but also around how well they used the design process to get there. Students also routinely perform fail-fast testing in the lab to ensure their implementation and testing plan is appropriate.

- *PCE 493 (4 credits):* The final course in the sequence is when students implement the plan described in their proposal. Fabrication intensive projects that utilize departmental technical staff and equipment must work within the constraints of the University and students must properly submit documentation (drawings) and data that allow scheduling of all work. A successful implementation allows time for critical analysis of the result and, if needed some rework and further analysis. This course culminates in a final report, poster and presentation to the sponsors and faculty.

- *Capstone Project Advising*: The bottom of Figure 5.2 shows the advising resources available for each student during their capstone experience. Every student project has an advisor and sponsor. Sponsors can be either from industry or faculty and are expected to be able to provide the information needed to define the requirements of the problem and possess the appropriate technical expertise to assist the student in design and implementation. They are also expected to pay for the project expenses and provide access to equipment not available on campus. Faculty advisors are responsible for guiding students through the design process, aiding in communication with sponsors, and giving directional feedback to the students. The course instructor is responsible for administering the sequence. This includes teaching supporting subject matter in PCE 491, but more importantly, they are responsible for establishing a timeline for deliverables, ensuring that students are meeting milestones, and primarily responsible for grading and assessment in the first two courses. In the third course (PCE 493), the course instructor is their faculty advisor. This advisor is then responsible for grading and assessment of the final deliverables in the final course in the sequence. Faculty that are neither sponsors, advisors, or the course instructor also provide assistance to students during the sequence.

- *Recent Capstone Projects:* The following table (Table 5.3) are the '21/'22 graduating class's capstone project titles with their sponsors and general design component. Additional information on these projects, including culminating coursework, can be found in the Appendices and display materials.

Table 5.3 PCE senior capstone project information.

Capstone Project Title	**Project Sponsor**	**Design Aspects**
Design of Extrusion-Based Additive Manufacturing System	PCE Program	Process Design
Method Development to Characterize Polymer Recycled Content	HP/Lavergne	Process Design
Characterizing Novel Vitrimer Composites	Mallinda	Process Design
Characterization of Thermoplastic Prepreg for Process Modeling	Convergent	Process Design
Demonstration Tools for Thermoset Composite Simulation	Convergent	Process Design
Process Design and Testing of Recycled Carbon Fiber with a Thermoset Matrix	Toray	Material & Process Design
Process Design and Testing of a Thermoplastic Composite with Recycled Carbon Fiber	Toray	Material & Process Design
Composites Design & Manufacturing with Multi-Material Caul Plate	Boeing	Material & Process Design
Molecular Design and Characterization of a Biobased Benzoxazine Reactive Diluent	Solvay	Material Design
Design of Sortation-by-Degradation Processes for Ocean Recovered HDPE	Ocean Plastics Recovery/HP	Process Design

Cooperative Education.

The PCE program allows the use of a cooperative education experience towards the technical elective requirement for the degree. The project that will be completed during the cooperative education experience must be submitted by the student prior to the start of the position and approved by the faculty advisor and work supervisor. No credit is given for past experience. At the completion of the project, a comprehensive report is developed by the student, reviewed by the supervisor (who provides feedback to the faculty advisor) and graded by the faculty advisor. The report must include an appropriate amount of technical content and detail the educational benefit of the experience.

Display Materials. All required materials will be made available during the visit in digital form. This includes course materials including course syllabi, textbooks, example assignments and exams, and examples of student work, typically ranging from excellent through poor. Evidence that the program educational objectives stated by the program are based on the needs of the stated program constituencies, evidence of a documented, systematically utilized, and effective process, involving constituents, for periodic review of the program educational objectives stated for each program, evidence of the assessment, evaluation, and attainment of student outcomes for each program and evidence of actions taken to improve the program are also included.

B. Course Syllabi

In Appendix A, a syllabus is included for each course used to satisfy the mathematics, science,and discipline-specific requirements required by Criterion 5 or any applicable program criteria.

CRITERION 6. FACULTY

A. Faculty Qualifications

The PCE program has four full-time tenured faculty (Nicole Larson, Nicole Hoekstra, Dr. Mark Peyron, and Dr. John Misasi), and a 0.3 FTE tenured faculty, Dr. David Rider. Each faculty member contributes to the four major elements of the plastics and composites field: structure, properties, processing, and performance.

Professor Nicole Larson's primary expertise is in composite materials, design, processing, and testing. These areas are enhanced by projects that Prof. Larson works on with industry partners and undergraduate students. Prof. Larson's formal education is in Mechanical Engineering with her graduate thesis focusing on an investigation of novel composite materials for the aerospace industry. Her professional experience at The Boeing Company focused on manufacturing issues related to composite structures and performance. Her experience at Starbuck's focused on machine design. This professional experience also provided a background in product design, project management, and quality.

Professor Larson is also an active member of the Society for the Advancement of Materials and Process Engineers (SAMPE) and WWU's Advanced Materials Science and Engineering Center. Additionally, service inside the University is wide and varied from chairing the Research and Creative Activities Council to serving on departmental scholarship committees.

Professor Nicole Hoekstra's primary research and teaching background is in thermoplastic processing, materials and tooling. Her undergraduate and graduate degrees come from the University of Minnesota in Mechanical Engineering. Prior to coming to Western Washington University, she worked as a Process and Design Engineer at a thermoplastics manufacturing company that produces chromatography hardware, surgical instruments, and diagnostic equipment. While at WWU, her research has included both industry-partnered projects and federally-funded work. Her research is typically high TRL and seeks to understand relationships between thermoplastic processing, materials, and properties for unique applications.

Professor Nicole Hoekstra serves at all levels of the university and profession. Some examples include chair of the ENGD Resources Committee, Director of WWU's Technology Development Center, workshops for industry professionals, SAMPE/SPE student chapter advisor, and numerous search committees.

Associate Professor Mark Peyron has been at WWU since 2007, first with the Chemistry Department, and then with the PCE Program since fall 2014. He has a PhD in Chemical Engineering, with specialization in polymer chemistry, from the University of Washington. His industrial and research experience includes modifying biopolymers for biomedical applications, developing magnetic resonance instrumentation and relaxation measurement methods, characterizing fuel cell membranes, optimizing pulp and paper processes, and designing methods for cleaning up hazardous waste sites. His expertise and research focuses on materials characterization, kinetics and modeling of thermosetting cure reactions and of thermoplastics crystallization, potentially biodegradable polymers and identifying methods for assessing their extent of degradation in the environment. He currently teaches Introduction to Thermoplastics Processing, Quality Assurance, Data Analysis and Design of Experiments, Advanced Materials Characterization, as well as elective classes in Sustainable Plastics and Composites and Directed Research sections. He also has secondary education certification from the State of Washington in the areas of chemistry and physics.

Dr. Peyron has been involved in committees with the materials science program AMSEC for eight years, including as chair as the executive committee, and for six years on the oversight committee with the Scientific Technical services, who manages a variety of analytical instruments for users throughout campus.

Associate Professor John Misasi's expertise is in polymeric materials design, synthesis, characterization, and processing. Dr. Misasi received his PhD in Polymer Science and Engineering with his dissertation focusing on the investigation of novel high-performance epoxy matrix materials for carbon-fiber composites in the aerospace industry. This industry- sponsored research provided him with professional development opportunities at both The Boeing Company and Australia's national laboratory (CSIRO) where he performed research expanding computational tools, synthetic protocols, and manufacturing techniques for aerospace materials. These combined professional and academic experiences allowed him a unique perspective on facilitating the development of next generation plastics and composites engineers. Professor Misasi currently focuses his research and industry collaborations on understanding the structure-property-processing relationships of recycled polymers and composites.

Dr. Misasi's service is student-focused, where he primarily spends his time advising student professional organizations (SAMPE and SPE), performs outreach activities, and advises students on their goals at Western and beyond. Additionally, he serves the University through a number of committees, including Western's Policies, Procedures, and Budget Committee, Technical Operations Committee, and in other functions in the Advanced Materials Science and Engineering Center's multidisciplinary program.

Associate Professor David Rider's primary background is in Polymer and Materials Science with further specializations in materials characterization, electrocatalysis, composite materials, polymer resins, and structure-properties-processing relationships. Dr. Rider's formal education is in Chemistry with his PhD thesis focusing the application of self-assembling iron-containing polymers for nanotechnology and devices. His professional experience at Agilent Technologies focused on the application of self-assembling iron-containing polymers for Raman detection platforms for highly sensitive chemical detection. While at the Xerox Research Center of Canada, he focused on the cure studies and application of acrylates for electronic paper. His professional experience at the National Institute for Nanotechnology at the University of Alberta focused on the application of light-absorbing polymers for solar cells. His current research interests are in the fields of new, functional polymer systems for aerospace composites and the use of polymers for the synthesis of nanoparticle catalysts.

Professor David Rider contributes to the University community generally by serving on advisory and curriculum committees to WWU's Advanced Materials Science and Engineering Center (AMSEC), among others. He also has or continues to work on WWU's College of Science and Engineering Policy & Planning Council and a Diversity, Equity and Inclusion committee.

B. Faculty Workload

Table 6-2 shows the faculty workload summary. The standard load for faculty in the Engineering and Design Department is 6 courses per year for non-research-active faculty and 5 for research-active faculty members. This load does not include independent study or undergraduate research courses. This does include laboratory contact hours. If a course has more than one lab section, an undergraduate TA is assigned to the course for assistance in the lab and, optionally, grading.

Note that the new faculty have 4 courses per year for their first year. This is to allows them to establish their scholarship while developing new courses.

C. Faculty Size

The PCE program has four full-time faculty plus a 0.3FTE faculty. Combined with the NTT instructors, the faculty size meets the requirement of the program without any overloads.

David Rider has a 1/3 appointment in ENGD and 2/3 appointment in Chemistry, with the Chemistry department being his "home" department for issues such as tenure, promotion, and service. David Rider's primary responsibility to the ENGD department is to teach one course per year and to occasionally advise senior projects. David Rider does not perform any advising, serve on program or department committees, or other service activities that are typical of a faculty member in the PCE program.

The program goal is to have an annual student to TT faculty ratio of six. This assures that the program can improve and that the students have close interaction with the faculty. This close interaction fosters one-on-one experiences with our students centered around program advising, career and further educational exploration, and undergraduate research opportunities. The PCE program currently accepts 24 students into the program each year. This rigid admission limit maintains the faculty to student ratio at the appropriate level.

As WWU is a predominately undergraduate university, faculty's number one responsibility is to teach. Therefore, all faculty in the PCE program are the primary instructors for each course. Although teaching assistants may help in the lab and with answering questions, course content is taught by faculty.

Since PCE faculty's teaching and scholarship are intertwined, undergraduate students also work alongside their faculty mentors when performing research and learn technical content and techniques directly from them.

D. Professional Development

All tenured and tenure-track faculty in the PCE program are very active in their professional development. Examples include research and scholarship, teaching and learning workshops, accreditation symposiums, industry technical and education conferences, workshops, seminars, and webinars.

Faculty development funding is available from the Department, College as well as from University-wide programs administered by the university's Research and Sponsored Programs Office. Department funding for tenure-track untenured faculty is $1500 and for tenured faculty is $1000. College funding up to $1000/year is available for conference registration at which faculty are presenting their work. In addition, if approved, up to $600/year is available from the college for conferences related expenses if faculty are not presenting.

The Research and Sponsored Program office has several programs to support faculty development and scholarship, including Summer Research and Summer Teaching grants of $6000 each, as well as research grant programs with maximums ranging from $1000 to $4000.

One of the main strengths of the PCE program is the level of interaction between industry leaders (employers) and PCE faculty. Each PCE faculty member works hand-in-hand with industry partners to solve their real-world problems. Faculty bring in PCE undergraduate students to solve these problems which enhances both the faculty's relevance to industry and the student's experience and education.

E. Authority and Responsibility of Faculty

The modification of all outcomes and objectives follows the procedures outlined earlier in Criterion 4 (see Figure 4.1). To change student program outcomes or program objectives, the PCE IAC must be involved. The need to make changes to these outcomes and/or objectives may be recognized by the faculty, or it may come out of discussions with the PCE IAC. However, once there is an understanding that changes are appropriate, the new program outcomes and/or objectives are drafted by the program faculty, discussed with the PCE IAC, and agreed upon by all. Once this happens, the idea is brought to the Department Curriculum Committee and then the whole ENGD Department faculty for consideration and approval. Once the proposal leaves the department it must be approved by the College Curriculum Committee and the Academic Coordinating Council (ACC), a standing committee of the Faculty Senate. The Dean or an appointed representative sits on the College Curriculum Committee, and the Provost or an appointed representative sits on the ACC.

Changes to student course outcomes are drafted by the faculty. Faculty members are involved in the assessment, evaluation, action formulation, and implementation of the accepted actions. Program objectives and program outcomes are developed by the program faculty as a whole.

Specific course outcomes are normally developed by the lead faculty member for that course, in consultation with their peers in PCE and any other program that has a stake in it.
Whether or not other faculty and the PCE IAC are involved in the development of course outcomes depends upon the magnitude of the change (large change vs. small) and if the course is shared by multiple programs. For a new course or a significant modification to a course, the course outcomes would be discussed with the PCE IAC as part of the normal discussion of curricular change, but minor changes might be undertaken by the program faculty alone. The Administration is not involved in the development or revision of outcomes and objectives, although there is an obvious need to make sure that the program outcomes and objectives are consistent with and support the Mission of the University.

Table 6-1. Faculty Qualifications

Plastics & Composites Engineering

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment[2] T, TT, NTT	FT or PT[3]	Years of Experience			Professional Registration/ Certification	Level of Activity[4] H, M, or L		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Nicole Hoekstra	MS, Mechanical Engineering, 1996	P	T	FT	2	24	24	None	Low	Low	Med
Nicole Larson	MS, Mechanical Engineering, 1999	P	T	FT	6	18	16	EIT	High	Med	Med
John Misasi	PhD, Polymer Science and Engineering, 2015	ASC	TT	FT	2	6	6	None	High	Med	Low
Mark Peyron	PhD, Chemical Engineering & Polymer Chemistry, 1994	ASC	TT	FT	11	15	15	None	Low	Med	High
David Rider	PhD, Chemistry, 2007	ASC	TT	FT	2			[redacted]	[redacted]	[redacted]	[redacted]
David Gill	PhD, Mechanical Engineering, 2002	ASC	TT	FT	14	7	7	[redacted]	[redacted]	[redacted]	[redacted]
Sura Alqudah	PhD, Industrial and Systems Engineering, 2014	ASC	TT	FT	2	14	7	[redacted]	[redacted]	[redacted]	[redacted]
Jill Davishahl	MS, Mechanical Engineering, 1999	AST	TT	FT	2	19	6	[redacted]	[redacted]	[redacted]	[redacted]

Eric Leonhardt	MS, Automotive Systems Engineering	ASC	TT	FT							
Tarek Algeddawy	PhD, Industrial and Manufacturing Systems	ASC	TT	FT	0	22	3				
Deborah Glosser	PhD, Civil Engineering, 2020	AST	TT	FT	10	6	2				
Steve Sandelin	BS, Electrical Engineering, 1995	I	NTT	FT	18	9	9				
Kirk Desler	MBA, Business Administration, 2018	I	NTT	PT	20	1	1				

Table 6-2. Faculty Workload Summary

Plastics & Composites Engineering

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Nicole Hoekstra	FT	PCE 491 (3) Fall 2021 ID 380 (4) Winter 2022 PCE 492 (3) Winter 2022 PCE 461 (4) Spring 2022 PCE 493 (4) Spring 2022	65	20	15	100%
Nicole Larson	FT	PCE 472 (4) Fall 2021 PCE 372 (4), Winter 2022 PCE 371 (4) Spring 2022	34	33	33	100%
John Misasi	FT	PCE 371 (4) Fall 2021 ENGR 170 (4) Winter 2022 PCE 431 (4) Winter 2022 PCE 331 (4) Spring 2022	40	30	30	100%
Mark Peyron	FT	PCE 471 (4) Fall 2021 PCE 342 (4) Winter 2022 MFGE 341 (4) Winter 2022 PCE 342 (4) Spring 2022	40	40	20	100%
David Rider	FT	ENGR 170 (4) Fall 2021 CHEM 308 (3) Spring 2022	30	50	20	33%
David Gill	FT	MFGE 231 (4) Fall 2021 MFGE 332 (4) Winter 2022				10%
Jill Davishahl	FT	ENGR 101 (2) Fall 2021, Winter 2022 ENGR 115 (4) Winter 2022, Spring 2022				25%
Eric Leonhardt	FT	ENGR 214, (4) Winter 2022				30%

		MFGE 261 (4) Spring 2022				
Tarek Algeddawy	FT	MFGE 250 (4) Spring 2022				
Steve Sandelin	FT	EECE 351 (4) Fall 2021, Spring 2022				
Kirk Desler	FT	ENGR 225 (4) Fall 2021, Winter 2022 MFGE 462 (4) Spring 2022				
Nipun Goel	FT	ENGR 214 (4) Fall 2021				
Deborah Glosser	FT	ENGR 225 (4) Spring 2022				

CRITERION 7. FACILITIES

A. Offices, Classrooms and Laboratories

General: The Engineering and Design department is housed in the Ross Engineering Technology (ET) building, built in 1987. This building contains seven classrooms, with the largest accommodating 60 students, a small seminar room, two computer labs, a lab suite for each of the engineering programs, and a lab suite to support long-term projects. The largest engineering classes have enrollments under 50, so most years all engineering classes are taught in the Ross ET building, and all engineering labs are held in the Ross ET building as well. None of the facilities in the Ross ET building are used in support of basic science instruction. Those programs are located in different building on campus and have sufficient laboratory space of their own.

1. **Offices**

All tenured and tenure-track faculty members have individual offices with a computer and the necessary software to support the courses they teach and their scholarship. Non-tenure track (NTT) faculty members have offices, but most share their office with at least one other NTT faculty member. NTT faculty members also have computers and the necessary software to support their teaching. The main administrative office, ET204, houses the Department's administrative staff and the offices of the Chair, and two senior faculty members. The technical staff also have offices that are located in or close to the laboratory facilities that they oversee.

2. **Classrooms** and associated equipment

PCE classes are generally taught in the Ross ET Building in ET 106, ET 107, ET 262 (computer lab), ET 304, ET 308 (computer lab), ET 321, or ET 322. All classrooms have an instructor station with a networked computer with all of the program software, connections for a laptop, and a document camera. The computer labs also have an instructor station, but without the document camera. The ENGD department maintains cameras that faculty can check out to be able to simulcast a class when there is the need to do so. On some occasions a scheduling conflict results in a program class being taught in a General University Classroom (GUC) in another building. GUCs all have the same equipment Ross ET classrooms, but they have integrated simulcasting systems. Depending upon the class, it may also be necessary to make arrangements for program software to be available in a GUC, though that has not been an issue during this review period.

3. **Laboratory facilities** (See also Appendix C)

The ENGD department maintains a large computer lab, ET 308, with 50 computers and a small computer lab, ET 262, with 22 computers. ET 308 is open 24/7, while ET 262 is available to students during weekdays. Computing resources and software are described in more detail in section 7.B below.

Figure 7.A.1 shows the PCE lab suite, which includes: ET 110, ET 111, ET 112, ET 113, ET 114, ET 122, ET 124, and ET 126.

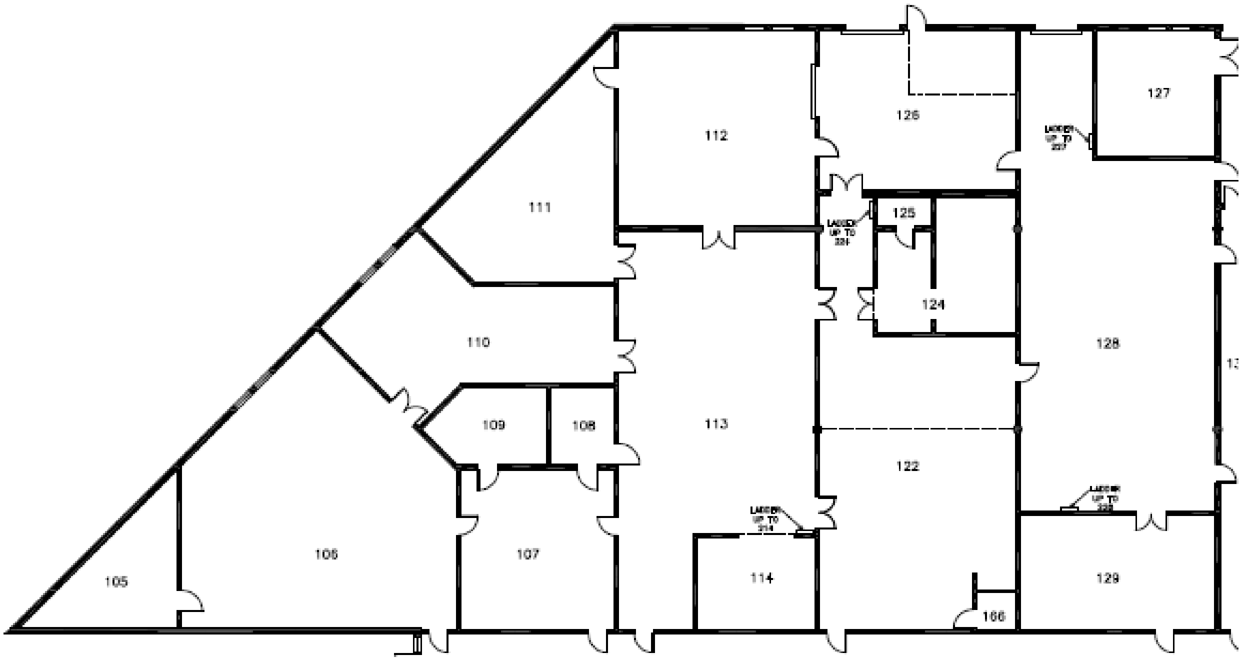


Figure 7.A.1: PCE Laboratory Suite and Surrounding Rooms

THERMOPLASTICS PROCESSING LABS (ET 113 and 114) – includes injection molding, extrusion, compression molding, thermoforming, a variety of ovens, and 3D printing equipment

FABRIC CUTTING LAB (ET 111) – includes some storage space and tables and racks for cutting fabrics and composite bagging materials

COMPOSITES LABS (ET 112 and ET 126) – includes an autoclave, multiple vacuum pumps, freezers, a ski press, a prepreg treater, and a press

SOFT TOOLING LAB (ET 122) – Includes common hand tools, down draft tables, band saws, table saws, plastics recycling equipment, grinders, and similar equipment

FINISHING LAB (ET 124) – An explosion-proof space with enhanced ventilation for use when painting or working with hazardous chemicals

POLYMER ANALYSIS LAB (ET 110) - Includes universal test stands, a hood, optical microscope, tensiometer, and non-contact ultrasound

In addition to these spaces, several pieces of analytical equipment are available for PCE faculty and students to use in the Advanced Materials Science and Engineering Center's Suite in ES 128/129.

B. Computing Resources

The ENGD department has 72 computers for the MFGE, PCE and ID programs located in ET 262 and ET 308. There are an additional 61 computers for the EECE program located in ET 331, ET 338, and ET 340. The 22 computers in ET 262 also contain the software for EECE. These computers are available for local use during building hours of 7am-9pm Monday through Thursday and 7am-6pm Friday through Sunday, except for ET 262 which is closed on weekends. Except for ET 262, students are not kicked out of the building or computer labs when the building is locked, so they can continue to work in the computer labs after the building is closed. In addition, all of these computers are available for remote access through Microsoft Remote Desktop 24/7.

The following software is used by the programs in the ENGD department and available on the lab computers: Altair Simulation Suite, Adobe Creative Cloud, AutoDesk (Fusion360, MoldFlow, SketchBook), CATIA, CGTech Vericut, ChemDraw, Cura, Dassault 3DExperience, DFMA, Keyshot, Matlab, MestReNova, Minitab, Origin, RoboDK, RoboGuide, Solidworks, Microsoft Project, Altium Designer, Anaconda, Click PLC, Eagle Layout Editor, Energia, Git, TourtiseGit, MCUXpresso, MultiSim, PLECS, PowerWorld Simulator, Microsoft Visio. Some of this software is professional versions, while others are more restrictive student editions through our license agreements with vendors.

In addition to the ENGD computer labs there are approximately 400 general university lab computers available for student use. These labs are in various buildings around campus and having varying building hours with some being open 24/7. The University also has some laptops available for checkout by students. Students in the dorms also have access to the lab computers provided by university residences.

File storage is primarily through Microsoft 365 (OneDrive, SharePoint, Teams), however some legacy content is hosted on the ENGD department's file server. The server is a 16 core Windows server with 256 GB ram and 11 TB of storage. It hosts faculty and staff home directories, GT-Suite and CATIA license servers, some departmental files, research data, and the Formula SAE student club files.

C. Guidance

Pre-major students are only allowed to use the equipment in the ENGD Makerspace, 3D printers, sewing machines, vinyl cutters, and a laser cutter, all of which are considered to be safe for novices to use. Nevertheless, students are given demonstrations and supervised when they first use one of the machines in the ENGD Makerspace. Students earn badges on the machines, which allow them to use the machines independently.

Instruction for software is provided in classes that require the use of that software, starting with the introduction of CATIA in the MFGE 261 Introduction to CAD class during students' first quarter in the major. The University's Student Technology Center (STC) also provides training and tutoring on software and the equipment that the STC has, which is very similar to the equipment in the ENGD Makerspace.

Before students are able to use lab suites in the Ross ET building, students who are newly accepted into the major must first complete an online Chemical Safety course and quiz that was created by the University's Environmental Health and Safety (EHS) department. Once students have passed the EHS course, they must attend a Laboratory Safety Orientation. At the end of the Laboratory Safety Orientation students receive a lab badge that is color-coded by major. Students' first badge is valid for spring of their sophomore year and all of their junior year. At the beginning of their senior year, students repeat the EHS course and attend a second Laboratory Safety Orientation, at which they receive a new lab badge that is valid for their senior year. Students who return for a fifth year repeat the senior Laboratory Safety Orientation and receive a new badge for that year.

Once students have a valid lab badge, they are able to enter lab suites. Before students are allowed to use any of the equipment in a lab suite, they participate in an orientation to learn the basic safety procedures and requirements for that lab suite. Each lab suite has an Instructional Technician to maintain the lab suite and its equipment and to enforce the lab rules. For basic equipment, such as drills and hand tools, faculty and staff do not give formal instruction but instead perform training on a case-by-case basis. For more advanced machinery, tooling, and processes each student must attend a laboratory demonstration performed either by the lab technician or course instructor before attempting to operate the equipment or perform the process. Students are only allowed to use the lab suites when they are supervised by a lab technician or a faculty member. The PCE lab suite is open during the day on weekdays, and in the evening Monday through Thursday for a limited set of activities. The MFGE lab suite is open during the day on weekdays. The Project Lab suite is open in the afternoon and evening Monday through Thursday, and during the day on Fridays.

Due to the COVID-19 pandemic, the Laboratory Safety Orientations were temporarily suspended, and students received their lab orientation and safety briefings directly in the lab suites that they were using for classes. During this period students were not able to use lab suites that they did not need for a class in which they were currently enrolled.

D. Maintenance and Upgrading of Facilities

Although the University is aware of the problem, at this point there is not a campus plan for regular replacement of lab equipment. At this time, equipment is supported through student lab fees, one-time financial support, and in-kind donations. This applies to both the replacement of existing equipment and the acquisition of new pieces with updated technology.

The primary funding source for equipment in the PCE program is currently the equipment replacement fee charged in every MFGE and PCE course. This fee supports an equipment replacement plan that is intended to replace each piece of laboratory equipment on a 20-year cycle and computers on a 5-year cycle. The computer portion of the fee also supports annual software costs, the maintenance of 3D printers that are available for all students in the programs to use, and the replacement of teaching computers and projectors in department classrooms. The fees are adjusted every year to take into account in-kind donations, steep discounts, or matching funds for equipment purchases and equipment maintenance. The fees may also be adjusted to shorten or lengthen the replacement cycle for specific pieces of equipment. The fee generally funds one large piece of equipment (> $50k) for the MFGE or PCE program each year and many smaller purchases as well. A portion of the fund is always set aside to address safety issues, if there are any safety issues to address. The average annual spending from the equipment fund for the last six years has been almost $120k.

The ENGD department is in the process of building an equipment endowment that can be used to supplement funding from lab fees. Large monetary donations made to the department in recent years have been added to this endowment, and the interest that it earns is being rolled back into the principle. It is the plan of the department to grow this endowment to be a sustainable source of funding that amounts to a third of the cost of equipment replacement, with the other two thirds coming from student lab fees, donations, and internal and external grants.

PCE equipment replaced during this review period via the methods outlined above includes an injection molding machine, a compression molder, an extrusion puller, vacuum pumps, a waterjet cutter, an upgrade to the autoclave, and a rotomolder.

Maintenance of existing equipment is primarily performed by the faculty and technical staff, and supported by the department's operating budget and lab fees. A portion of the department's operating budget is reserved for equipment repair each year, and it is generally sufficient to cover equipment repair costs. In specific cases when the Department budget has not been adequate to cover equipment repair, the Dean's office has supplied additional funds.

E. Library Services

Engineering & Design is supported by the library with journals, books, and a reference collection, however, like the rest of campus, the library has experienced a severe reduction in its budget, and is faced with rapidly increasing subscription costs. Thankfully this does not have an effect on the PCE program because the library purchases materials on-demand when asked. A librarian is assigned to the Department to assist with research, instruction, and purchasing materials. The book collection is somewhat dated, but access to journals articles is good. Journals are available online, many e-books are online, and several reference items are online also. Journal subscriptions are considered when requested and ordered when usage merits the purchase. Databases purchased by the library to support ENGD include:

- Web of Science
- SciFinder (Chemical Abstracts Service)
- EBSCO Academic Search Complete ACM Digital Library
- Computer Abstracts International SPIE Digital Library
- IEEE Xplore
- ASTM
- Engineering Index and INSPEC are available by appointment

The library catalog is connected to Summit, a local union catalog of 40 academic libraries and WorldCat, the OCLC union catalog of libraries around the world. To obtain information the library does not own, the library provides an inter-library loan service. Journal articles are delivered online, books are delivered to faculty departmental offices.

CRITERION 8. INSTITUTIONAL SUPPORT

A. Leadership

The primary program leadership is shared between the Program Director and Department Chair. The Program Director reports to the Department Chair, who reports to the Dean of the College of Science and Engineering, who reports to the Provost and Vice President for Academic Affairs, who reports to the University President.

The Program Director shares responsibility for the program curriculum and resources with the Department Chair. For the PCE program, the Program Director is Professor Nicole Larson and the Department Chair is Dr. Jeff Newcomer. Professor Larson has been a faculty member in the PCE program since 2005, has been the PCE Program Director since 2014. As Program Director, Professor Larson is responsible for the curriculum, the PCE program's 3.33 other tenured and tenure-track faculty, limited-term faculty, the instructional technician, approximately 45 PCE majors, and the program laboratory suite. Appointment of the Program Director is based on a joint recommendation of the Chair and the program faculty.

The Engineering and Design (ENGD) Department Chair, Dr. Jeff Newcomer, who has been the Chair since fall 2012, shares responsibilities with Program Directors for curriculum and facilities for five programs – Electrical and Computer Engineering, Manufacturing Engineering, Plastics and Composites Engineering, First-Year Programs, and Industrial Design. These programs comprise a total of over 400 majors and pre-majors. The Chair, with appropriate consultation with Department faculty and staff, is responsible to the Department, the College, and the University for leadership in matters effecting the Department including, but not limited to:

- Faculty teaching assignments and workloads;
- Course scheduling;
- Curricular planning;
- Recommending appointment of new faculty and staff, including opportunity hires;
- Administering the space and equipment allocated to the Department;
- Budget management and authority;
- Addressing student and faculty concerns by using the relevant university procedures;
- Administering faculty and staff development and performance reviews;
- Reviewing and evaluating faculty tenure and promotion cases;
- Managing the Department's resources;
- Management of assessment and accreditation efforts;
- Management of lab safety programs, including maintaining compliance and training;
- Working with the Foundation to obtain donations for the Department; and
- Other duties assigned by the Dean.

The Chair is also responsible for the development and maintenance of departmental records, for facilitating the harmonious functioning of the Department, for management of the Department's resources, and for providing information to the Dean in a timely manner for use in personnel and departmental resource decisions.

The Dean, Dr. Brad Johnson, is responsible for the leadership of all departments and centers in the College of Science and Engineering (CSE), including the:

- Biology Department,
- Chemistry Department,
- Computer Science Department,
- Engineering & Design Department,
- Geology Department,
- Mathematics Department,
- Physics & Astronomy Department,
- Science, Mathematics and Technology Education (SMATE) program,
- Internet Studies Center, and
- Advanced Materials Science and Engineering Center (AMSEC).

The Dean also has an Associate Dean, Dr. Jackie Caplan-Auerbach, who primarily handles curriculum, assessment, and student considerations such as academic honesty violations and grievances. Dean Johnson started as Dean fall 2017 and Dr. Caplan-Auerbach started as Associate Dean during fall 2017 as well. College-wide decisions are made by the Dean in consultation with several advisory committees including the:

- Policy, Planning, and Budget Council (PPBC),
- Curriculum & Assessment Committee,
- Diversity, Equity, and Inclusion Committee,
- Personnel Committee,
- Technical Operations Committee, and
- Dean's Advisory Committee (DAC).

Each of these committees has a representative from each department. DAC is made up of department Chairs and the SMATE and AMSEC Directors

The Provost, Dr. Brent Carbajal, is responsible for all academic affairs at Western including eight colleges/schools:

- College of Business and Economics,
- College of Fine and Performing Arts,
- College of Humanities and Social Sciences,
- College of Science and Engineering,
- Fairhaven College of Interdisciplinary Studies,
- Graduate School,
- The College of the Environment, and
- Woodring College of Education.

The Dean of each of these colleges reports to the Provost, as does the Dean of the Libraries and five Vice Provosts. The Provost is one of five Vice Presidents that report the President, Dr. Sabah Randhawa, who in turn reports to the Board of Trustees.

Leadership is involved in program decisions in proportion to the impact of the change on the Department and other academic units. Proposals for program changes, ranging from small course changes to program expansion, originate in the program. The Chair ensures that changes that impact multiple programs have input from all of the effected programs, and the curricular change process ensures that programs external to the Department are aware of and approve academic changes that impact them.

All academic course and program changes are reviewed and approved by the ENGD Curriculum Committee, the Department Chair, the CSE Curriculum Committee, and the Academic Coordinating Commission (ACC), which is the university-level curricular body.

All proposals for program expansion are discussed in the ENGD department, by both the PPBC and DAC committees at CSE, at the University Planning and Resources Council (UPRC), and by the Council of Deans run by the Provost, before going to the President and the Vice Presidents for final consideration. Successful proposals are either funded by the Provost or included in the University's operating budget request to the State. The First-Year Programs Director position, four EECE faculty positions and a EECE staff position have been funded through this process during this review period.

Due to the COVID-19 pandemic, the University put in place a hiring freeze from March 2020 to July 2021.

- EECE: Despite the hiring freeze, the Dean and Provost recognized the growing interest in EECE and authorized faculty searches for two positions during the 2020-21 academic year.
- MFGE: Since MFGE did not have any open faculty or staff positions during this period, the MFGE program was unaffected by the hiring freeze.
- PCE: The PCE program was in the middle of a faculty search when the hiring freeze went into effect, and that search was cancelled. The tenure-track line still exists, but because the University's enrollment is down almost 10% compared to pre-pandemic levels, the search for a new PCE faculty member was not authorized for the 2021-22 academic year. The search has been authorized for the 2022-23 academic year.

Leadership has been more than sufficient for maintaining program quality and continuity. The ENGD leadership group, made up of the Chair and the five Program Directors, has a good mix of experienced members and relatively new members with fresh perspectives. The Dean, who was a department chair for nine years and Associate Dean for three years before becoming Dean, is very experienced and has been very supportive of program needs. The Provost and the Associate Vice President for Academic Affairs, Dr. Brian Burton, have been in their positions for nine years and have also been very supportive of the program and its needs. The only concern is that both Provost Carbajal and Associate Vice President Burton are retiring summer 2022, Dean Johnson has been appointed as the new Provost, a position he will begin on August 1, 2022, and

Dr. Janelle Leger, the current Chair of Physics and Astronomy, has been named the Interim Dean of CSE.

B. Program Budget and Financial Support

1. The PCE program's budget is a subset of the ENGD Department's budget. The Department's annual recurring budget includes funding for twenty-three permanent, full-time faculty positions and eleven permanent, full-time staff positions (salary and benefits), including five faculty positions (one of which is currently vacant) and one staff position exclusively for the PCE program. There are also three permanent, full-time faculty positions in the Department that are funded through the Institute for Energy Studies (IES), one of which is fully in the EECE program, and a permanent, full-time faculty position in Chemistry that is 0.333 FTE in the PCE program. Staff positions and their role in support of the PCE program are briefly discussed in Section 7.C below. During this review period, the Department has added five faculty positions, and both of the staff positions that were part-time at the last review are now full-time positions.

   The Department has a $75,000 operating budget. The Department's operating budget has increased by $2,000 for each new faculty position added to the Department, but otherwise has been steady for many years. The Department's operating budget is divided into a portion for each program, funding for faculty travel ($1,500/yr for tenure-track faculty members and $1,000/yr for tenured faculty members), funding for equipment repair, and a small amount to support the main office. The current breakdown of the Department operating budget is:
   - EECE: $4,000
   - FYP: $1,600
   - ID: $1,600
   - MFGE: $3,200
   - PCE: $3,200
   - Travel: $24,000
   - Technicians: $4,500
   - Repair: $13,000
   - Chair/Office: $19,900

   Because the College supports faculty travel, including registration fees, for up to two trips per year, a portion of the money budgeted for Travel in the Department operating budget is often used for repairs or to support programs. The Department budget allocations are reviewed every few years, most recently during the 2021-22 academic year due to the addition of FYP and the cancellation of the Industrial Technology-Vehicle Design program, and adjustments to allocations are made if they are warranted by changes in programs.

   For the 2022-23AY (FY2023), the Engineering and Design Department is giving more budgetary control to the Program Directors, including control over the travel funding that is allotted to program faculty members. Since most travel costs are actually covered by the College, this will give the programs more flexibility. The new program allotments for the engineering programs are:

- EECE: $19,750
- FYP: $5,350
- MFGE: $11,450
- PCE: $11,450

Beyond its recurring budget, the Department has multiple funding sources, including annually requested recurring funds and numerous self-sustaining funds:

- The College of Science and Engineering provides annual funding for non-tenure track faculty members (NTTs) on an as-needed basis and 1,000 hours of funding per quarter for undergraduate teaching assistants (UTAs). The annual request is prepared by the Chair and submitted to CSE during winter quarter of the previous fiscal year. The request the 2021-22AY (FY2022) was funded at is usually initially funded at ~$183,000 for salary with $50,000 set aside for UTAs and an additional ~$50,000 set aside for benefits, and the Dean's Office approved additions of $25,000-$30,000 to that request as things changed during the academic year (most of which impacted the Industrial Design program, not engineering). This funding has always been sufficient to meet Department needs, and the Dean's Office has always provided full funding for all requested NTT sections. However, requests for UTAs during the 2021-22 academic year exceeded the 1,000 hrs/qtr that had been sufficient in previous years, so the 2022-23 academic year request was increased to ~$187,000 for salaries with $80,000 set aside for UTAs. The reduction in funding for NTT salaries is due to a reduction in need for NTT led sections due to new hires in the EECE program, so all of the requested sections were funded.
- The Department maintains seven lab fee funds for consumables, including one that specifically support the PCE lab suite. Fees are set based upon expected materials use and other costs, such as specialized software licenses, and attached to each class that uses the lab or lab suite supported by the fund. These funds are supposed to be at or near zero balance at the end of each academic year, and they rarely exceed $5,000 at any given moment.
- The Department maintains three lab fee funds for equipment and computers: 1) a fund to support computers, equipment, and software for EECE, 2) a fund to support computers, annual software costs, and 3D printing for MFGE, PCE, ID, and First-Year Programs (FYP), and 3) a fund to support major equipment purchases in MFGE, PCE, and ID. Computers are replaced on a five-year cycle and major equipment is replaced on a twenty-year cycle. More information is given about the computer and equipment replacement approach in Section 7.D.
- The Department maintains two self-sustaining funds, one related to fees accrued through use of equipment by external users and one general fund. These funds are used for infrastructure improvements and occasionally used for repairs if operating budget funds and funds from the Dean's Office are insufficient. The two funds currently have a combined balance of ~$150,000.

- The PCE program has a fund that is supported by project fees. This fund is used to pay the salary and benefits of the PCE Research Associate and costs associated with projects paying into the fund.
- The Department has a general Foundation fund. This fund is used for program enhancements and to support faculty professional development. The current balance of the Foundation fund is ~$121,000.
- Each engineering program has a Foundation fund. These funds are used for program enhancements at the discretion of the Program Directors for each program. The current balance of the EECE, MFGE, and PCE funds are ~$3,200, ~$36,000 and ~$19,000 respectively. While these funds are not frequently used, the MFGE program spent ~$46,000 on laboratory equipment from its fund in summer 2021.
- The Department is building an equipment endowment. When the principal value reaches $1,000,000, the intent is to spend interest from that fund on major equipment purchases, which should allow for the reduction in what students pay in lab fees for the equipment replacement funds. The current balance of the equipment endowment is ~$630,000.

2. As Western is primarily a teaching University, there are many programs to support teaching. The College funds undergraduate teaching assistant (UTA), the Center for Instructional Innovation and Assessment (CIIA) sponsors events, and provides resources and support for implementation, the Office of Research and Sponsored programs (RSP) supports summer teaching grants, and the Science, Math, and Technology Education (SMATE) program has been offering grant funded curriculum development workshops and teaching orientation workshops for new faculty for the last two years. In addition, the Department will send faculty to workshops or classes to improve teaching and/or content knowledge. This is generally done on an as-needed basis, and it has not been needed recently.

   As mentioned above in Section 8.B.1, the College has been providing funding for 1,000 hours of UTA support each quarter. UTAs are used primarily to support lab activities, and sometimes as graders as well. Priority is given to lab support followed by classroom support and then grading, so as demand for UTA hours has increased, support for grading has been rare, but all requests for lab and classroom support have been accommodated.

   While the College provides support for laboratories and grading, the CIIA provides support for innovation. The mission of the CIIA is:

   > [D]edicated to the enhancement of teaching and learning on the campus of Western Washington University. The Center promotes discussion and debate about teaching and learning, provides support to faculty in instructional innovation and course development, and helps nurture a culture of educational innovation and instructional excellence across disciplines.

   The CIIA realizes its mission through: 1) sponsoring events including workshops, webinars, and summer grant opportunities, 2) serving as a clearinghouse for teaching, learning, and assessment resources, and 3) providing support for implementation of new teaching and assessment methods. The CIIA ran a number of paid workshops to support faculty members switching to online teaching during the pandemic, which was greatly helpful for engineering faculty members, most of whom had never taught an online class before.

Although it is primarily a research support office, RSP overlaps with the CIIA a bit in that it offers grants to support teaching innovation. RSP provides a competitive grant opportunity for Western faculty to get $6,000 of summer salary to "to provide faculty with time to engage in projects that will result in significant enhancement of instruction." An individual faculty member is eligible to receive a summer teaching grant every other summer.

A different sort of grant support is provided by SMATE. While SMATE's primary focus is preparation of K-12 teachers, SMATE's mission is:

> [T]o improve teaching and learning of science, mathematics, engineering, and computer science by all and for all. We accomplish this through teaching, research, professional development, and partnerships with people and communities in the university, the state, the region and throughout the world. Ultimately we expect to see the results of our work in the healthy and socially just communities around us.

In addition to its grant and workshop activities, SMATE sponsors a paid, three-day teaching workshop for new faculty members before the academic year begins, and almost all new faculty members in engineering participate in this workshop.

3. Maintenance and upgrade of infrastructure and facilities and acquisition, maintenance, and upgrade of equipment are different processes at Western. While general maintenance of infrastructure and facilities is completed by Facilities Management (FM), upgrade of infrastructure and facilities is run through the University's capital budget process. In contrast, acquisition, maintenance, and upgrade of equipment is primarily a Department process that uses a combination of lab fees, grants, in-kind donations, working with industry partners, and sometimes includes the College, the Western Foundation, and University's Student Technology Fee (internal) grant process.

   General infrastructure and facilities maintenance is conducted by FM based primarily upon their campus-wide plan, which is regularly updated. Upgrade of infrastructure and facilities is part of the University's capital budget process. Major capital projects, such as building construction, building renovation, and building expansion are part of the University's ten-year capital plan. Classroom and laboratory renovations and improvements, both programmatic and infrastructure, are part of the University's minor capital project process. This process begins with the submission of a proposal, which can be done by any individual or group on campus. The proposals are then separated into programmatic proposals and preservation proposals, the latter of which includes anything that is related to safety as well. Preservation proposals are assessed and prioritized by FM. FM completes projects in that order as funding allows.

   Programmatic proposals all go to the college or division level where they are all prioritized. The Provost's office then prioritizes all projects from the colleges. The project lists from the Provost and the other Vice Presidents are reviewed by UPRC, which may recommend changes, and then ultimately reviewed and approved by the President. The faculty have input at the College through PPBC and DAC, and at the university level through UPRC. Once the proposed projects are all prioritized, they are scheduled and completed as funding allows. Funding for programmatic projects has been limited recently, but the ENGD Makerspace was funded for an upgrade during the 2021-22 academic year, with the work due to take place during summer 2022.

Unlike infrastructure and facilities, the University does not have a general equipment acquisition, maintenance, and upgrade process, so this is managed by the Department. As mentioned above in Section 8.B.1, the primary source of regular funding is student lab fees. To make sure that these funds are used well and expediently, the Department maintains and annually updates an equipment priority list and acquisition plan.

Whenever possible, lab fee funds are supplemented by grant funds, donations, and University funding sources. Another source of equipment funding has been the University's Student Technology Fee (STF) program. This program is funded by the university-wide student technology fee, and a portion of the funds are set aside to fund equipment acquisition through a proposal process. During this review period, the Department received electronics simulation software for the EECE Energy program; a Universal Cobot for MFGE labs suite; a twin-screw extruder, two microscopes, a Selective Laser Sintering 3D printer, a universal test stand, and a sheet press for the PCE lab suite; and equipment for the Makerspace through the STF program.

During this review period, the PCE program has acquired or replaced the following equipment:

- Chemical recycling reaction vessel for composites recycling
- Additional hopper drier and mold heater
- KRUSS Contact Surface Angle instrument
- Lab Scale Hot-Melt Filmer
- Thermoformer
- Falling Dart Impact Tester
- 3 new TAZ printers for student use
- Universal Test Stand Fixtures
- High temperature FDM printer – Intamsys Funmat HT
- Melt pump extruder
- Side feeder Twin Screw Extruder
- Compression molder
- Bruker MALDI-TOF Imaging system
- Agilent Q-TOF LCMS system
- SpeedMixer dual action centrifugal mixer
- MultiDrive mill for polymer milling
- Rotational molder
- Single screw extruder
- Injection molder
- Rheometer
- RTM

4. Resources have been and remain adequate to attain student outcomes. There are three facets to resources required to attain student outcomes: 1) salaries sufficient to hire and retain appropriately qualified faculty and staff, 2) sufficient operating funds to support annual activities, and 3) consistent funding for the acquisition, maintenance, and upgrade of equipment. While there is room for improvement, especially in the equipment funding situation, there is and has been sufficient support to meet student outcomes.

   As is discussed below in Sections 8.C, 8.D, and 8.E, salaries and benefits are competitive enough to have allowed the Department to attract and retain faculty and staff. While faculty searches have been complicated by the pandemic recently, we have had only one top candidate turn down Western for a job at another university during this review period, and no faculty members have left for other faculty positions. The faculty contracts have had consistent salary increases, and the compression and equity adjustments have raised salaries for senior faculty members to appropriate levels when compared to national averages for engineering. Staff positions are a bit more challenging, due to the rigidity of the State classification system, but almost all of ENGD staff positions have been reviewed and reclassified to higher levels during this review period, so staff retention has been consistently good as well, though there has been some turnover among the classified staff.

   As was discussed above in Section 8.B.1, the Department operating budget has been sufficient for operation as it is well supplemented by College and one-time funds. The additional funds from the College for faculty and staff travel and professional development essentially expand the Department operating budget by ~30% each year. The one drawback of this funding model, as opposed to the funds being in the Department, is that it makes long-term planning for professional development more difficult because funding must be requested for each specific event. Fortunately, the Department has sufficient one-time funds to supplement funding for activities that the College will not or cannot fund. The University was also very good about supporting the additional costs incurred from the switch to online instruction due to the pandemic, so the Department did not have to bear those costs out of its operating budget or one-time funds.

   Finally, as was discussed above in Section 8.B.3, funding for acquisition, maintenance, and upgrade of equipment has been sufficient, but there is not as large of a regular funding stream as is desirable. Ideally the student lab fees would be about one third of the funding for equipment rather than the largest share. When the Department's equipment endowment gets large enough, and it is getting close, it will be able to provide some regular funding for equipment acquisition, maintenance, and upgrade. For this reason, the equipment endowment is one of the fundraising priorities at this point and time. It would be ideal if the University were also able to consistently contribute to the planned replacement of equipment, but while there have been discussions about doing so, no plans have ever emerged from those discussions.

C. Staffing

The Department currently has three permanent, full-time office classified staff people, seven permanent, full-time technical classified staff people, and one full-time soft-money technical professional staff person. The office staff support all five programs in the Department. Six of the eight technical staff have primary focus areas for supporting labs and programs, while the last two support all five programs in the Department. Below is a brief description of each staff person's responsibilities:

Administrative Services Manager B (ASM), Amy Lazzell – The ASM serves as both the Department Financial Manager and Office Manager. The ASM maintains and tracks budget information for all Department funds including operating, lab fee, foundation, grant, start-up for new faculty hires, and self-sustaining. The ASM also manages payroll, purchasing, hiring procedures including all personnel forms, and serves on the Department Resources Committee. Finally, the ASM supports academics directly by managing the lab fee change process. The ASM is a 1.0 FTE position.

Program Coordinator (PC), Lisa Ochs – The PC serves as the pre-major advisor for all five programs in the Department, designs and manages the Department website, maintains advising and outreach materials such as program planning guides, and supports assessment activities. The PC also supports academics by managing the entering of the course schedule into the University's system. At any given time the PC has 150-300 pre-major advisees, of whom 40-60 are pre-majors in the PCE program. The PC is a 1.0 FTE position with a 0.083 FTE temporary reduction.

Office Assistant 3 (OA), Jodie Perman – The OA serves as the first point of contact for the Department and does several jobs that are important to program support. She orders lab badges for all majors, collects and files syllabi for all classes, and manages textbook orders for classes. The OA is a 1.0 FTE position.

Electronics Technician 4 (ET) for EECE, Reza Afshari – The ET for EECE is responsible for maintaining the EECE labs, supporting the lab activities in them, and enforcing lab rules, including all safety rules. In this role, the ET for EECE also orders parts, and designs and fabricates equipment to support labs and other faculty activities. The ET for EECE is assigned to the EECE program, but does support other areas in the Department when electronics work is needed, as long as such work does not interfere with EECE program needs. The ET for EECE is a 1.0 FTE position.

Instructional and Classroom Support Technician 4 (ICST) for MFGE, Ben Kaas – The ICST for MFGE is responsible for maintaining the MFGE labs, supporting the lab activities in them, and enforcing lab rules, including all safety rules. In addition to working with students in the labs on class and senior projects, the ICST for MFGE maintains equipment, orders parts for the lab, and prepares materials for the lab activities. The ICST for MFGE also runs biweekly meetings of the technical staff so that they may are aware of what is going on in all of the labs and are able to support each other. The ICST for MFGE is a 1.0 FTE position. Because this job has gotten more complicated with time, it is currently being reviewed for possible reclassification or conversion to a Professional Staff position.

Instructional and Classroom Support Technician 4 (ICST) for PCE, Currently Open – The ICST for PCE is responsible for maintaining the PCE labs supporting the lab activities in them, and enforcing lab rules, including all safety rules. The ICST for PCE is also the Chemical and Material Safety Officer. In this role the ICST for PCE maintains inventories of materials, makes sure that all new materials and chemicals are properly logged and have Safety Data Sheets on file, and makes sure that all disposals of materials and chemicals are done properly. The ICST for PCE is a 1.0 FTE position. The ICST for PCE position has been open since January 2022, so the work has been covered by a part-time temporary ICST person (0.67 FTE), extra support for the PCE faculty from CSE, and extra UTAs. A new ICST for PCE is expected to start on July 5, 2022. Because this job has gotten more complicated with time, it is currently being reviewed for possible reclassification or conversion to a Professional Staff position.

Instructional and Classroom Support Technician 3 (ICST) for Project Lab and Evenings, Mark Dudzinski – The ICST for Evenings is responsible for the Projects labs and works until 9:00 p.m. Monday through Thursday during the academic year to provide students supervised access to certain labs, including the Projects labs, the ID Model Making Shop, and portions of the PCE labs, but not the MFGE labs. The ICST for evenings is a 1.0 FTE position.

Instructional and Classroom Support Technician 3 (ICST) for Industrial Design, *Lisa Collander* – The ICST for ID primarily supports the ID program and labs, but also supports the Makerspace. The ICST for ID is a 1.0 FTE position.

Research Associate 2 (RA) for PCE, Sean Ryan – The RA for PCE works with students and faculty on funded industry sponsored research projects and senior projects. His responsibilities vary with each project, but always involve acting as a liaison with the sponsoring companies, ordering supplies and equipment, and supervising student work on the projects. The RA for PCE is a 1.0 FTE soft-money position.

Information Technology Customer Support – Journey (ITCS) Colin Hanson – The ITCS provides computer and general IT support for faculty, staff, classrooms, computer labs, and general labs for the Department. The ITCS works with other ITCS people in support of the College, but he is fully assigned to support the Department. The ITCS is a 1.0 FTE position.

Engineering Technician Lead (ETL), Stephen James – As the senior technician in the Department, the ETL oversees overall lab safety and organization for the ET building. The ETL also coordinates major building and lab projects, maintains and updates the Department's Emergency Response plan, and coordinates the lab badge program, including the annual lab safety lectures all majors must attend. The ETL is a 1.0 FTE position.

Staff have access to on-campus training through Academic Technology User Services (ATUS), Human Resources (HR), and University courses, which may be taken on a space-available basis. For off-campus training, the College provides $600/year to each member of the staff for staff travel, and staff may request additional funding from the Department as well. For retention, the state classification system does not allow for salary adjustments outside of the proscribed increases, but as staff get more experience and take on additional responsibilities it is common to request that they be moved to a higher classification.

In addition to staff who work exclusively for the Department, there are a number of administrative offices that support the Department. Along with standard university offices such as Academic Advising, Admissions, the Office of Civil Rights and Title IX Compliance (CRTC), Financial Aid, HR, Public Safety, Purchasing, and the Registrar's Office, the following offices support the Department in the following manners:

- ATUS – Computer support for students and computer/software training for faculty, staff, and students.
- Career Services Center – Posting of job and internship opportunities, and the organization and management of three career fairs each year, one of which has an engineering focus.
- Counseling and Wellness Center – Support for students dealing with life problems and emotional concerns.
- Disability Access Center – Support and accommodations for differently-abled students to ensure that they get equal access to curricular and co-curricular activities.
- Environmental Health and Safety (EHS) – Support for technical staff and faculty to make sure that labs are safe and compliant with regulations, including material storage and disposal. EHS Collects and disposes of waste materials from Department labs. EHS conducts safety related training for faculty, staff, and students. EHS conducts assessments of new procedures to assess risk and make sure that PPE is appropriate. EHS will, on request, audit labs for safety and compliance.
- Equity and Inclusion – The University has a number of offices that support students from diverse backgrounds, including:
    - Ethnic Student Center
    - LGBTQ+ Western
    - Lesbian Gay Bisexual Transgender Advocacy Council
    - Queer Resource Center
    - Womxn Center
- Facilities Management (FM) – In addition to general building maintenance and repair, FM works with technical staff to make modifications and improvements where needed. Recently FM made a number of improvements to electrical connections for equipment to improve safety in Department labs.
- Capital Planning and Development (CPD) – Works with faculty and staff to develop plans for space improvements. These may result in minor, intermediate, or major capital projects. CPD then oversees the implementation of funded plans.
- Foundation of WWU – Each college has a foundation officer. The foundation officer works with the Dean and the departments, usually through the Department Chair, to identify and pursue opportunities for philanthropic support from both individual and corporate donors. The foundation officer identifies potential donors, serves as point person for communication with them, and helps develop proposals for funding.
- Government Relations – Works with State and Federal governments to obtain resources for initiatives such as the Transition to Engineering decision package that resulted in funding for 4.0 FTE of faculty and 3.5 FTE of staff.

- Office of Research and Sponsored Programs (RSP) – Provides support for development and submission of external grants. Provides several different types of small internal grants for faculty and students.
- University Communications – Publicizes accomplishments of faculty and students and helps develop materials for external fundraising. Works closely with Government Relations to support their efforts.
- Veteran Services – Provides comprehensive services to veterans, service members, and their dependents as they pursue their education at WWU.

D. Faculty Hiring and Retention

1. The process for hiring new faculty involves the Program, the Department, the Dean's office, and the Provost's office. First the Program proposes a faculty search. Then the Department determines its hiring priorities and provides them to the Dean. Prior to the COVID-19 pandemic, the Dean, in consultation with the Dean's Advisory Council (DAC) and the Policy, Planning, and Budget Council (PPBC), would determine the hiring priorities for the College and then authorize searches as funding allowed. Since the beginning of the pandemic, the Dean is required to provide hiring priorities to the Provost, who has been authorizing searches based on priority of student access. Due to the reduction in enrollment due to the pandemic, a number of faculty searches have been deferred, but some have been authorized to occur during the 2022-23 academic year, including a PCE faculty search that was cancelled in the 2019-20AY. Once the Dean approves a search, the Department selects a Chair for and members of a Search Committee for the position(s), and the Search Committee creates a position description and recruitment plan. The position description is reviewed, possibly amended, and approved by the Department faculty and the Chair. The position description and plan must then be approved by the Dean, the Provost, Human Resources (HR), and the Office of Civil Rights and Title IX Compliance (CRTC) before the position is posted.

   Once recruitment begins, all applications are reviewed by the members of the Search Committee. Once the Search Committee has reviewed all of the applications, it develops a list of five to twelve candidates for phone interviews. A list of candidates for on-campus interviews, usually three, is developed from the phone interviews. On-campus interviews are two days long, and involve the candidate teaching a sample class, giving a research talk, and meeting individually with faculty and administrators, and in groups with students and staff. Once on-campus interviews are complete, the Search Committee makes a recommendation for hiring priorities to the Department. Once the Department has approved a hiring recommendation, the search process is reviewed by CRTC and then approved by the Dean, the Provost, and HR. Once all of the approvals are in place, the Search Committee Chair notifies the top candidate, and the Department Chair begins negotiation of terms and conditions of employment with that candidate. The Dean and Provost also review and approve the formal offer to the candidate before it is tendered.

   A standard package for a new faculty hire includes at least one summer of funding, start-up funding to support the new hire's research, course release for the new hire's first year or two, and funds for relocation expenses. The Department Chair, with approval of the Dean, has some latitude to offer additional salary based upon the candidate's experience, additional summer support, additional start-up funds, or additional course releases. Before a formal offer can be tendered, the Dean, the Provost, HR, and CRTC must all approve the search process and outcome. During this review period, the Department conducted nine faculty searches to fill eight faculty positions, two replacement and six new, for engineering faculty members. Prior to the pandemic, four of six searches were successful, and the top candidate accepted the Department's offer. During one unsuccessful search no offer was tendered. During the other unsuccessful search, which was for two positions, one person turned us down and one accepted the position, but later had to withdraw due to complications due to the pandemic. Since the beginning of the pandemic, searches have been more difficult. One search was cancelled due to the hiring freeze the University imposed in March 2020; that search has now received authorization to restart, and it will occur during the 2022-23 academic year. One search for two positions was authorized despite the hiring freeze. That search resulted in one hire, one person turning us down to take another job, and one person turning us down due to complications due to the pandemic. The most recent faculty search, once again for two positions, resulted in two new hires who will be joining the EECE program in fall 2022.

2. Strategies used to retain current faculty include: 1) professional development funding for travel and webinars, which is described in Section E below, 2) sections in the faculty contract that provide for merit and equity and compression raises, and 3) a retention fund for competitive counter offers maintained by the Provost. Salary increases are determined through negotiations between the University Administration and the United Faculty of Western Washington (UFWW), the faculty union. In addition to general cost-of-living raises and raises associated with promotions, the contract has provided for merit raises based upon exceeding expectations on post-tenure review (PTR), and for equity and compression raises. PTR is conducted every five years. Faculty are reviewed for performance in teaching, research, and service, and required to meet expectations in all three areas. A faculty member who exceeds expectations in one or more areas receives a raise. Equity and compression raises are based upon comparison to the faculty member's field, so the salaries of engineering faculty members in the Department are compared to national averages, and adjustments to salaries are made accordingly. At this time University Administration and UFWW just negotiated a new contract and have agreed to revisit the equity and compression formula. The result of this revisiting is that there were no equity and compression raises during 2021-22 academic year, but the raises are expected to return during the 2022-23 academic year.

E. Support of Faculty Professional Development

Faculty professional development is supported by the Department, the College, the Office of Research and Sponsored Programs (RSP), and the University. The Department provides travel/professional development funds for all tenured and tenure-track (probationary) faculty members. Tenured faculty members have an annual Department travel/professional development allotment of $1,000, and tenure-track faculty members have an annual allotment of $1,500. In addition to travel for conference, workshops, and training sessions, these funds can be also be used for on-line development activities such as webinars. In addition, the department will contribute additional funds as needed for justified faculty development activities. These funds come from either indirect cost recovery, foundation funds, or other one-time funding sources.

The College provides funding for travel to conferences, symposia, and meetings. If the faculty member is presenting one or more papers, the College will fund registration fees up to $1,000 per event for up to two events, and also provides $700 to $1,400 for domestic travel, depending upon location, and $1,500 to $2,400 for international travel, depending upon location, for up to two events. The College will also provide these funds for travel to conferences where the faculty member is not presenting a paper and for other opportunities, such as training sessions, provided that there are funds available. Faculty members presenting papers have first priority for College travel funding, and support for a second trip is subject to the availability of funds. The College also provides the Department Chair with an additional $1,000 for travel to conferences.

RSP provides several internal funding programs that support faculty. RSP provides up to $5,000 for Pilot Projects to generate data for grant applications, $6,000 in salary for Summer Research grants, $6,000 in salary for Summer Teaching grants, a small grants program that provides up to $1,000, and manuscript preparation support for up to $2,200, and a New Initiatives Fund that will provide up to $25,000 to support preparation of major grant proposals (>$500,000) that involve multiple researchers. Prior to the pandemic, the Center for Instructional Innovation and Assessment (CIIA) provided faculty summer grants of $4,000 to attend a five-day workshop to acquaint faculty with models, open-source resources, and ideas for web-based course enhancements, after which the CIIA provides assistance and support for implementing the enhancements. Since the start of the pandemic, the CIIA has offered numerous paid workshops for faculty on online and hybrid instruction. It is expected that CIIA will return to summer workshops at some point in the near future.

Finally, the University provides sabbaticals (professional leave) for tenured faculty members to the extent that state law allows. Faculty are eligible for sabbatical after six years, and leave eligibility is accrued at the rate of one quarter of leave for every two years of service. Because state law limits the number of faculty who can be on leave at one time, professional leave is competitive. Sabbatical proposals for one, two, or three quarters of leave are submitted by a faculty member to the Department Chair. The Chair then writes a recommendation to the Dean. Sabbatical proposals are evaluated and prioritized by the College Personnel Committee. The Personnel Committee makes a recommendation to the Dean, who makes a recommendation to the Provost. All sabbatical applications are reviewed by the University Professional Leave Committee (UPLC), which makes a recommendation to the Provost. Based upon these recommendations and the amount of leave available under state law, the Provost awards sabbatical leaves. Due to State restrictions, the number of quarters of leave awarded to an individual faculty member may be lower than the number of quarters requested.

PROGRAM SPECIFIC CRITERIA

The Program Criteria for "Materials and similarly named programs" is as follows:

1. Curriculum
The curriculum must prepare graduates to apply advanced science (such as chemistry, biology and physics), computational techniques and engineering principles to materials systems implied by the program modifier, e.g. polymers; to integrate the understanding of the scientific and engineering principles underlying the four major elements of the field: structure, properties, processing, and performance related to material systems appropriate to the field; to apply and integrate knowledge from each of the above four elements of the field using experimental, computational and statistical methods to solve materials problems including selection and design consistent with the program educational objectives.

2. Faculty
The faculty expertise for the professional area must encompass the four major elements of the field.

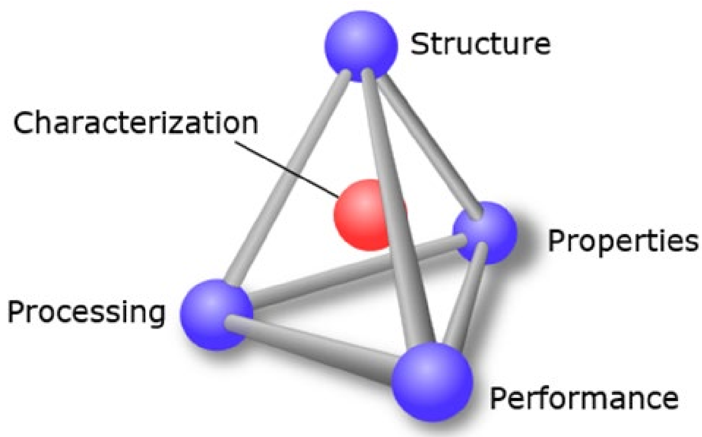


Figure P.1. – The relationship between structure, processing, performance, and properties

A. Curriculum

The PCE curriculum prepares graduates to apply the tools and concepts learned in advanced science courses, computational techniques, and engineering principles to material systems. Many fundamental classes feed into the higher-level courses where the material can be utilized to understand more advanced concepts. A flowchart of the full prerequisite structure can be seen in Section 5, Figure 5.1.

Once students enter the PCE program their first class is PCE 371 – Introduction to Plastics Materials and Processes. At the very start of the program students learn the importance of the relationship between structure, properties, performance, and processing and how they are intertwined. Figure P.1. above is an image that is often used in the program to illustrate just how important these relationships are. In every materials and processing course within the major (PCE 331, 371, 372, 431, 471, 472) these relationships are emphasized and built upon. Figure P.2. is a slide from the first PCE 371 lecture that the students attend. Students learn about how performance fits into the mix in a later lecture.

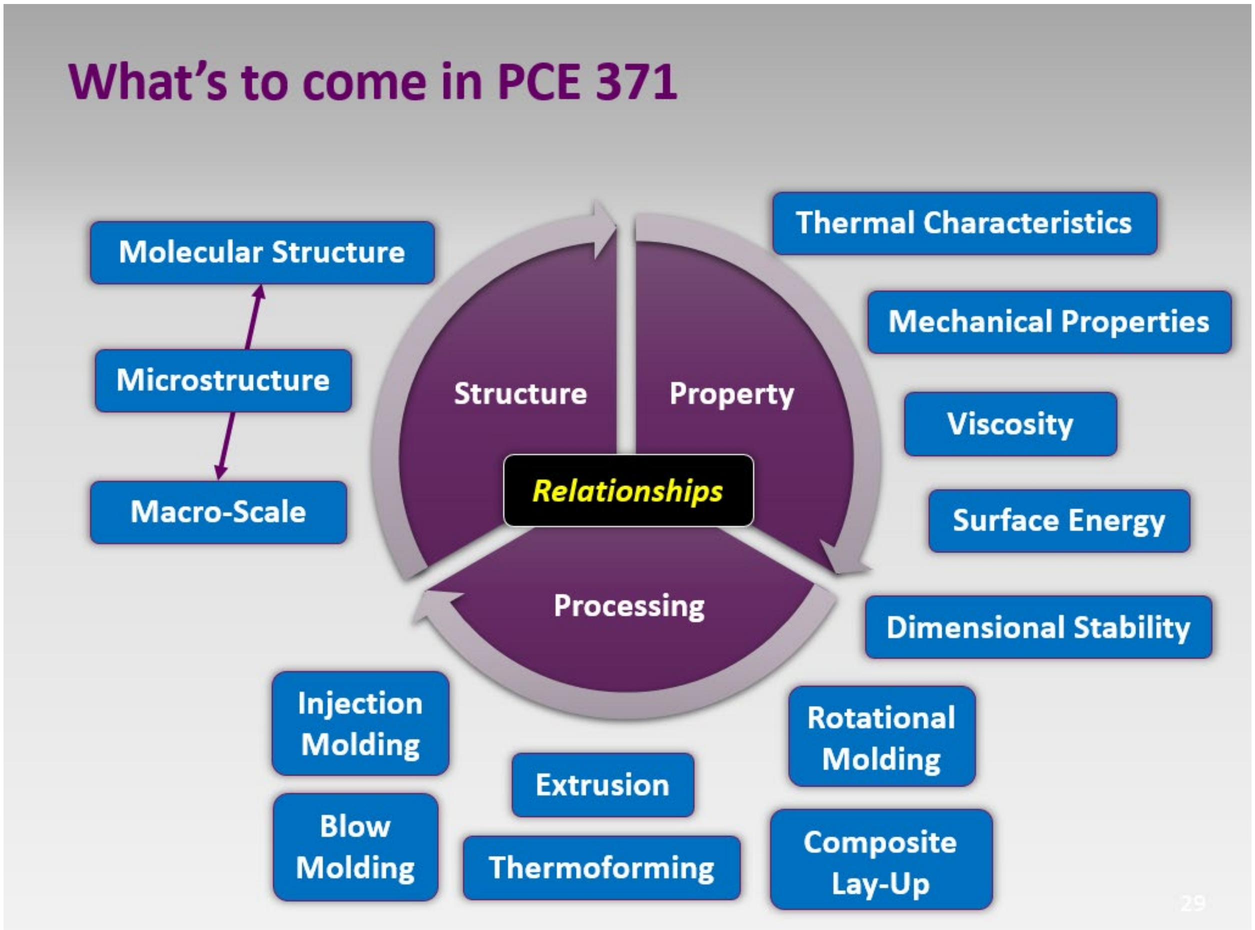


Figure P.2. – A slide from the first PCE 371 lecture that students attend as new PCE majors into the program

An example of how the four elements (structure, properties, processing, and performance) integrate into the coursework for one of the PCE upper-division courses can be seen in Figure P.3 below. This example also illustrates how students are required to design the materials that they will use to solve the problem that is defined in the project. Students also determine the processing conditions necessary to produce the final product that they have designed. Statistical methods and characterization techniques are then used to determine if the developed product satisfies the goals of the project.

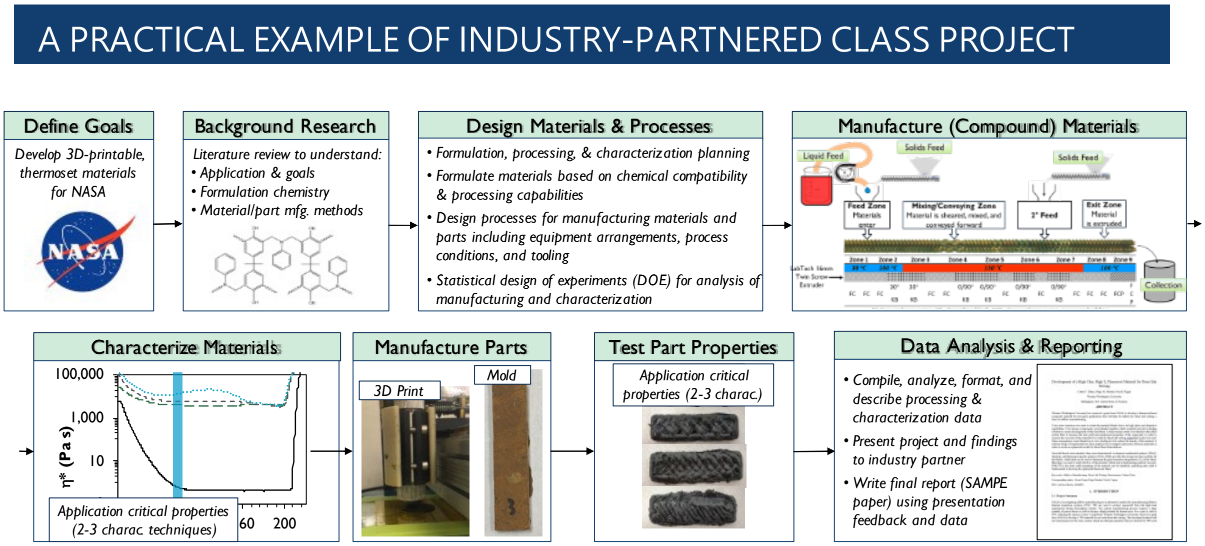


Figure P.3. Example of a project from the PCE 431 – Advanced Materials and Processes course that incorporates structure, property, processing, and performance relationships into the curriculum through a material design project where students design, manufacture, and test materials for specific applications.

In PCE 471, Advanced Materials and Characterization, students learn a variety of characterization techniques to determine the identity of an unknown polymer. Along the way they are asked to use statistical and experimental methods to analyze test results to determine what that means about the polymer structure and how to processes it. Examples of how fundamental and prerequisite courses emphasize the structure-properties-processing-performance is described below (originally from Criterion 5).

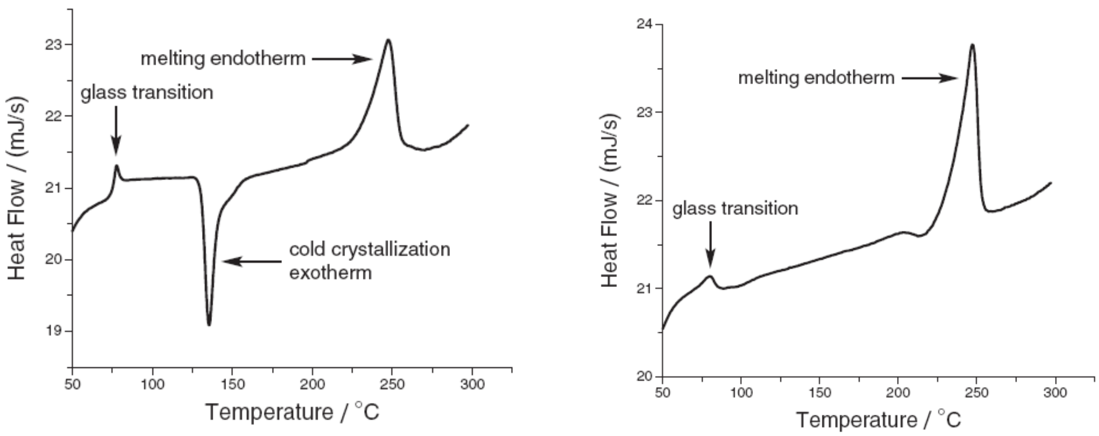
> "Students perform a wide range of advanced characterization experiments and interpret data from a wide variety of polymeric materials. Specifically, students use TGA (thermogravimetric analysis) and identify upper processing temperatures for various materials, a concept discussed in PCE 371 and PCE 331. They use DSC (differential scanning calorimetry) to trace thermal histories of materials and to intentionally quench and slow-cool materials to alter the amorphous and crystalline content and material thermal stability, as a follow-up to material covered in PCE 371 (Introduction to Polymer Materials & Processes) and PCE 331 (Injection Molding). Students also analyze DSC data from thermoset curing experiments to examine cure cycles needed to achieve thermal and mechanical requirements of composites made from these resins; this content is initially covered in PCE 372 (Introduction to Composite Materials and Processes). Students extrude or press specimens for DMA (dynamic mechanical analysis) to examine how the modulus of elasticity and viscoelasticity change with temperature, as introduced in PCE 371 (Introduction to Polymer Materials & Processes) and other classes. Finally, students use IR (infrared) spectroscopy to identify vibrational features of materials, content that was

introduced and applied in the foundational CHEM 251 & CHEM 308 (Introduction to Organic Chemistry and Polymer Chemistry) courses."

A specific exercise example is highlighted below, from Lab 3, DSC. The full laboratory exercise itself, along with other examples, is in Appendix G.

"Completely amorphous polymers such as atactic polystyrene can be characterized using their glass transition temperature (T_g) which represents a transition from a rigid glassy state to a rubbery liquid like state. In DSC, the T_g is captured by an appreciable change in the heat transfer rate vs. temperature plot; this is really representing a change in polymer morphology and microstructure that manifests itself as a change in specific heat capacity (c_p). Since amorphous polymers soften considerably beyond their T_g (modulus decrease by a factor of 10^3 or more), the T_g often specifies the ultimate in-service temperature of the material. Semi-crystalline polymers such as Nylon consist of amorphous ***and*** crystalline domains, and they exhibit a glass transition and a melting transition.

Furthermore, depending on processing conditions and chemical structure, semi-crystalline materials may also exhibit a crystallization peak on heating (see Figure 2a).



a) **b)**

Fig. 2: Thermal transitions in a semi crystalline polymer: **a)** crystallization on heating; **b)** no crystallization on heating (T. D'Amico, C.J. Donahue, E.A. Rais, J. Chem. Ed. (2008) 85, 404). Note: endothermic direction is up.

The degree of crystallinity is influenced by processing conditions and thermal history of the polymer. For example, when a semi-crystalline polymer is cooled from the melt, the degree of crystallinity increases with decreasing cooling rates. In this lab, the impact of two different cooling procedures on the thermal properties of a semi crystalline polymer is examined."

A final example of this, and of how the students are required to employ selection and combination of materials and processes, is in PCE 472 - the Advanced Composites course. Students in this course learn about the constituents of composite materials and how they interact and behave. In this course students perform labs and projects where they are required to choose the appropriate constituent materials, design a part, design the layup sequence based on theoretical calculations from classical lamination theory and finite elemental analysis, create the tooling, manufacture the designed part, and test it. Once tested, students compare the actual results to the theoretical ones to determine where any discrepancies lie and their cause. Students are encouraged to analyze how and why their selections and designs did or did not perform as intended.

Additional examples of how these relationships are used in assignments are in Appendix G.

B. Faculty Qualifications

As denoted in Criteria 6, the faculty in the PCE program have extensive experience in the plastics and composites fields and encompass the four elements described earlier. Below are excerpts of faculty qualifications.

Prof. Nicole Larson

Professor Nicole Larson's primary expertise is in composite materials, design, processing, and testing. These areas are enhanced by projects that Prof. Larson works on with industry partners and undergraduate students. Prof. Larson's formal education is in Mechanical Engineering with her graduate thesis focusing on an investigation of novel composite materials for the aerospace industry. Her professional experience at The Boeing Company focused on manufacturing issues related to composite structures and performance. Her experience at Starbuck's focused on machine design. This professional experience also provided a background in product design, project management, and quality.

Prof. Nicole Hoekstra

Professor Nicole Hoekstra's primary research and teaching background is in thermoplastic processing, materials and tooling. Her undergraduate and graduate degrees come from the University of Minnesota in Mechanical Engineering. Prior to coming to Western Washington University, she worked as a Process and Design Engineer at a thermoplastics manufacturing company that produces chromatography hardware, surgical instruments, and diagnostic equipment. While at WWU, her research has included both industry-partnered projects and federally-funded work. Her research is typically high TRL and seeks to understand relationships between thermoplastic processing, materials, and properties for unique applications.

Dr. Mark Peyron

Associate Professor Mark Peyron has been at WWU since 2007, first with the Chemistry Department, and then with the PCE Program since fall 2014. He has a PhD in Chemical Engineering, with specialization in polymer chemistry, from the University of Washington.

His industrial and research experience includes modifying biopolymers for biomedical applications, developing magnetic resonance instrumentation and relaxation measurement methods, characterizing fuel cell membranes, optimizing pulp and paper processes, and designing methods for cleaning up hazardous waste sites. His expertise and research focuses on materials characterization, kinetics and modeling of thermosetting cure reactions and of thermoplastics crystallization, potentially biodegradable polymers and identifying methods for assessing their extent of degradation in the environment. He currently teaches Introduction to Plastics Materials and Processing, Quality Assurance, Data Analysis and Design of Experiments, Advanced Materials Characterization, as well as elective classes in Sustainable Plastics and Composites and Directed Research sections. He also has secondary education certification from the State of Washington in the areas of chemistry and physics.

Dr. John Misasi

Associate Professor John Misasi's expertise is in polymeric materials design, synthesis, characterization, and processing. Dr. Misasi received his PhD in Polymer Science and Engineering with his dissertation focusing on the investigation of novel high-performance epoxy matrix materials for carbon-fiber composites in the aerospace industry. This industry-sponsored research provided him with professional development opportunities at both The Boeing Company and Australia's national laboratory (CSIRO) where he performed research expanding computational tools, synthetic protocols, and manufacturing techniques for aerospace materials. These combined professional and academic experiences allowed him a unique perspective on facilitating the development of next generation plastics and composites engineers. Professor Misasi typically teaches program courses PCE 371, PCE 372, PCE 331, PCE 431, as well as prerequisite courses such as ENGR 170. His research and industry collaborations are currently focused on understanding the structure-property-processing-performance relationships of recycled polymers and composites.

Dr. David Rider

Associate Professor David Rider's primary background is in Polymer and Materials Science with further specializations in materials characterization, electrocatalysis, composite materials, polymer resins, and structure-properties-processing relationships. Dr. Rider's formal education is in Chemistry with his PhD thesis focusing the application of self-assembling iron-containing polymers for nanotechnology and devices. His professional experience at Agilent Technologies focused on the application of self-assembling iron-containing polymers for Raman detection platforms for highly sensitive chemical detection. While at the Xerox Research Center of Canada, he focused on the cure studies and application of acrylates for electronic paper. His professional experience at the National Institute for Nanotechnology at the University of Alberta focused on the application of light-absorbing polymers for solar cells. His current research interests are in the fields of new, functional polymer systems for aerospace composites and the use of polymers for the synthesis of nanoparticle catalysts.

Promotional Materials

Plastics & Composites Engineering

"The PCE major is an incredible program that facilitates learning through an experience-based approach which prepares young professionals for both industry and graduate studies."

Juliana Covarrubias
PCE Senior, Class of 2022

ABET Accredited | 150 credits | Bachelor of Science

The only program of its kind in the nation. The PCE program prepares students for industry with practical experience in design, materials, manufacturing, economics, testing, and analysis of materials in well-equipped laboratories.

Are you intersted in?

- sustainability in materials and manufacturing
- making a difference in the world
- problem solving
- making and designing stuff
- hands-on learning
- working with industry on real-world solutions

By the numbers

7 quarters of pre-major coursework

24 majors enrolled annually

75% students complete internships

10-15 undergraduate research positions

79% alumni working or in graduate school

6 full time faculty and staff

Plastics & Composites Engineering

Get involved!

PCE students have opportunities to work alongside faculty on industry-sponsored research projects. Many of our students have landed internships and full time employment with companies after being on a research team. Research topics include **ocean plastics recycling, reducing aerospace composite waste, compostable plastics, and high performance 3D printing for space applications.**

Hands-on Learning

Our laboratories are well equipped with industry-grade machines and instruments. Students have access to thermoplastic processing, composite and thermoset processing, and materials testing. Some of our equipment includes an **autoclave, pneumatic ski press, extruders, injection molders, and cnc machines.**

Recent alumni employment

- **Nike** Process Engineer
- **Boeing** Manufacturing Engineer
- **Tesla** Mechanical Design Engineer
- **Janicki Industries** Project Engineer
- **Systima Technologies** Design Engineer

Areas of study

- Polymer/composite materials
- Traditional manufacturing
- Additive manufacturing/3D printing
- Tooling and part design

Contact information
ENGD@wwu.edu
360.650.3380

Engineering & Design
516 High Street, MS9086
Bellingham, WA 98225

Our alumni say:

"The PCE professors and leaders provide the education, community, and opportunities necessary for success after graduation."
Katherine Ray, Class of 2019
Process Engineer, Nike

"WWU takes a multi-disciplinary approach to problem solving and positions you to be an effective team member on any project you are a part of."
Robert Kearney, Class of 2017
Product Development Engineer, Boeing

"The department offers incredible opportunities for those who are willing to seek them out. Be open to new experiences and try to get out of your comfort zone, you may find a passion for an aspect of engineering you did not know you had!"
Lina Ghanbari, Class of 2019
PhD student, University of Southern Mississippi

WESTERN WASHINGTON UNIVERSITY
MAKE WAVES.

Engineering & Design

Western Washington University

Active Minds Changing Lives

WHAT SETS US APART

Small class sizes
Hands on experiential learning
Undergraduate research opportunities
Connections with industry partners

Engineering & Design

College of Science & Engineering

WESTERN WASHINGTON UNIVERSITY

Electrical Engineering, BS

The Electrical Engineering major prepares graduates to conduct research, and design, develop, test and oversee the development of electronic systems and the manufacture of electrical and electronic equipment and devices. This includes a broad range of applications and specializations that generally involve both hardware and software—areas such as power systems, communications, analog and digital signal processing, embedded systems, and control systems. This major offers two concentrations; Electronics and Energy. The program is accredited by the Engineering Accreditation Commission of ABET.

Manufacturing Engineering, BS

The Manufacturing Engineering major prepares graduates to work in different manufacturing practices and includes research, design, and development of systems, processes, tools and equipment. A Manufacturing Engineer's focus is to turn raw materials into a new or updated product in the most economic and efficient way possible. Manufacturing Engineers get opportunities to be innovative in design and manufacturing that can lead to patenting and start-up companies. This program develops these skills with the help of intensive laboratory components spread throughout its courses. The program is accredited by the Engineering Accreditation Commission of ABET.

Plastics & Composites Engineering, BS

The Plastics & Composites Engineering major prepares graduates to develop, process, and test materials used to create a range of polymer products from computer chips to aircraft wings. Extensive laboratory experience in design, materials, processing, economics, testing, and analysis is a crucial part of the hands-on curriculum. Sustainable design and materials development is increasingly emphasized. Through these experiences, students learn to apply theoretical knowledge learned in the classroom to solve practical, application-based problems in industry. The program is accredited by the Engineering Accreditation Commission of ABET.

Industrial Design, BS

The Industrial Design program prepares graduates to begin work as professional designers in corporate, consulting, or entrepreneurial positions. Students learn creative problem-solving methodologies, user-centered design, drawing and rendering skills, three dimensional model-making techniques, materials, manufacturing processes, ergonomics, design principles, and design thinking. These skills and techniques are applied in the design of many products that comprise a student's portfolio. The program is accredited through the National Association of Schools of Art and Design (NASAD).

Industrial Technology-Vehicle Design, BS

This program will be placed in moratorium beginning Fall 2019 and is no longer accepting new students. Students are encouraged to seek advising about other opportunities in the department.

STUDENT CLUBS

There are many student clubs affiliated with the Engineering & Design Department. Student Clubs provide excellent professional development and networking opportunities. Students are strongly encouraged to participate.

INTERNSHIPS

Although not required, internships offer an invaluable way to gain work experience, sample potential career areas, and help build a resume and/or a portfolio. Students are encouraged and assisted with applying for internships. Attending career fairs and participating in field trips are a good way to get in touch with employers.

RESEARCH OPPORTUNITIES

Students have numerous opportunities to participate in interdisciplinary projects and undergraduate research with faculty. Additionally, students can choose to work on projects directly with industry partners as part of their coursework.

Why Western Washington University?

Western's Engineering & Design programs place an emphasis on practical, hands-on laboratory experiences, in addition to strong theoretical course work. Each program's curriculum is designed with input from an industrial advisory committee to prepare graduates for professional positions in industry.

Where are our graduates working?

Graduates of the programs have consistently been placed in positions appropriate to their field of study.

Job titles of some of our graduates:

- Electronic Design Engineer
- Electrical Engineer
- Industrial Designer
- User Experience Designer
- Composite Design Engineer
- Manufacturing Planner
- Material Scientist
- Manufacturing Engineer
- Process Engineer
- Ski Boot Design Engineer
- Hardware Design Engineer
- Test Engineer

Recent graduates are employed by the following companies:

- ⇒ Alcoa
- ⇒ Architectural Elements
- ⇒ Boeing
- ⇒ Blue Origin
- ⇒ Fluke
- ⇒ Hexcel
- ⇒ Honeywell Aerospace
- ⇒ Janicki Industries
- ⇒ Microsoft
- ⇒ Nike
- ⇒ Oculus
- ⇒ PACCAR
- ⇒ R & D Plastics
- ⇒ Safran
- ⇒ SpaceX
- ⇒ Teague
- ⇒ Terex Corporation
- ⇒ Tesla Motors

Advising and Admissions

After acceptance to WWU, students start out as a **pre-major** and then **apply to their major of interest**. Our programs are competitive and require specific prerequisite courses. **Seek advising early from the pre–major advisor for curriculum questions and major admission requirements.**

Visiting Campus

To schedule a tour of the facilities and get advising questions answered in person, contact the pre-major advisor to schedule an appointment.

Lisa Ochs, Pre-major Advisor

360.650.4132 lisa.ochs@wwu.edu

Western Washington University

Bellingham, Washington

WESTERN WASHINGTON UNIVERSITY

Engineering & Design

Ross Engineering Technology Building
516 High Street MS9086
Bellingham, WA 98225
360.650.3380
cse.wwu.edu/engd

Appendices

A-G

Appendix A
Course Syllabi

1. Manufacturing Engineering 231: Introduction to the Manufacturing Process

2. 4 Credits and categorization of credits: Engineering Topic.

3. David Gill (Instructor) and Ben Kaas (Lab Instructor)

4. No textbook required.
   a. other supplemental materials
      - Dial Calipers
      - Safety Glasses

5. Specific course information
   a. An introduction to the manufacturing processes used to cast, form, cut, and join metal when creating parts per an engineering drawing. Students will be required to complete a fabrication project using machining processes. Includes an introduction to metrology and CNC.
   b. prerequisites or co-requisites: ENGR 170 or ID 380; MFGE 261 or concurrent
   c. required for program

6. Specific goals for the course
   a. 1. Will know how to utilize the entire manufacturing cycle from creating of basic form (casting, forming) through the addition of precise features (machining) to a full assembly (joining). You will understand processes and the terminology used to identify and describe the equipment, tooling and expendables used in these processes.
      2. Will understand how a process can be modeled from first principles, have the ability to calculate key process parameters, and understand the limitations of your calculations.
      3. Will be able to utilize basic metrology principles and to choose different measuring instruments for the purpose of verifying dimensions and tolerances on fabricated parts.
      4. Will have video experiences in the operation of manual lathes, mills, drills, sheet metal bending and welding equipment. This knowledge will help you know the capabilities and limitations of each tool along with important related safety, health and environmental concerns.
      5. Will have discussed the fabrication of a part using information from an engineering drawing in order to achieve the desired part performance.
   b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
   a. Big Idea 1 –Creating parts by RESHAPING material (Casting, Forming). Big Idea 2 – CHIP FORMING (subtractive) processes remove material, but greatly increase a part’s value. Big Idea 3 – Creating features by ADDITION or NON-

CHIP FORMING processes. Big Idea 4 – Creating products by JOINING and ASSEMBLING parts. Big Idea 5 – MEASUREMENT is the only way to know if the part is correct.

1. Manufacturing Engineering 250: Introduction to Manufacturing Automation

2. 4 Credits, and categorization of credits: engineering topic

3. Jeff Newcomer

4. Textbook: no required textbook for this course
    a. Suggested Textbook: Industrial Automation and Robotics, Gupta, A.K., Arora, S. K., and Westcott, J. R., 2017.

5. Specific course information
    a. An introduction to the fundamentals of manufacturing automation including pneumatics, sensors, programmable logic controllers, robotics, locating principles and machine vision for inspection.
    b. Prerequisites: PHYS 162; MFGE 261 or concurrent
    c. Required

6. Specific goals for the course
    a. 1. Assess and improve or redesign a pneumatic system. 2. Program robots to complete fundamental manufacturing tasks. 3. Describe the role of peripheral devices for basic robotic systems and when they are appropriate. 4. Integrate fundamental automation tools to implement an automation system to work with a structured, repetitive manufacturing task.
    b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

7. Brief list of topics to be covered
    a. 1. Pneumatic Cylinders & Flow Control Valves 2. Directional Control Valves 3. Robotics & Optical Encoders 4. SCARA Robot Programming 5. Machine Vision

1. Manufacturing Engineering 261: Introduction to Computer-Aided Design

2. 4 Credits, and categorization of credits engineering topic

3. Derek Yip-Hoi

4. Textbook: MFGE 261 – Introduction to CATIA, Derek Yip-Hoi (e-Text through www.StudyCAD.com)

5. Specific course information
   a. Introduction to parametric, Computer-Aided Design. Covers sketching and feature-based modeling in the creation of 3D parts for engineered products, assembly modeling and drafting. Emphasizes modeling of machined and plastic components and generation of drawings with proper dimensioning and GDT. Introduction to fabrication using rapid prototyping.
   b. Prerequisites: ENGR 104 or ENGR 115

6. Specific goals for the course
   1. Model parts and assemblies that capture design intent using parametric, feature-based CAD modeling techniques.
   2. Demonstrate knowledge of CAD modeling techniques that capture the structure and manufacturability of molded and machined parts.
   3. Read and create engineering drawings of parts and assemblies with appropriate views, dimensions, annotations, tolerances and GD&T.
   4. Apply the design process in developing and ranking design alternatives.
   5. Work as part of a team in managing a project to meet intermediate milestones and design goals.

1. Manufacturing Engineering 341: Quality and Continuous Improvement

2. 4 Credits and categorization of credits: engineering topic.

3. Sura Al-Qudah

4. Recommended textbooks:
    a. Setter, Craig Joseph, Six Sigma: A Complete Step-by-Step Guide: A Complete Training & Reference Guide for White Belts, Yellow Belts, Green Belts, and Black Belts, The Council for Six Sigma Certification, 2018
    b. Summers, Donna C. S., Six Sigma: Basic Tools and Techniques, Pearson, 2007
    c. Dennis, Pascal, Lean Production Simplified, Boca Raton: CRC Press, Third Edition, 2015

5. Specific course information
    a. A practical application of quality and continuous improvement tools including Lean and Six Sigma as applied to manufacturing operations. Principles and applications of Measurement System Analysis (MSA) for variable and attribute data. Proper use and interpretation of inspection equipment.
    b. prerequisites or co-requisites: MATH 345 or MATH 341
    c. Required for program.

6. Specific goals for the course
    a. Demonstrate knowledge of the key concepts of quality assurance and Lean Six Sigma - Apply quality tools to continuously improve manufacturing processes and products - Apply and analyze creative problem-solving tools in the improvement of processes and products - Apply statistical process control tools in a practical way - Use inspection equipment such as micrometers, dial calipers, and coordinate measuring machines.
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Quality concepts, Lean Enterprise, VSM, QFD, FMEA, DMAIC (I), DMAIC (II), Measures and metrics, SPC for variables, Process capabilities, SPC for attributes

1. Plastics & Composites Engineering 331: Injection Molding

2. 4 Credits, and categorization of credits engineering topic

3. John Misasi

4. Textbook: Injection Molding Handbook (3rd Edition), Rosato, Rosato, Rosato, 1980
    a. Recommended Texts: 1. Statistical Design of Experiments with Engineering Applications, Kamel Rekab, 2005, 2. Pocket Book of Technical Writing for Engineers and Scientists, Leo Finkelstein, 2008, 3. Material Science of Polymers for Engineers, Osswald, Tim A.; Menges, Georg, 2012; Supplementary Ebooks: 1. Total Quality Process Control for Injection Molding, 2. Handbook of Troubleshooting Plastics Processes.

5. Specific course information
    a. Theory and practice of injection molding. Analysis of machine functions, processing parameters, production tooling, process control systems, quality assurance, automation, rheology of polymers, heat transfer. Extensive lab experience.
    b. Prerequisites: PCE 371 and CHEM 162
    c. Required

6. Specific goals for the course

    1. Understand the fundamentals of the injection molding process.
    2. Experience in performing injection molding.
    3. Introduction to advanced/emerging injection molding processes and technologies.
    4. Introduction to computational fluid dynamics software for plastics and composites.
    5. Introduction to the qualification of a new mold into production.
    6. Understand the engineering principles of a viscous fluid in a channel.
    7. Researching and presenting a technical topic to peers using written and oral communication

7. Brief list of topics to be covered

    1. Effects of Injection Molding Process Parameters on Polymer Flow: Simulation
    2. Four Phases of Injection – Controlling Shrinkage
    3. Process qualification

1. Plastics and Composites Engineering 342: Data Analysis and Design of Experiments

2. 4 Credits and categorization of credits: engineering topics.

3. Mark Peyron

4. Textbook: NIST Process Statistics Website

5. Specific course information
    a. A practical approach to Design of Experiments and the analysis of data, including analysis of variance, linear, multiple linear, and nonlinear regression. Emphasis on the proper use and interpretation of the techniques in solving engineering problems rather than on theoretical development. Application of these tools using statistical software.
    b. prerequisites or co-requisites: MFGE 341
    c. required

6. Specific goals for the course
    a. Perform basic uncertainty analysis for sample data and models, including error propagation analysis, as appropriate. Apply the concept of correlation and interpret linear regression and multiple linear regression analyses. Create a calibration curve with confidence bands and perform numerical data interpolation. Assess the validity of a regression model for curve fitting or ANOVA applications and apply to simple non-linear models. Properly apply regression techniques, including when "linearized" analysis vs non-linear analysis is best. Design an effective experiment to model non-linear effects and interactions between experimental variables. Correctly apply analysis of variance and regression techniques to identify significant factors in a complex engineering systems. Design and interpret an effective screening experiment. Design multi-factorial and partial factorial experiments to test for all main effects and interaction effects. Produce professional-quality graphs, tables and technical reports.
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Statistical fundamentals, uncertainty analysis, error propagation, applications of regression analysis, calibration curves, interpolation, non-linear models & numerical integration (textbook and outside resources). Analysis of variance (ANOVA) & applied multiple regression analysis (textbook & outside resources) Fundamentals of factorial experimental designs & factorial screening designs (text & outside resources). Response surface designs (text & outside resources) and special topics (time permitting).

1. Plastics and Composites 371: Plastics Materials & Processes

2. 5 Credits and categorization of credits: engineering topic.

3. John Misasi

4. Required Text
    a. Baur, Erwin; Osswald, Tim A.; Rudolph, Natalie. Plastics Handbook: The Resource for Plastics Engineers. Hanser Publications. 3rd-5th Edition.
5. Specific course information
    a. Polymer science and analysis of basic plastics materials; experience in product design, tooling, and processing of thermoplastic.
    b. prerequisites or co-requisites: ENGR 115; ENGR 170
    c. Required for majors

6. Specific goals for the course
    a. Create an awareness of the growth and impact of plastics on industry and society, Develop an understanding of the unique properties and characteristics of plastics materials, Acquaint the student with common manufacturing processes and recent technological advancements that are used in creating products from plastics, Realize the design potential of plastics and encourage creative expression with these materials, Develop the student's proficiency in basic methods and safe techniques of processing plastics materials, Advance technical communication skills through formal laboratory reports and other writing exercises, Create an awareness of the growth and impact of plastics on industry and society
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Polymer Properties and Identification
    b. Single Screw Extrusion
    c. Thermoforming
    d. Rotational Molding
    e. 3D Printing
    f. Compression Molding
    g. Injection Molding and Plastics Recycling

1. Plastics and Composites Engineering 372: Introduction to Composites

2. 5 Credits and categorization of credits: engineering topic.

3. Nicole Larson.

4. Required Text: Fundamentals of Composites Manufacturing, Materials, Methods, and Applications, Second Edition, by A. Brent Strong, ISBN: 0-87263-854-5.

5. Specific course information
   a. Polymer and reinforcement systems; material testing; mold design and development; laboratory involvement in reinforced plastics production processes.
   b. prerequisites or co-requisites: PCE 371
   c. indicate whether a required, elective, or selected elective (as per Table 5-1) coursein the program

6. Specific goals for the course
   a. To increase the student's knowledge of the unique properties and characteristics of reinforced plastics. To acquaint the student with common manufacturing techniques and procedures used in the production of reinforced plastic products and composite structures. To strengthen the student's ability to deal with design, tooling, materials selection, and process control in the manufacture of composite materials. To promote an awareness of new applications for composites and emerging trends in processing and manufacturing with these materials
   b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
   a. Students can choose from 9 tooling methods. Each project will have a series of gates. At each gate you will be required to meet with the professor and lab technician to discuss your progress and receive a grade for that portion BEFORE moving onto the next. Each failure to meet a deadline will cause you to lose all of the points for that section of the project. A separate sheet will be given on the day that the project is assigned to explain the grading and project in more detail. I reserve the right to deny any project that I feel is not appropriate for this course.

1. Plastics and Composites Engineering 431: Advanced Materials and Processing

2. 4 Credits and categorization of credits: engineering topic.

3. John Misasi

4. Subramanian, Muralisrinivasan Natamai. Polymer Blends and Composites. Somerset: John Wiley & Sons, Incorporated, 2017. Polymer Science and Plastics Engineering.
    a. Rulison, Christopher. Dispersability Predictions – Some Practical Examples. KRUSS. 2001. Application Report. Web.
    b. Pierre G. Lafleur and Bruno Vergnes. Polymer Extrusion. John Wiley & Sons, Incorporated, 2014. ProQuest Ebook Central.
    c. Murphy, John. Additives for Plastics Handbook. Elsevier Science & Technology, 2001. ProQuest Ebook Central.

5. Specific course information
    a. Principles of polymer formulation and modification. Additives and modifiers, compounding processes and equipment. Use of experimental design in compound formulation.
    b. prerequisites or co-requisites: PCE 342; PCE 471
    c. indicate whether a required, elective, or selected elective (as per Table 5-1) coursein the program

6. Specific goals for the course
    a. Develop proficiency in the advanced characterization of polymers and composite materials. Develop proficiency in designing and conducting experiments in addition to analyzing and interpreting data. To develop an understanding of the principles of compound design, including compatibility and compound properties. To enhance awareness of the ingredients used in polymer compounds and their functions. Gain experience presenting and writing a technical paper. To enhance the understanding of manufacturing processes used in compounding
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Polymer Mixing
    b. Overcoming immiscibility using polymer processing
    c. Characterization of polymers

1. Plastics & Composites 461: Tooling for Plastics Processing

2. 4 Credits, and categorization of credits: engineering topic.

3. Nicole Hoekstra

4. Textbook: no required textbook for this course

5. Specific course information
    d. Design and construction of various types of production molds that are used for processing plastics. Product design in relationship to molding techniques and various techniques and materials used to construct the molds are the major units of study. Extensive lab work.
    e. Prerequisites: MFGE 332; PCE 331

6. Specific goals for the course
    c. 1. Ability to understand terminology, functions and fundamental design of IM tooling components and technologies. 2. Ability to translate understanding of IM tooling to less complicated tooling for other plastics and composites manufacturing processes. 3. Ability to understand the construction of IM tooling (CAD, CAM, CNC and manual machining). 4. Strengthen students' design skills using the design process and by evaluating numerous tool designs. 5. Ability to manage complex project of designing, manufacturing, and utilizing a custom injection mold in a diverse team. 6. Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives. 7. Understanding of the economics of IM tooling design and manufacturing.
    d. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

1. Plastics and Composites Engineering 471: Advanced Materials & Characterization

2. 4 Credits and categorization of credits: engineering topic.

3. Mark Peyron

4. No required textbook

5. Specific course information
    a. Structure, properties, processing and applications of engineering polymers. Advanced analysis and testing of polymers for engineering applications.
    b. prerequisites or co-requisites: CHEM 308; PHYS 163; PCE 331.
    c. Required for majors.

6. Specific goals for the course
    a. Develop proficiency in the advanced characterization of polymers and composite materials. Design experiments to investigate an unknown engineering polymer. Validate advanced investigative techniques in order to appropriately understand chemical & material properties and applications of engineering polymer materials. Interpret data from various testing technique and instruments to develop an awareness of the ingredients used in thermoplastics and composites. Gain understanding of structure, properties, processing relationships for advanced thermoplastics and engineering polymers. Recognize the important engineering and high-performance polymers, including their structures. Apply infrared spectroscopy to solid polymers and chemical composition techniques for microscopy. Recognize the influence of polymer molecular weight and crystallinity on mechanical and thermal properties. Investigate the thermal properties of polymers using differential scanning calorimetry and thermal gravimetric analysis, and relate the results to the morphology of polymers. Apply models of viscoelastic behavior to understand dynamic mechanical analysis techniques and results. Gain experience writing a technical report and the practice producing professional-quality graphs, tables and presentations.
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. I. Thermal and chemical analysis of polymers, including chemical decomposition analysis-coupled techniques. II. Characterization of viscoelasticity of polymers, including rheology and dynamic mechanical analysis. III. Microscopy and coupled chemical analysis. IV. Oral presentations and writing of technical documents that combines conclusions from all testing techniques and instrumentation.

1. Plastics and Composites Engineering 491: Research, Planning, and Ethics

2. 3 Credits and categorization of credits: engineering topic.

3. Nicole Hoekstra

4. No required textbook

5. Specific course information
   a. First in the series of three capstone project courses. Explores profession and ethical responsibilities, discussion concerning contemporary issues, and the impact of engineering solutions in a global context. Project planning and research skills are also discussed and practiced.
   b. prerequisites or co-requisites: ENG 101; PCE 342 or concurrent.
   c. indicate whether a required, elective, or selected elective (as per Table 5-1) coursein the program

6. Specific goals for the course
   a. An ability to communicate effectively with a range of audiences. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
   b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
   a. First in the series of three capstone project courses. Explores profession and ethical responsibilities, discussion concerning contemporary issues, and the impact of engineering solutions in a global context. Project planning and research skills are also discussed and practiced.

1. Plastics & Composites 492: Plastics Capstone Project Proposal
2. 3 credits, and categorization of credits: engineering topic.
3. Nicole Hoekstra
4. No required textbook
5. Specific course information
    a. The second course in the capstone project sequence. Takes project specifications defined in the first course and furthers the planning and design work necessary to support project implementation in the final course. Experience culminates in the writing of a formal project proposal that clearly defines expected project results, resource requirements and project milestones
    b. Prerequisites: PCE 491, PCE 471, PCE 342
    c. Required

6. Specific goals for the course
    a. An ability to identify, formulate, and solve complex engineering problems by **applying principles** of engineering, science, and mathematics.
    b. An ability to **apply engineering design** to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
    c. An ability to **communicate** effectively with a range of audiences.
    d. An ability to **recognize ethical and professional responsibilities** in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
    e. An ability to **develop** and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
    f. An ability **to acquire and apply new knowledge** as needed, using appropriate learning strategies.

1. Plastics & Composites 493: Plastics Capstone Project Implementation

2. 4 Credits, and categorization of credits: engineering topic.

3. Advisors: Nicole Hoekstra

4. Textbook: no required textbook for this course

5. Specific course information
    a. The third and final course in the capstone project sequence. Implements a plan to design, analyze and/or fabricate a process, material, product, tool, piece of equipment or enhancement to a manufacturing system. The results of the project will be fully documented and communicated through journaling, a final report, a poster and an oral presentation.
    b. Prerequisites: PCE 492

6. Specific goals for the course
    e. 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. 2. An ability to communicate effectively with a range of audiences.

1. CHEM 161: General Chemistry
2. Credits, contact hours, and categorization of credits

   5 credits, basic science

3. Instructor: Elizabeth Raymond
4. Chemistry An Atoms-Focused Approach, 3rd ed, by Gilbert, Kirss, Bretz, and Foster
   a. Other supplemental materials: scientific calculator
5. Specific course information
   a. Brief description – catalog description

      Matter, measurement, dimensional analysis, stoichiometry, atomic and molecular structure, periodic trends, and molecular interactions. Lab included.

   b. Prerequisites: MATH 114
   c. Required course
6. Specific goals for the course
   a. Specific outcomes

   - Develop an understanding of the structure of atoms and the development of modern atomic theory.
   - Use the concepts of bonding and the electronic structure of the atom to predict the three-dimensional shapes and electron distributions within molecules.
   - Use the periodic table to predict the chemical properties and electronic structure of elements.
   - Correctly use symbolism and vocabulary to communicate chemical ideas.
   - Understand how the interactions between particles (atoms, ions, and molecules) dictate the physical properties of matter.
   - Correctly use mathematical models and methods to describe a chemical event quantitatively.

   b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

1. CHEM 162: General Chemistry II

2. Credits, contact hours, and categorization of credits

   5 credits, basic science

3. Instructor: Spencer Anthony-Cahill

4. Chemistry An Atoms-Focused Approach, 3rd ed, by Gilbert, Kirss, Bretz, and Foster

   a. Other supplemental materials: subscription to Smartwork 5 is required for labs; scientific calculator

5. Specific course information

   a. Brief description – catalog description

      Solutions, types of chemical reactions, gas laws, thermochemistry, thermodynamics, and kinetics. Lab included.

   b. Prerequisites: CHEM 161

   c. Required course

6. Specific goals for the course

   a. Specific outcomes

      - Understand the chemical behavior of ionic and molecular substances in aqueous solution.
      - Understand how and why temperature, pressure, and concentration affect the dynamic behavior of chemical and physical systems.
      - Develop the ability to relate physical variables (e.g., temperature, pressure) to chemical and physical systems and to be able to interpret and apply relevant physical and chemical mathematical models.
      - Understand the effects of energy (e.g., heat) flow in and out of chemical systems.
      - Correctly use mathematical models and methods to describe kinetics, heat transfer, and the behavior of gases.
      - Describe, apply and explain the effects of the thermodynamic quantities enthalpy, entropy, and free energy on chemical and physical processes.
      - Predict the effects of temperature, pressure, concentration and energy flow on the dynamic behavior of chemical and physical systems.
      - Use quantitative and scientific reasoning to frame and solve problems.

1. CHEM 251: Elementary Organic Chemistry

2. Credits, contact hours, and categorization of credits

   5 credits, basic science

3. Instructor: Jennifer Griffith

4. Essential Organic Chemistry, 3rd ed, by Bruice

   a. Other supplemental materials: goggles, lab coat

5. Specific course information

   a. Brief description – catalog description

      Reactions, nomenclature and uses of carbon compounds; an abbrieviated course in organic chemistry

   b. Prerequisites: CHEM 161

   c. Required course

6. Specific goals for the course

   a. Specific outcomes

      - Understand structure and bonding in organic compounds, including the concepts of molecular hybridization theory, charge distribution, resonance, and stereochemistry
      - Be able to name / recognize the functional groups associated with organic compounds;
      - apply the rules of organic nomenclature
      - Use knowledge of acid/base theory, electronic effects and steric effects to predict/explain reactivity of organic compounds
      - Use knowledge of intermolecular forces to predict/explain physical properties of organic compounds
      - Apply knowledge of acid/base theory, electronic effects and steric effects to propose reasonable mechanisms for reactions;
      - Conversely, apply knowledge of reaction mechanism to predict/explain the outcome of a reaction.
      - Use experimental conditions/data to propose reasonable reaction mechanisms

b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

- Electronic structure and bonding, Acid/base chemistry
- Intro to organic structures
- Delocalized/aromatic systems
- Carbonyl chemistry
- Determination and more spectroscopy

1. CHEM 308; Introduction to Polymer Chemistry

2. Credits, contact hours, and categorization of credits

   3 credits, basic science

3. Instructor: Amanda Murphy

4. Introduction to Polymers, 3rd ed, Young and Lovell

   a. Other supplemental materials: none listed

5. Specific course information

   a. Brief description – catalog description

      Types of polymers, methods of polymerization, and preparation of important commercial thermoplastic and thermosetting plastics. Addition and condensation polymers are prepared in the laboratory.

   b. Prerequisites: CHEM 161; CHEM 251; PCE 371

   c. Required course

6. Specific goals for the course

   a. Specific outcomes

      - Gain hands-on experience synthesizing important types of polymers and understand key types of polymer synthesis reactions.
      - Gain important conceptual operational understanding of important analytical methods for characterizing polymer structure and properties.
      - Be able to perform relevant calculations to model polymer solution properties, molecular weight distributions, viscosity and certain reaction rate models.
      - Be able to communicate concisely and effectively using professional, industrial style methods for reporting results.
      - Learn to think more like professional engineers and applied, working scientists and to practice effective collaborations with peers.

   b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

- Chain polymerizations
- FTIR characterization
- Polymer structure overview
- Condensation polymerization
- Bulk vs. emulsion radical polymerization

1. CSCI 140; Programming Fundamentals in C++

2. Credits, contact hours, and categorization of credits

   4 credits, math

3. Instructor: See-Mong Tan

4. No textbook listed

   a. Other supplemental materials: none listed

5. Specific course information

   a. Brief description – catalog description

      Basic concepts of computer programming using the C++ programming language. Topics covered: introduction to computer architecture, and elements of a language such as control structures, functions, basic I/O, one dimensional and parallel arrays, text file I/O.

   b. Prerequisites: MATH 112 or higher

   c. Required course

6. Specific goals for the course

   a. Specific outcomes

      - A good understanding of navigating the UNIX development environment
        - How to use development tools in C++, including Makefiles and GNU C++
        - The use of a text editor in writing code
      - A strong understanding of basic types in C++, including int, float, double, char, string
      - A strong understanding of console I/O
      - A strong understanding of compound types like arrays and vectors
      - A strong understanding of C++ functions and return types
      - A strong understanding of loops in C++, including how to construct solutions to accumulator problems in C++
      - A basic understanding of C++ classes and inheritance
      - A basic understanding of pass by value, pass by reference and pointer types in C++
      - A basic understanding of file I/O using the C++ standard library

- A strong understanding of how to use code and the computer algorithms required to synthesize the solution to a reasonable sized problem (a simple console-based arcade game)

b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

1. Electrical and Computer Engineering 351: Electronics for Engineering

2. 4 Credits, and categorization of credits: Engineering Topic

3. Stephen Sandelin

4. Electronic Coursepack (via Canvas)

5. Specific course information
    a. Analysis of basic electric circuits. Design of simple circuits using passive elements and electronics to modify input signals and produce desired output signals. Analog-to-digital conversion and introductory microcontroller development. Laboratory reinforces the circuit concepts presented in the classroom and promotes competent use of basic electronic instruments.
    b. prerequisites or co-requisites: Math 125, PHYS 162
    c. Not required

6. Specific goals for the course
    a. Students will have a working knowledge of the analysis of basic electric circuits, the design of simple circuits using passive elements and electronics to modify input signals and produce desired output signals. How analog-to-digital conversion and introductory microcontroller development works.
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Circuits Review: Voltage, Current, KVL, KCL, Voltage and Current Dividers
    b. DC Analysis: Node/Mesh analysis, Superposition, Source Transforms and Thevanin/Norton
    c. AC Circuits: Capacitors, Inductors, Impedance
    d. Semiconductors: Diodes, Bipolar Junction Transistors, Field Effect Transistors
    e. Power Circuits: Buck and Boost converters
    f. Amplifiers: Operational Amplifiers, Instrumentation Amplifiers
    g. Digital Basics: Number Bases, Analog to Digital Conversion
    h. Microcontrollers: Basic Architecture, Programming Techniques, Port Control

1. Engineering 101: Engineering, Design, & Society

2. 2 Credits, and categorization of credits: Engineering Topics

3. Jill Davishahl

4. No textbook required

5. Specific course information
    a. Introduces students to field of engineering and design and explores the relationship between engineering, design, technology, and society. Provides a structure for students to explore and understand the role of social justice in engineering and design while developing foundational skills necessary for student success. Topics include societal impact of technology, the relevance of social justice in the engineering and design profession, ethical decision making, and social mindfulness in design.
    b. prerequisites or co-requisites: None
    c. Required for majors

6. Specific goals for the course
    a. • Demonstrate knowledge of the engineering and design professions and associated technologies. • Conceptually explain the design process. • Explain the role of social justice in engineering practice. • Effectively communicate knowledge and understanding of professional ethics and responsibility. • Describe how contemporary issues impact engineering design and practice. • Reflect on how your life experience, privilege, and culture affect the way you may practice engineering and/or design.
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Engineering and social justice
    b. Social mindfulness in design
    c. Exploring alternative mindsets
    d. Identify and belonging
    e. Creativity and visual communication
    f. Ethical decision making
    g. Engineering design and society

1. Engineering 115: Innovation in Design

2. 4 Credits, Engineering Topic

3. Jill Davishahl

4. Textbook: No textbook required for this course

5. Specific course information
    a. This project-based course introduces students to the engineering design process and explores the role of creativity, teamwork, and communication in innovative design. Topics include design thinking, creativity in design, team dynamics, engineering graphics, role of failure in design, importance of diverse perspectives, and the global impact of design.
    b. prerequisites or co-requisites: ENGR 101
    c. Required for majors

6. Specific goals for the course
    a. 1. Solve a design problem using the engineering design process. 2. Apply ethical analysis and creative problem-solving techniques to develop and design solutions for diverse user groups. 3. Use and select appropriate tools and technical skills necessary to build, test, and evaluate design concepts. 4. Participate in developing a functional project team. 5. Collaborate with team members in situations requiring creative problem solving. 6. Provide and accept feedback, resolve conflicts in a professional manner, and promote diversity of thought. 7. Communicate engineering concepts, ideas, and decisions effectively and professionally in a variety of ways such as written, visual, and oral. 8. Demonstrate the ability to mentally manipulate 2-dimensional and 3-dimensional figures. 9. Evaluate relationships between physical quantities by applying dimensional analysis.
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course.

7. Brief list of topics to be covered

    a. 1. Social Responsibility, Creativity, and Diversity 2. Teamwork & Collaboration 3. Communication of Design Ideas 4. Technology & Skill Development

1. Engineering 170: Introduction to Materials Science and Engineering

2. 4 Credits, and categorization of credits: Engineering Topics

3. David Rider

4. 1) Required Textbook: Introduction to Materials Science for Engineers, 8e, Shackelford, James.
    a. a. Student Companion Site: MasteringEngineering (accessible through Canvas)
    b. 2) Recommended Textbook: Fundamentals of Materials Science and Engineering, W.D. Callister & D.G. Rethwisch, John Wiley & Sons, 4th Ed., 2012.
    c. 3) Scientific calculator.

5. Specific course information
    a. The course examines the relationship between structure, properties, processing and performance of materials. Students are introduced to physical and mechanical properties of materials (including metals, polymers, ceramics and composites) and materials selection, based on engineering design criteria. Processing topics include strengthening, deformation, phase equilibria, microstructure and thermal treatments.
    b. prerequisites or co-requisites: N/A
    c. Required for majors

6. Specific goals for the course
    a. Conceptually explain the classification schemes that are used to categorize engineering materials. 2. Explain the differences in the mechanical behavior of engineering materials based upon bond type, structure, composition, and processing. 3. Describe the basic structures and repeat units for common thermoplastics and relate the distribution of molecular weights, degree of polymerization, percent crystallinity, and glass transition temperature to properties in service. 4. Describe how and why defects (point, line and interfacial) in materials greatly affect engineering properties and limit their use in service. 5. Calculate engineering stress, strain and the elastic modulus from data and for basic engineering applications. 6. Describe why each of the fundamental mechanical engineering properties of materials covered in the course (stress, strain, elastic constant, creep, fatigue, wear, hardness, Poisson's ratio, toughness, ductility, flexural strength, impact strength, elongation) are important in engineering design. 7. Select the appropriate engineering materials and size basic parts, including the use of appropriate safety factors and cost, for specific engineering applications using mechanical properties such as: yield strength, tensile strength, ductility or elongation, impact strength, toughness, Poisson's ratio, flexural strength, hardness, fatigue life, and creep. 8. Work in teams to research and then orally communicate current properties and applications of engineering materials and how to measure such characteristics using modern equipment and instrumentation. 9. Apply ethical principles and professional responsibilities in the selection of materials in engineering design. 10. Use binary phase diagrams to predict microstructures and also to understand precipitation hardening. Understand how

thermal treatments affect the microstructure and, thus, properties of materials. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. I. Atomic structure and bonding characteristics; crystal structure & unit cells
    b. II. Polymers; imperfections, deformation & strengthening in solids
    c. III. Mechanical properties of materials; phase diagrams and microstructure
    d. IV. Composites, ceramics, ferrous and selected non-ferrous metals

1. Engineering 214: Statics

2. 4 Credits, and categorization of credits: Engineering Topic

3. Nipun Goel

4. Recommended Text: Hibbeler, R. C., Engineering Mechanics: Statics, 14th Ed., Pearson, 2016

5. Specific course information
   a. Statics is the study of forces on bodies at rest.
   b. prerequisites or co-requisites: MATH 124; MATH 125 or concurrent; MATH 204 recommended; and PHYS 161
   c. Required for majors

6. Specific goals for the course
   a. 1. Draw complete and correct free body diagrams for rigid body systems. 2. Write an appropriate set of equilibrium equations from a free body diagram. 3. Solve equilibrium equations using appropriate tools to find unknown loads on a static system. 4. Apply linear algebra techniques to solve systems of equations.
   b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
   a. Drawing complete and correct free body diagrams for rigid body systems. Writing an appropriate set of equilibrium equations from a free body diagram. Solving equilibrium equations using appropriate tools to find unknown loads on a static system. Applying linear algebra techniques to solve systems of equations.

1. Engineering 225: Mechanics of Materials

2. 4 Credits, and categorization of credits: Engineering Topic

3. Kirk Desler

4. Recommended Text: Hibbeler, R. C., Mechanics of Materials, 10th Ed., Pearson

5. Specific course information
    a. Principles and basic concepts of structural analysis including: internal forces, stress, strain, axial loading, torsion, bending, combined loads, and buckling. Introduction to stress transformation and failure analysis.
    b. prerequisites or co-requisites: ENGR 170; ENGR 214; MATH 125
    c. Required for majors

6. Specific goals for the course
    a. 1. Determine internal force at any point in a structure 2. Determine stress at any point in a structure 3. Determine deflection at any point in a structure 4. Develop a safe solution to an open-ended problem 5. Select appropriate materials to meet structural needs
    b. explicitly indicate which of the student outcomes listed in Criterion 3 or any otheroutcomes are addressed by the course.

7. Brief list of topics to be covered
    a. Statics Review (shear and moment diagrams), Stress & Strain, Materials & Axial Loading, Torsion, Centroids & 2nd Area Moment of Inertia, Bending, Transverse Shear, Combined Loading & Stress Transformation, Beam Design & Deflection, Buckling, Intro to Failure Theories.

1. MATH 124; Calculus and Analytic Geometry I
2. Credits, contact hours, and categorization of credits

   5 credits; math

3. Instructor name: Greg Shwartz
4. Calculus, by Hughes-Hallett, Gleason, McCallum, et al;; 7th ed.
   a. Supplemental materials: graphic calculator
5. Specific course information
   a. Brief description – catalog description

      Average and instantaneous rates of change, interpretation, computation, and application of derivatives to optimization, rates, graphing, and antiderivative problems. Graphing calculator required.

   b. Prerequisites: MATH 115 or 118
   c. Required course
6. Specific goals for the course
   a. Specific outcomes
      - Develop ability in problem solving.
      - Interpret and communicate mathematics
      - Work comfortable with the following types of functions: trigonometric, polynomial, absolute value, exponential, logarithmic, rational and hyperbolic, as well as functions of defined parametrically, or by graph or table.
      - Apply the concepts of transformation, composition, symmetry and inverses to the functions listed above.
      - Understand and apply the concept so limits and continuity.
      - Understand and apply the limit definition of a derivative numerically, algebraically and graphically
      - Understand the relationship between the graph of a function and its derivatives
      - Use the derivative rules to determine the derivative of a function, whether given in equation form, graphic form, or via tables.
      - Strengthen algebraic simplification skills by simplifying derivatives.
      - Understand and apply the concept of implicit differentiation.
      - Evaluate the first and second derivatives of a function and interpret the results.
      - Construct and interpret sign charts.
      - Use the first and second derivative tests to determine the extrema of a function.

- Create and interpret functions that model real world applications then use calculus to optimize those functions.
- Use differentiation to reveal and compare related rates.
- Become familiar with L'Hopital's Rule and its application.
- Become familiar with the hyperbolic functions and their derivatives.
- Work with parametric equations and their derivatives.
- Become familiar with antiderivatives and differential equations.

b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

1. MATH 125; Calculus and Analytic Geometry II
2. Credits, contact hours, and categorization of credits

   5 credits; math

3. Instructor name: Andrew Richardson
4. Calculus, 7th ed, by Hughes-Hallett, Gleason, McCallum, et al.
   a. Supplemental materials: graphic calculator
5. Specific course information
   a. Brief description – catalog description
      The definite integral, techniques of integration, applications including area and volume, growth and decay, introduction of differential equations.
   b. Prerequisites: MATH 124
   c. Required course
6. Specific goals for the course
   a. Specific outcomes
      - understand the definite integral as a limit of Riemann sums
      - estimate definite integrals using Left Hand Sums, Right Hand Sums, Midpoint, Trapezoid, and Simpson Rules
      - understand under what conditions a technique for estimating an integral results in an overestimate or an underestimate
      - find antiderivatives graphically
      - use the FTC to evaluate definite integrals and to represent a particular antiderivative
      - compute antiderivatives and definite integrals using substitution (including change of limits) and integration by parts
      - compute antiderivatives and definite integrals of rational functions which may require a technique of partial fractions or trigonometric substitution
      - determine whether an integral with an infinite limit of integration converges
      - compute improper integrals
      - use integration to compute an areas, volumes, quantities dependent on density, centers of mass, work, force of a fluid, and arc lengths
   b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed
7. Brief list of topics covered

1. MATH 345; Statistics for Engineers
2. Credits, contact hours, and categorization of credits

   4 credits; math

3. Instructor name: Amy Anderson
4. Textbook: Applied Statistics and Probability for Engineers, 5th ed, by Montgomery and Runger
   a. Supplemental materials: calculator
5. Specific course information
   a. Brief description – catalog description

      Basic probability, discrete and continuous probability distributions. Descriptive statistics and the use of computer statistical packages. Statistical inference, including 1- and 2-sample hypothesis tests and confidence intervals for means and proportions, paired t test and sample size calculations.

   b. Prerequisites: MATH 125
   c. Required course
6. Specific goals for the course
   a. Specific outcomes
      - Explain the concepts of a population, a sample, and variability.
      - Distinguish between retrospective studies, observational studies, and designed experiments as means of data collection.
      - Understand the concepts of sample space and events, and the interpretation of probability.
      - Use the addition rule, multiplication rule and total probability rule in probability computation.
      - Understand the concepts of conditional probability and independence, and Bayes Theorem, and be able to solve problems involving these concepts.
      - Understand the concept of a random variable, both discrete and continuous.
      - Obtain the probability mass function of a discrete random variable for some random experiments or situations.
      - Understand the probability mass function(p.m.f.), probability density function (p.d.f.), cumulative distribution function (c.d.f.), the relationship between the p.m.f. /p.d.f. and the c.d.f., and be able to obtain one from the other.
      - Calculate the mean and variance of a random variable (both discrete and continuous), and evaluate probabilities involving the distribution of the random variable, using calculus if necessary.

- Understand the characteristics of the binomial, Poisson, continuous uniform and exponential distributions, and solve basic problems involving these distributions.
- Understand the importance of the normal distribution and solve elementary probability problems involving the normal distribution.
- Calculate the basic statistical measures of a data set, i.e., sample mean, sample standard deviation, sample median, range.
- Construct and interpret frequency distributions, histograms, boxplots and probability plots.
- Understand the concept of a sampling distribution and be able to use the central limit theorem.
- Understand the concept of a confidence interval and how it is used for estimation.
- Construct a confidence interval for the population mean, the population proportion, the difference in two population means or the difference in two population proportions.
- Compute the sample size needed to estimate population mean or population proportion.
- Understand the idea behind hypothesis testing, and p-value.
- Conduct a hypothesis test for the population mean, population proportion, difference in two population means and difference in two population proportions, and compute the p-value for the test.
- Know when to use and how to conduct a paired t test.
- Use a statistical software package, such as Minitab and/or Excel, to plot graphs, to calculate basic statistical measures such as the mean and the median of a data set, and to compute the probabilities involving well-known distributions

b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

1. PHYS 161: Physics with Calculus I

2. Credits, contact hours, and categorization of credits

   5 credits, basic science

3. Instructor: Takele Seda

4. Physics for Scientists and Engineers, 4th ed, by RD Knight

   a. Other supplemental materials: none listed

5. Specific course information

   a. Brief description – catalog description

      Kinematics and dynamics of particles; work and energy; gravitation; collisions and conservation of momentum. Includes lab.

   b. Prerequisites: MATH 124 or concurrent

   c. Required course

6. Specific goals for the course

   a. Specific outcomes

      - construct and utilize graphs, vector diagrams, and natural language to *qualitatively* describe how objects move and respond to forces.
      - use math to *quantitatively* describe how objects move and respond to forces.
      - use the concepts of conservation of energy and momentum to qualitatively and quantitatively describe how objects move.
      - Implement a structured approach to solving physics problems, particularly those posed in natural language (i.e. the type of problem that students will face outside the classroom)

   b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

1. PHYS 162: Physics with Calculus II
2. Credits, contact hours, and categorization of credits

   5 credits, basic science
3. Instructor: Svenja Fleischer
4. Physics for Scientists and Engineers, 4^{th} ed, by RD Knight, 2017
   a. Other supplemental materials: none listed
5. Specific course information
   a. Brief description – catalog description

      Electrostatics, DC circuits, magnetic fields, and electromagnetic induction. Includes lab.
   b. Prerequisites: PHYS 161, MATH 124, and MATH 125 or concurrent
   c. Required course
6. Specific goals for the course
   a. Specific outcomes

      - Apply core concepts of electromagnetism to the motion and interactions of charged particles. These
      - concepts include electric and magnetic forces, electric and magnetic fields, electric potential and potential
      - energy, and the principle of superposition.
      - Apply concepts of current, voltage, resistance, and capacitance to analyze DC circuits.
      - Apply mathematical models to make quantitative predictions in the context of electromagnetic interactions.
      - Collect and analyze data, and build mathematical models by inferring patterns in observations of natural
      - phenomena.
      - Apply concepts and mathematical models to perform multi-step analysis of real-world phenomena.
      - Communicate scientific ideas, explanations, and arguments clearly and concisely.

- Transfer the mathematical and conceptual foundation developed in this class to future science courses.

b. Explicitly indicate which of student outcomes listed in Criterion 3 or any other outcomes are addressed

7. Brief list of topics covered

1. PHYS 163: Physics with Calculus III

2. Credits, contact hours, and categorization of credits

   5 credits, basic science

3. Instructor: Takele Seda

4. Physics for Scientists and Engineers, 4th ed, by RD Knight, 2017

   a. Other supplemental materials: none listed

5. Specific course information

   a. Brief description – catalog description

      Rigid body kinematics and dynamics; rotation and oscillation; waves in elastic media; light as a wave; interference and diffraction of light; geometric optics. Includes lab.

   b. Prerequisites: PHYS 162, MATH 124, and MATH 125 or concurrent

   c. Required course

6. Specific goals for the course

   a. Specific outcomes

      - Apply core concepts of classical mechanics to the motion of a rigid body in 2 dimensions. These concepts include force and Newton's laws, torque and Newton's 2nd law for rotations, the work-energy principle, and the conservation of linear and angular momentum.
      - Be able to solve equations of motion for oscillatory situations in analytical and graphical ways.
      - Understand wave properties of light and sound including interference, diffraction, and polarization.
      - Be familiar with concepts of geometric optics including reflection, refraction, lenses and optical instruments.
      - Apply concepts and mathematical models to perform multi-step analysis of real-world phenomena involving incompressible fluids.
      - Collect and analyze data to infer patterns in natural phenomena.
      - Communicate scientific ideas, explanations, and arguments clearly and concisely.

Appendix B
Faculty Vitae

1. Name: Nicole Larson

2. Education:
   - M.S., Mechanical Engineering, University of Washington, (1999)
   - B.S., Mechanical Engineering; Minor in Physics, Bradley University (1997)

3. Academic Experience:
   - Professor, Engineering & Design Department, Western Washington University 0/2015 - present
   - Associate Professor, Engineering Technology, Western Washington University 9/2010 – 9/2015
   - Assistant Professor, Engineering Technology, Western Washington University 9/2005 – 9/2010
   - Instructor, Engineering/Materials Science Technology, Edmonds Community College 7/2003 – 8/2005

4. Non-Academic Experience:
   - Project Engineer, Starbucks Coffee Company, Seattle, WA 9/00 – 9/03
   - Senior Engineer/Scientist, Sienna Technologies, Woodinville, WA 2/00 – 7/00
   - Senior Engineer, Boeing Commercial Aircraft Group, Renton, WA 6/97 – 2/00

6. Membership in Professional Organizations:
   - Society for the Advancement of Materials and Process Engineering (SAMPE)
   - Society of Plastics Engineers (SPE)
   - American Society of Engineering Educators (ASEE)

8. Service Activities:
   Western Washington University (WWU) Service – last five years
   - Program Director, PCE program: 2014 –
   - CSE Personnel Committee Chair: 2014 -
   - CST Personnel Committee Member: 2013 -
   - Course Development for new 3-course PCE Capstone Series - 2014
   - AMSEC Curriculum Committee: 2014 -
   - Member of 5 search committees for new PCE and MFGE faculty: 2013-2014
   - Member of PCE faculty Search Committee – 2014 -2015
   - Member of Program Coordinator Search Committee – 2014
   - Engineering & Design Department Faculty Mentor – 2013 -
   - Mentored Over 63 Undergraduate Research Students – Since 2009 -
   - Faculty Advisor to PET & PCE majors: 2005 –
   - Resource Committee Member: 2006 -
   - Faculty Advisor for Society for the Advancement of Materials and Process Engineering (SAMPE) Chapter: 2007 –
   - Scholarship Committee Member: 2006 -
   - Member of Career Counselor Search Committee – 2014 -2015
   - Member of Academic/Career Advisor Search Committee – 2014

- Scholar’s week participant and judge: 2014, 2015
- AMSEC (Advanced Materials Science & Engineering Center) member: 2005 -
- Patents and Copyright Committee: 2009 -

9. Notable Recent Publications:

M. Standiford, C. Grubb, N. Larson, “Development of Unidirectional Carbon Prepreg Using a Solvent Dip Process,” Society for the Advancement of Materials and Process Engineering, May 2021 - Under Review

E. Smith, C. Grubb, J. Misasi, N. Larson; “Developing a Procedure for Prepreg Tack Characterization,” Composites and Advanced Materials Expo, September 2019

N. Larson, D. Frye; “Teaching Composites Manufacturing Through Tooling,” American Society for Engineering Education Annual Conference Proceedings, June 2019

Newcomer, J. L., & Larson, N., & Morton, T. D., & Yip-Hoi, D. M. (2019, June), “Transitioning to Engineering Without Losing Experiential Learning,” 2019 ASEE Annual Conference & Exposition, Tampa, Florida. https://peer.asee.org/33463

G. Lindskog*, C. Grubb, D. Peebles*, N. Larson; “Manufacturing and Characterization of Basalt Fiber-Phenolic Resin Composites,” Society for the Advancement of Materials and Process Engineering, May 2017

C. Grubb, N. Larson “Development of Safety Protocol, Features, and Fail-Safes for a Laboratory-Scale Manufacturing,” American Society for Engineering Education Annual Conference, June 2016

Hackler, Ryan*; Hollcraft, Andrew*; Kirkness, Tyler*; Larson, Nicole; Hoekstra, Nicole; Rider, David; "Relief of Cure Stress in Prepreg Composites with Engineered Voids: A Solution to Warping in Composite Phenolic Resin/Fiberglass Laminates," Industrial & Engineering Chemistry Research (Journal), 2015#

A. Lockwood*, N. Larson, “Out of Autoclave Surface Finish Investigation.” Society for the Advancement of Materials and Process Engineering Technical Conference, May, 2015 #

10. Professional Development:

SPE Annual Technical Conference participant, 2008, 2009, 2011, 2013
SAMPE Annual Conference Participant 2007, 2009, 2010, 2013-2015
Science in Society Conference Participant 2011
ASEE Annual Conference Participant 2015
“ABET Fundamentals of Program Assessment Workshop” course taken, ABET: 2014

1. Name: John M. Misasi

2. Education
   - PhD, Polymer Science and Engineering, University of Southern Mississippi (2015)
   - B.S., Plastics Engineering Technology, Western Washington University, (2011)

3. Academic Experience
   - Associate Graduate Faculty, School of Polymer Science and Engineering, University of Southern Mississippi, 9/20-present
   - Associate Professor, Engineering and Design, Western Washington University, 9/19-present
   - Assistant Professor, Engineering and Design, Western Washington University, 9/15-9/19

4. Non-Academic Experience
   - Industrial Trainee Fellow, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia (2013)
   - Graduate Research Intern, Boeing Research and Technology, Seattle, WA (2012)

5. Certifications or professional registrations

6. Current Membership in Professional Organizations
   - Society of Plastics Engineers (SPE)
   - Society for the Advancement of Materials and Process Engineering (SAMPE)
   - American Chemical Society (ACS)
   - American Society for Engineering Education (ASEE)

7. Honors and Awards
   - First place paper at the Waterborne Symposium Technical Conference (2019)
   - SAMPE Young Emerging Professionals Leadership Award (2018)
   - First place winner of the Waterborne Symposium Poster Competition (2015)
   - First place winner of The Society of Plastics Engineers Polymer Modifiers and Additives Division Writing Challenge (PMAD Challenge, 2014)
   - CSIRO Industrial Trainee Research Fellow (2013)

8. Service activities (within and outside of the institution)
   - Mentored 44 undergraduate research students, 2013-present
   - Mentored 29 undergraduate capstone students, 2012-present
   - Mentored 2 graduate students, 2017-present
   - Helped obtain funding for and/or organized the purchase of 10 pieces of equipment
   - SAMPE/SPE student chapter advisor
   - Industry and community outreach volunteer and coordinator
   - Department resource committee member (2017-2021)
   - Faculty search committee member (x2, 2019-2020)
   - Materials science seminar committee member and chair (2016-2020)
   - College technical operations committee member (2018-2020)

- College policy, planning, and budget council member (2020-present)
- University advising for incoming freshmen and community college students
- Article reviewer for 6 journals (on-going)
- Conference paper reviewer and session chair SAMPE (on-going)
- Seven guest lectures to students and industry (2017-present)
- Nine hosted speakers for PCE and AMSEC students (2016-present)

9. Publications
   - Misasi, John; Dao, Buu; Dell'Olio, Carmelo; Swan, Sam; Issadazeh, Salumeh; Wiggins, Jeffrey; Varley, Russell. *Polyaryletherketone (PAEK) thermoplastic composites via in-situ ring opening polymerization*. Composites Science and Technology, Volume 201, 2021, 108534, ISSN 0266-3538. (50%)
   - Kim, Steven; Wu, Hao, Devega, Alexa; Sico, Mallory; Fahy, William; Misasi, John; Dickens, Tarik; Koo, Joseph. *Development of polyetherimide composites for use as 3D printed thermal protection material.* Journal of Materials Science (2020): 1-18. (15%)
   - Wu, Hao; Kim, Steven; Fahy, William; Haewon, Kim; Kafi, Abdullah; Bateman, Stuart; Langston, Jon; Atak, Ozen; Reber, Roderick; [2]Misasi, John; Koo, Joseph. *Evaluation of additively manufactured ultra-performance polymers to use as thermal protection systems for spacecraft.* Journal of Applied Polymer Science, 2020, 137:e49117. (15%)
   - [1]Misasi, John; Jin, Qifeng; Wiggins, Jeffrey; Morgan, Sarah. *Hybrid POSS-Hyperbranched Polymer Additives for Simultaneous Reinforcement/Toughness Improvement in Epoxy-Amine Networks*. Polymer. 2017, 117, 54-63. **(75%)**
   - [2]Misasi, John; Jin, Qifeng; Wiggins, Jeffrey; Morgan, Sarah. *Simultaneous Reinforcement and Toughness Improvement in an Aromatic Epoxy Network with an Aliphatic Hyperbranched Epoxy Modifier.* Polymer. 2015, 73, 174-182. **(75%)**
   - Larson, Nicole; [2]Misasi, John. *Development of thermoplastic panels for Haiti*. International Journal of Science in Society. 2011, 3 (1), 75-86. **(30%)**
   - [s]Owen, Christofer; Grubb, Cecile; Misasi, John. *Impacts of degraded surface removal on mechanical recycled marine debris.* Technical Paper. ANTEC. 2021. (60%)
   - [s]Covarrubias, Juliana; [s]Owen, Christofer; Impink, [s]Evan; [s]House, Molly; Grubb, Cecile; Hokestra, Nicole; Misasi, John. *Some properties of 100% recycled ocean plastic olefins.* Technical Paper. ANTEC. 2021. (60%)
   - [s]Dojan, Carter; Hjelstrom, Kevin; Grubb, Cecile; Misasi, John. *Direct ink writing of benzoxazine nanocomposites.* Technical Paper. SAMPE. 2021. (50%)
   - [s]Hamernik, Levi; Grubb, Cecile; Misasi, John. *Synthesis & characterization of a high-performance reversible epoxy curative.* Technical Paper. SAMPE. 2021. (40%)
   - Wu, Hao; Kim, Steven; Fahy, William; Kafi, Abdullah; Bateman, Stuart; Yee, Colin; Langston, Jon; Atak, Ozen; Reber, Roderick; [2]Misasi, John; Koo, Joseph. *Ablation Performances of Additively Manufactured High-Temperature Thermoplastic Polymers.* Technical Paper. AIAA SciTech Forum. 2020. (15%)
   - [s]Smith, Edwin; Grubb, Cecile; Larson, Nicole; Misasi, John. *Developing a procedure for prepreg tack characterization.* Technical Paper. CAMX. 2019. (50%)
   - Kafi, Abdullah; Wu, Hao; Atak, Ozen; Kim, Haewon; Kim, Steven; Langstrom, Jon; McDermott, Ryan; Fahy, William; Reber, Roderick; [2]Misasi, John; Bateman Stuart; Koo,

Joseph. *Evaluation of ultra-performance polymers for use as thermal protection systems.* Technical Paper. CAMX. 2019. (10%)

- [s]Davis, Charles; [s]Antonson, Jordan; [s]Smith, Paul; Kaas, Ben; [1]Misasi, John. *Characterization of POSS-ULTEM nanocomposites and their FFF printed-part properties.* Technical Paper. CAMX. 2019. (75%)
- [s]Ghanbari, Lina; [s]Croshaw, Chris; [s]Hamernik, Levi; Grubb, Cecile; [1]Misasi, John. *Development of a continuous b-stage reaction vessel for benzoxazine network pre-polymers.* Technical Paper. Waterborne Symposium. 2019. *1st Place Technical Paper.* (50%)
- [s]Lew, Scott; Perkins, Frederick, Hoekstra, Nicole; [1]Misasi, John. *Improving the electrical conductivity of PC/ABS printing filament for fused filament fabrication using carbon nanostructures*. Technical Paper. ANTEC. 2018. (50%)
- [s]Lynch, Sean; Grubb, Cecile; [1]Misasi, John. *Reversible epoxy-amine networks through hexahydrotriazine groups.* Technical Paper. SAMPE. 2018. (75%)
- Grubb, Cecile ; [s]Hill, Gabriel; [1]Misasi, John. B*alancing infusion viscosity and flame retardancy of a RTM benzoxazine.* Technical Paper. SAMPE. 2018. (50%)
- [s]Donegan, Brady; Grubb, Cecile; [1]Misasi, John. *Degree of cure and its effects on a formulated benzoxazine's flame properties.* Technical Paper. SAMPE. 2018. (75%)
- [s]Hill, Gabriel; [s]Donegan, Brady; Grubb, Cecile; [1]Misasi, John. *The effects of continuous reactive blending on benzoxazine/polyethylene glycol blends*. Technical Paper. SAMPE. 2017. (75%)
- [s]Carpenter, Chris; Grubb, Cecile; [1]Misasi, John. *The effects of reactive diluents on flame properties of benzoxazines.* Technical Paper. SAMPE. 2017. (75%)
- [s]Sealy, Mark; Grubb, Cecile; [2]Misasi, John; Peyron, Mark. *Use of Dynamical Mechanical Testing and Chromatography to Assess the Degree of Cure of Phenolic Prepreg.* Technical Paper. SAMPE. 2017. (10%)

10. Briefly list the most recent professional development activities
    - "Designing Engaging Learning Experiences for Undergraduates". Online webinar describing unique methods for engaging students in the virtual and on-campus classroom. Harvard. 2021.
    - "Blended/Online Bootcamp." Online course to learn pedagogical techniques for online/blended/hybrid teaching. Western Washington University. 2020.
    - "More effective NSF proposals". Grant writing workshop. Western Washington University. Research and Sponsored Programs.
    - SPE Annual Technical Conference Participant, 2011-2021
    - SAMPE Annual Technical Conference Participant, 2011-2021

1. Name: Mark Peyron

2. Education:
   - Ph.D., Chemical Engineering, University of Washington (1994)
   - B.S., Chemical Engineering, University of Idaho (1984)

3. Academic Experience:
   - Associate Professor, Engineering & Design, Western Washington University (WWU) 9/2014 – present
   - Advanced Materials Science and Engineering Center, WWU, 2009 – present.
   - Adjunct Faculty, Chemistry, WWU 2005-2014
   - Substitute Teacher (long-term), Honors Chemistry, Squalicum High School 2007
   - Co-Teacher, Honors/AP Chemistry, Bellingham High School (2006-2007)
   - Research Engineer, Medicinal Chemistry, University of Cambridge (1992-96)

4. Non-Academic Experience:
   - Process Development Engineer, Summit Engineering, Ferndale, WA 2007-08
   - Materials Development Engineer, Amoco, Absorption Corp., (self-employed) 1997-2004
   - Environmental Engineer, Envirosphere Co., Bellevue, WA 1988-1990
   - Process Engineer, Weyerhaeuser Co., Federal Way, WA 1983-1984

5. Certifications or Professional Registrations:
   - Secondary Education Certification, Physics & Chemistry, Western Washington University (2007)

8. Service Activities:

   Western Washington University
   - Scientific Technical Services Advisory Committee, 2015 – present.
   - Scientific Technical Services Advisory Council,
   - Advanced Materials Science and Engineering Center (AMSEC) executive committee member or chair (2018-2021) and numerous AMSEC committees (2015 - present).
   - Scholars Week participant (project supervisor) and/or poster session judge (2011 – 2019).
   - Chemistry Dept. Curriculum Committee (2010-2012)

   Outside of Institution
   - Presentation as part of the Sierra Club Educational Forum: The Truth About Plastics. Talk entitled "*Plastics 101: What's, How's and Where's*". Whatcom Community College, April 2019.
   - Community Advisor, for Bellingham High School student team: Washington State University's Clean Energy and other competitions (2008, 2011, 2015, 2017)
   - Tutor in reading/math for low-achieving students, Bellingham & Seattle, (periodically, 1995 – 2007)

9. Recent Notable Publications:

Watts, Adam; Peyron, Mark (2022). “MATLAB-Based Combinatorial, Isoconversional Analysis for Characterizing Thermoset Cure Kinetics”. SAMPE (Society for the Advancement of Material and Process Engineering). *Peer-reviewed and accepted; publication delayed because conference was cancelled. Already accepted SAMPE 2022.*

Cofer, Taylor; Brodhagen, Marion; Peyron, Mark; Zinkgraf, Matthew (submitted 2022). “Biodegradable plastic degradation products alter germination and growth of the toxic fungus Aspergillus”, Submitted to: Plastics in the Environment: Understanding Impacts and Identifying Solutions (Jan. 2022).

Manos, Nikolas U.; Alindayu Christian; Peyron, Mark (2019). “*Influence of Void Content on the Dielectric Permittivity of 3D Printed Parts*” *The Composites and Advanced Materials Expo (CAMX)*, Sept. 23-26, 2019, Anaheim, CA.

Seely, Mark; Peyron, Mark; Grubb, Cecile; Misasi, John (2017). “Use of Dynamic Mechanical Testing and Chromatography to Assess the Degree of Cure of Phenolic Prepreg”, *SAMPE Seattle*, May 22-26, 2017, Seattle, WA.

Peyron, Mark; Gill, David; Grubb, Cecile; Zywiak, Zachary; Anderson, Severn; Hoch, Adam (2016). “Co-Printing Test Specimens as Surrogates for Complex Part Characterization”, *The Composites and Advanced Materials Expo (CAMX)*, Sept. 26-29, 2016, Anaheim, CA

Miles, Carol; Ghimire, Shuresh; Peyron, Mark; Hayes, Douglas (2015). “Biodegradable Mulch Films & Their Suitability for Organic Agriculture”. *BC Organic Grower*, **18**(4).

Brodhagen, M.; Peyron, M.; Miles, C.; Inglis, D.A. (2015). “Biodegradable plastic agricultural mulches and key features of microbial degradation”. Applied Microbiology and Biotechnology, DOI 10.1007/s00253-014-6267-5.

Moore-Kucera, J.; Cox, S.B.; Peyron, M.; Bailes, G.; Kinloch, K.; Karich, K.; Miles, C.; Inglis, D.A.; M. Brodhagen (2014). “Native soil fungi associated with compostable plastics in three contrasting agricultural settings”. Applied Microbiology and Biotechnology, **98**(14) 6467-85. DOI 10.1007/s00253-014-5711-x.

10. Professional Development

Participant in NSF-funded research C-Core project (WWU, Whatcom Community College and Skagit Valley College) aimed at integrating active learning in higher education STEM classes (2013 – 2016).

Participant in NSF-funded North Cascades Olympics Science Partnership (NCOSP) to train STEM educators in secondary and primary education (2005, 2006).

1. Name: Sura Al-Qudah

2. Education:
   - Ph.D., Industrial and Systems Engineering, State University of New York at Binghamton, (2014)
   - M.S., Industrial and Systems Engineering, State University of New York at Binghamton, (2010)
   - B.S., Electronics Engineering, Yarmouk University, Jordan, (2004)

3. Academic Experience:
   - Associate Professor, Western Washington University (WWU) 9/2020 – present, FT
   - Assistant Professor, Western Washington University (WWU) 9/2014 – 8/2020, FT
   - Teaching Assistant, Binghamton University, 12/2012-7/2014,
   - Research Assistant, Binghamton University, 1/2011-5/2012,
   - Teaching Assistant, Binghamton University, 9/2010-1/2011,
   - Research Assistant, Binghamton University, 8/2008-5/2010
   - Teaching Assistant, Yarmouk University, 2/2005-6/2007

4. Non-Academic Experience:
   - Electronics Engineer, Biomedical Center of Excellence, Yarmouk University, Jordan, 9/2005-6/2007, PT
   - Medical electronics intern, Royal Medical Services, Prince Rashed Military Hospital, Irbid, Jordan. 8/2003-2/2004, PT

5. Certifications or Professional Registrations:
   - Fundamentals of GD&T - ASME Y14.5-2009 (W17)
   - CMM fundamentals certificate (2015)
   - PC-DIMS for CMM 101-102-103 certificate (2015)
   - Black-belt Lean Six-Sigma, Binghamton University (2012)

6. Membership in Professional Organizations:
   - Society of Women Engineers (SWE)
   - Society of Manufacturing Engineers (SME)
   - American Society for Quality (ASQ)
   - American Society for Engineering Education (ASEE)

7. Honors and awards:
   - Excellence in Teaching Award, "The National Society of Leadership and Success (NSLS)," Sigma Alpha Pi, (S18).
   - Scholars' week Outstanding Students Award – Faculty advisor role (S18).
   - Three ASSIST travel grants funded by NSF (EEC-1548200), Academic Leadership for Women in Engineering (ALWE) (F16, F17, F18).
   - Two RSP Research Awards submitted by two of my undergraduate students ($500) (W17).

8. Service Activities:
    - MFGE Program Director (F21-current)
    - MFGE Acting Program Director (F17, W18)
    - Faculty advisor for MFGE undergraduate students in different academic levels (F15-current)
    - MFGE & EECE hiring committee member (2017-2018-2020)
    - CSE Equity, Inclusion, and Diversity (EID) Committee member, E&D representative (2017-2020)
    - President's Council for Equity, Inclusion, and Social Justice (By invitation 2019-2020)
    - Computer-Human Interface track chair for IEMS Conference (2016-2017)
    - Reviewer for IEEE Transactions on Engineering Management (2015-current)

9. Notable Recent Publications & Presentations:
    - **Alqudah S.,** Brobst J., Litzler E., Davishahl J., Klein A., "Becoming Engaged Engineering Scholars: Insights from Year 1", 127th Annual American Society for Engineering Education (ASEE); 2020.
    - Davishahl J., **Alqudah S.,** "Complete Work: Investigation of Sense of Belonging to Engineering in Introductory Classes," 127th Annual American Society for Engineering Education (ASEE); 2020.
    - Klein A. (PI), **Alqudah S. (co-PI),** VanderStaay S., Brobst J., "DUE-1834139: Becoming Engaged Engineering Scholars (Bees): Success Programs for Retention in Engineering", Awarded August 2018. $957,532, National Science Foundation. December 2018 to November 2023.
    - **Alqudah S.,** Froning* A., Sumpter* K., Ortega Martinez E.*, Alqudah, A., "A Novel Design of an Ergonomic Surgical Body Support System", Industrial & Systems Engineering Research Conference (ISERC), Orlando, FL, May 18-21, 2019,

10. Professional Development:
    - Sustaining Inclusive, Student-centered Instruction in WWU Departments Workshop, Sep 15, 2021
    - 2021 ABET Symposium (virtual), April 2021
    - Engaging Students in Online Environments, Aug 10-14, 2020
    - Teaching a Synchronous Course, Aug 3-7, 2020
    - Integrated Enterprise Excellence: Going Beyond Lean Six Sigma and the Balanced Scorecard, ISERC pre-conference workshop, FL, May18, 2019
    - CSE STEM Equity & Inclusion Workshops (ISMs), Cultural Awareness of Self, WWU, April 2019.
    - The Academic Leadership for Women in Engineering (ALWE) Workshops, During SWE Conferences in 2017 & 2018
    - Scholarship of Teaching & Learning Residency (SoTL), North Cascades Institute, WA, Sep 6-8, 2016.

1. Name: Tarek AlGeddawy

2. Education
- Ph.D., Industrial and Manufacturing Systems, University of Windsor, 2011
- M.Sc., Industrial Engineering, Cairo University, 2004
- B.Sc., Mechanical and Production Engineering, Cairo University, 1999

3. Academic experience
- Associate Professor, Western Washington University, 2021-present, full-time
- Assistant Professor, Western Washington University, 2018-2021, full-time
- Assistant Professor, University of Minnesota Duluth, 2013-2018, full-time
- Visiting Researcher, Intelligent Manufacturing Systems Center, 2014-2015, part-time
- Instructor, University of Windsor, 2012, part-time
- Research & Teaching Assistant, University of Windsor, 2006-2011, full-time
- Teaching Assistant, American University in Cairo, 2003-2004, part-time
- Research & Teaching Assistant, Cairo University, 1999-2006, full-time

4. Non-academic experience
N.A.

5. Professional registrations
N.A.

6. Professional organizations membership
- North American Manufacturing Research Institution (NAMRI) of Society of Manufacturing Engineers (SME), scientific committee member since 2016.
- Egyptian syndicate of Engineers, member since 2000.

7. Honors and awards
- Outstanding academic adviser award Nomination, 2016, UMD.
- Best poster award, 2013, UWindsor, Ontario FEDDEV projects.
- Best paper award of the year, 2012, Journal of Engineering Design.

8. Service activities
- MFGE major student advisor, 2019-present.
- CSE Tech Ops committee member representing Engineering & Design department, 2020-present.
- RCA subcommittee member for additional competitive grants, 2020-present.
- Search committee member for EECE faculty, 2021/active.
- Search committee member for director of 1st year engineering program, 2019/2020.
- Search committee member for MFGE support technician, 2019.

9. Publications

Ghanei, S., AlGeddawy, T. (2020) An Integrated Multi-Period Layout Planning and Scheduling Model for Sustainable Reconfigurable Manufacturing Systems, Journal of Advanced Manufacturing Systems. 19(1), 31-64.

AlGeddawy, T. (2020) A Digital Twin Creation Method for an Opensource Low-cost Changeable Learning Factory. 30th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2020. Procedia Manufacturing. 51(1):1799-1805.

AlGeddawy, T., ElMaraghy, H. (2020) A Holistic Multi-Domain Association Model for Industrial Data. 30th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2020. Procedia Manufacturing. 51(1):920-925.

Tohidi, H., AlGeddawy, T. (2020) Optimizing Modular Fixtures Setup Time in an Automated Assembly Line. Advances in Design, Simulation and Manufacturing III, DSMIE-2020. In: Advances in Design, Simulation and Manufacturing III. Edited by: Ivanov V, Trojanowska J, Pavlenko I et al. Cham: Springer International Publishing. pp 336-346.

AlGeddawy, T. (2019) A Simplified Changeable Learning Factory Design Based on a Granularity Complexity Model. 29th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2019. Procedia Manufacturing, 38(1): 654-662.

Tohidi, H., AlGeddawy, T. (2019) Change Management in Modular Assembly Systems to Correspond to Product Geometry Change, International Journal of Production Research. 57(19), 6048-6060.

AlGeddawy, T. (2017) A New Model of Modular Automation Programming in Changeable Manufacturing Systems, 27th International Conference on Flexible Automation and Intelligent Manufacturing FAIM2017, Procedia Manufacturing, 11(1), 198-206

AlGeddawy, T., Samy, S., ElMaraghy, H. (2017) Best Design Granularity to Reduce Assembly Complexity of Modular Products, Journal of Engineering Design, 28(7-9), 457-479.

AlGeddawy, T., ElMaraghy, H. (2016) Design for Energy Sustainability in Manufacturing Systems, CIRP Annals, 65(1), 409–412.

Ghanei, S, AlGeddawy, T. (2016) A New Model for Sustainable Changeability and Production Planning, Proceedings of the 49th CIRP Conference on Manufacturing Systems, Procedia CIRP, 57(1), 522–526.

10. Professional development

- Joint Center for Aerospace Technology Innovation (JCATI) project SU2021-SP2022, PI: solving the resin buildup cleaning problem in composite part tools in aerospace industry, with a team of 5 undergrads and a Co-PI from PCE.
- Automation, Robotics and Learning Factories (2018-present): advancing the automation and robotics area in MFGE by introducing industry standard software, hardware and systems

integration, developing an industrial grade learning factory (LEAF) from the ground up, while involving undergrads in the design, fabrication and installation processes.

- Equity, Diversity and Inclusion: participation in the STEM Concept workshop by ISM (2019), focused on cultural awareness of self and experiences of others.

1. Name: Jill Davishahl

2. Education:
   - M.S., Mechanical Engineering, University of Washington, 1999
   - B.S., Mechanical Engineering, Union College, 1997

3. Academic Experience:
   - Assistant Professor and First Year Programs Director, Western Washington University, 2020-present, full-time
   - Non-tenure Track Faculty and Director of Pre-Engineering Development, Western Washington University, 2018-2020, full-time
   - Tenured Faculty, Bellingham Technical College, 2018, full-time
   - Tenure Track Faculty, Bellingham Technical College, 2014-2017, full-time
   - Non-tenure Track Faculty, Western Washington University, 2012-2014, full-time
   - Tenured Faculty and Engineering Department Chair, Edmonds Community College, 2004-2009, full-time
   - Tenure Track Faculty, Edmonds Community College, 2001-2004, full-time
   - Temporary Faculty, Edmonds Community College, 2000-2001, full-time

4. Non-Academic Experience:
   - Engineering Consultant/Design Engineer, Prosthetics Research Study, Seattle, WA, 1999-2000
   - Software Engineer & Consultant, American Management Systems, 1999-1999

5. Certifications or Professional Registrations:

6. Membership in Professional Organizations:
   - American Society of Engineering Education
   - ASEE LGBTQ+ Advocacy in STEM Virtual Community of Pracitice
   - Technology Alliance Group for Northwest Washington (TAGNW)
   - Washington Council for Engineering and Related Technical Education
   - Engineers Without Borders

7. Honors and awards:
   - ASEE Best Professional Interest Council (PIC) 3 Paper 2019
   - ASEE Best Division Paper: Mechanics Division 2019
   - ASEE Best 3rd Division Paper: Energy Conversion & Conservation Division 2019
   - Club Advisor of the Year. Edmonds Community College 2006

8. Service Activities:
   - Diversity, Equity, and Inclusion Committee; College of Science & Engineering (2019-current)

- Community Ambassador; College of Science & Engineering (2019-current)
- Curriculum Committee; Engineering + Design Department (2018-current)
- Faculty Lead: Engineering + Design Makerspace (2018-current)
- Student Technology Liaison Program (2020 – current)
- Becoming Engaged Engineering Scholars (2020 – current)
- Digital Badge Program (2020 – current)
- Pre-Major Orientation Sessions (2019 – current)
- Makerspace Student Technology Workshops, 5 (2019-2020)
- Makerspace Peer Mentor Program (2019 – 2020)
- Bellingham Public Schools Career and Technical Education Advisory Board Member (2015-present)

9. Notable Recent Publications & Presentations:

J. Davishahl, C. Grubb. "Engineering Faculty Experiences Teaching Social Justice to First Year Students." *2021 IEEE Frontiers in Education Conference (FIE)*, Oct 2021. Draft accepted.

J. Davishahl, E. Mediavilla, A. Nelson. "Cultivating community for first year students: Experiences in adapting a peer mentoring program to remote format." *Proceedings of the First Year Engineering Experience Conference*, August 2021. Draft accepted.

J. Davishahl, J. Newcomer. "Broadening Engineering Orientation for First Year Students." *Proceedings of the 126th American Society of Engineering Education Conference and Exposition,* June 2021.

J. Davishahl, S. Al-Qudah. "Complete Work: Investigation of Sense of Belonging to Engineering in Undergraduate Introductory Classes." *Proceedings of the 125th Annual American Society of Engineering Education Conference and Exposition*, June 2020.

S. Alqudah, E. Litzler, J. Brobst, **J. Davishahl**, A. Klein. "S-STEM Becoming Engaged Engineering Scholars: Insights from Year 1." *Proceedings of the 125th Annual American Society of Engineering Education Conference and Exposition*, June 2020.

X. Jiang, **J. Davishahl,** D. Hickenbottom, D. Saunders, T. Thorton. "Photovoltaic System Performance Under Partial Shading: An Undergraduate Research Experience." *Proceedings of the 125th Annual American Society of Engineering Education Conference and Exposition*, Tampa FL, June 2019

E. Davishahl, T.R. Haskell, **J. Davishahl**, L. Singleton, W.H. Goodridge. "Do They Understand Your Language? Assess Their Fluency with Vector Representations." *Proceedings of the 125th Annual American Society of Engineering Education Conference and Exposition*, Tampa FL, June 2019

J. Davishahl, X. Jiang, S. Dever, L. Bear, T. Christman, D. Hickenbottom, S. Winters. "A Cross-Institutional Collaboration: Analysis of Power Electronics for Solar Panel Arrays."

Proceedings of the 124th Annual American Society of Engineering Education Conference and Exposition, Salt Lake City UT, June 2018

S. Al-Qudah, **J. Davishahl**, E. Davishahl, M. Greiner. "Investigation of Sense of Belonging to Engineering in Undergraduate Introductory Classes, WIP." *Proceedings of the 124th Annual American Society of Engineering Education Conference and Exposition*, Salt Lake City UT, June 2018

4. Name: Kirk Desler

5. Education:
   - M.B.A., Business Administration, Western Washington University (2018)
   - B.S., Plastics Engineering Technology, Western Washington University, (2000)

6. Academic Experience:
   - Instructor, Engineering & Design Department, Western Washington University, 2021-present

8. Non-Academic Experience:
   - Operations Manager, Amazon, 2020-2021
   - Operations Manager, Safran Cabin, 2012-2020
   - Lead Tool Design Engineer, Safran Cabin, 2007-2012
   - Composites Design & Process Engineer, Innovative Composites Engineering, 2001-2006
   - Process Engineer, Hexcel, 2000

9. Certifications or Professional Registrations:

10. Membership in Professional Organizations:

11. Honors and awards:

12. Service Activities:

13. Notable Recent Publications & Presentations:

14. Professional Development:

1. Name: Deborah Glosser

2. Education:
    - Ph.D., Civil Engineering, Oregon State University, 2020
    - M.S., Geology and Planetary Science, University of Pittsburgh, 2013
    - J.D., Law Degree, Duquesne University School of Law, 2005
    - B.A., Computational Linguistics, The Ohio State University, 2002

3. Academic Experience:
    - Assistant Professor, Western Washington University, 2020-present, full-time
    - PhD Research Associate, Civil Engineering, Oregon State University, 2017-2020, full-time
    - Graduate Student Researcher, University of Pittsburgh, 2010-2011, full-time

4. Non-Academic Experience:
    - Senior Energy Analyst, Electrical and Natural Gas Utility Regulator, Oregon Public Utility Commission, 2016, full-time
    - Research Scientist, Physics Geologic and Engineered Systems and Structural Materials, US Department of Energy, 2012-2016
    - Regulatory Analyst/Attorney, Ernst & Young and Others, 2005-2010

5. Certifications or Professional Registrations:

6. Membership in Professional Organizations:
    - American Concrete Institute (ACI)
    - American Society of Civil Engineers (ASCE)
    - Society of Petroleum Engineers (SPE)
    - American Geophysical Union (AGU)

7. Honors and awards:
    - ACI Wason Medal for Materials Research (2021) – Honor bestowed by the Board of Directors of the American Concrete Research Institute
    - ASTM International Mather Scholarship (2019) – Competitive merit-based scholarship for demonstrated contributions in cement or concrete materials research.
    - National Defense Science and Engineering Graduate Fellowship (2018) – Alternate Selectee.
    - PacTrans Fellowship (2017 and 2018) – The PacTrans fellowship is an annual merit-based cash award for contributions to civil engineering research offered by the Pacific Northwest Transportation Consortium.
    - University Laurels Block Grant (2018) – The UGLBG program is a competitive tuition remission scholarship administered by the Oregon State University Graduate School awarded based on student merit.
    - Provosts Distinguished Graduate Student Scholarship (2017) – The Provost's Distinguished Graduate Fellowship Program is a prestigious Oregon State University fellowships, and is

comprised of twelve-month stipends, plus tuition scholarships and subsidized health insurance for one year.

8. Service Activities:

9. Notable Resent Publications & Presentations:

Glosser, D., Suraneni, P., Isgor, B., Weiss, J., Determining reactivity of fly ash using glass content in thermodynamic calculations, (2020) Cement and Concrete Research ACI Materials (2021)

Glosser, D., Suraneni, P., Isgor, B., Weiss, J., Estimating reaction kinetics of cementitious pastes containing fly ash, Cement and Concrete Composites (2021)

Glosser, D., Isgor, B., Weiss, J., Non-equilibrium thermodynamic modeling framework for OPC/SCM Systems, *invited paper, ACI Materials (2020)

Glosser, D, Bauer, J., A graph theoretic model for predicting fracture networks, (book chapter) in: Hydraulic fracturing and well simulation, Wiley books, editor: Fred Aminzadeh, ISBN 1119555698, (2019)

Bharadwaj, K., **Glosser,** D. Isgor, B., Weiss, J., Toward the Prediction of Pore Volumes and Freeze-Thaw Performance of Concrete Using Thermodynamic Modelling, (2019) Cement and Concrete Research, Vol. 124, https://doi.org/10.1016/j.cemconres.2019.105820

Glosser, D. Choudhary, A., Ideker, J., Trejo, D., Isgor, B. Weiss, J. Thermodynamic Investigation of Cementitious Mixtures Incorporating Off-Spec Fly Ashes, (2019), World of Coal Ash Proceedings

Choudhary, A., **Glosser**, D. Isgor, B, Weiss, J., Experimental Test Method to Determine the Reactivity of Fly Ash for Use in Mixture Proportioning (2019), World of Coal Ash Proceedings

Isgor, B., Weiss J., Ideker, J, **Glosser,** D.: Development of a performance-based mixture proportioning procedure for concrete incorporating off-spec fly ash, submitted to Energy Power Research Institute, Interim Technical Report on Thermodynamic modeling of mixtures using off-spec fly ashes, Corvallis, OR (2018).

Glosser, D, Choudhary, A., Isgor, B., Weiss J.; Investigation of the reactivity of fly ash and its effects on mixture properties, American Concrete Institute Materials Journal (Special Edition), (2019). * *invited paper,* Vol. 114 issue 4

1. David D. Gill

2. Education
   - Ph.D., Mechanical Engineering, North Carolina State University, 2002
   - MSME, Mechanical Engineering, Purdue University, 1997
   - BSME, Mechanical Engineering, Texas Tech University, 1994

3. Academic Experience
   - Associate Professor, Western Washington University, 9/2019 - present
   - Assistant Professor, Western Washington University, 9/ 2014 – 8/ 2019

4. Non-Academic Experience
   - Sandia National Laboratories, Principal Member of the Technical Staff, Solar-Thermal Technologies Organization. Proposing and performing research into novel solar-thermal energy storage systems, June 2009 – June 2014, Full time position
   - Sandia National Laboratories, Principal Member of the Technical Staff, Mesoscale Manufacturing Organization, Proposing and performing research in novel manufacturing methods for high-precision meso-scale components, Oct. 2006 – May 2009, Full time position
   - Sandia National Laboratories, Senior Member of the Technical Staff, Mesoscale Manufacturing Organization, Proposing and performing research in novel manufacturing methods for high-precision meso-scale components, Aug. 2002 – Oct. 2006, Full time position
   - Caterpillar Large Engine Center, Lafayette, IN, Manufacturing Engineer and Field Test Engineer, Manufacturing engineer for the 3500 series connecting rod production line and field test engineer for 3500 long-stroke, stationary engine evaluation, Feb. 1997 – June 1999, Full time position

5. Professional Registration
   - Registered Professional Engineer in the State of New Mexico, License 17153

6. Current Membership in Professional Organizations
   - Society of Manufacturing Engineers (faculty advisor for student chapter)
   - American Society of Mechanical Engineers

7. Honors and Awards
   - 2017 ASEE Annual Conference, Engineering Design Graphics Division of ASEE Chair's Award for Best Paper Presented in the EDGD Sessions
   - Department of Energy Award of Excellence for Outstanding Service to DOE in the LENS Qualification Project (role was PI/PM), 2009
   - Outstanding Paper Award – 2006 Solid Freeform Fabrication Symposium
   - RV Jones Memorial Scholarship, American Society for Precision Engineering, 2001

8. Service Activities
   - Session Co-chair, "MSEC 3-1-1 Machining of Composites", 2017 ASME-Manufacturing Science & Engineering Conference, Los Angeles, CA, USA, June 4-8, 2017
   - WWU Campus Laboratory and Chemical Safety Committee member, 2015-present
   - WWU, Engineering and Design Department, Resource Committee, new appointment beginning Fall 2018
   - WWU, Engineering and Design Department, Manufacturing Automation Faculty Search committee, 2017/18
   - WWU, Engineering and Design Department, Manufacturing Technologist search committee 2017
   - Board Member, Hillcrest Chapel, 2020-present

9. Publications and Presentations
   - "Investigation and Modeling of Flag Generation in Honeycomb Sandwich Panel Machining", D. Yip-Hoi, D. Gill, ASME 2018 International Mechanical Engineering Congress and Exposition, Nov. 9-15, 2018, Pittsburgh, PA, USA (To Be Presented) (50%)
   - "'To the Boards' – Team-Based Design for Student-Centered Learning", D. Gill, J. Newcomer, Proceedings of the 2017 International Mechanical Engineering Congress & Exposition, Nov. 3-9, 2017, Tamp, FL, USA (95%)
   - "Use of Model-Based Definition to Support Learning of GD&T in a Manufacturing Engineering Curriculum", D. Yip-Hoi, D. Gill, Proceedings of the 2017 ASEE Annual Conference & Exposition, June 25-28, 2017, Columbus, OH (35%)
   - "Studying the Mechanisms of High Rates of Tool Wear in the Machining of Aramid Honeycomb Composites", D.D. Gill, D.M. Yip-Hoi, <u>M. Meaker</u>, <u>T. Boni</u>, <u>E.L. Eggeman</u>, <u>A.M. Brennen</u>, <u>A. Anderson</u>, Proceedings of the ASME 2017 20th International Manufacturing Science and Engineering Conference, June 4-8, 2017, Los Angeles, CA, USA (50%)
   - "Co-Printing Test Specimens as Surrogates for Complex Part Characterization", M. Peyron, D. Gill, C. Grubb, <u>Z. Zywiak</u>, <u>Anderson</u>, <u>A. Hoch</u>, The Composites and Advanced Materials Expo, Sept. 26-19, 2016, Anaheim, CA (15%)

10. Professional Development Activities
    - "Synchronous Couse Help Session", Aug. 6, 2020
    - "Engaging Group & Collaborative Work", July 23, 2020
    - "Screencast-O-Matic Power User", July 22, 2020
    - "Blended/Online Course Development Boot Camp", July 21-Aug. 4, 2020
    - "Interfolio Training", June 23, 2020 (1hr)
    - "VERICUT Verification Web Training", June 16-18, 2020 (24 hrs)
    - "VERICUT Force Optimization Web Training", June 3-4, 2020 (8 hrs)
    - "OMAX Waterjet Training", Bellingham, WA, September 10-12, 2018
    - "The Tenure Process", New Faculty Spring Event, April 12, 2017, WWU

- “Composites 101” workshop, AeroDef 2017 Conference, March 7, 2017, Ft. Worth, TX
- “Teaching 3D Spatial Skills Workshop”, Western Washington University, April 28-29, 2016

1. Name: David Rider

2. Education
   - B.Sc., Chemistry, Simon Fraser University, 1997-2002
   - Ph.D., Chemistry, University of Toronto, 2002-2007

3. Academic experience
   - WWU, Assistant Professor, 2010-present, full time
   - University of Alberta, Postdoctoral Fellow, 2007-2010, full time

4. Non-academic experience
   - Agilent Technologies, intern, lab researcher in nanotechnology, 2005, part time
   - Xerox Research Center of Canada, intern, lab researcher in nanotechnology, 2002, part time
   - Cominco Engineering Services Ltd., intern, operator of demonstration scale equipment for refining of metals from earth, 1999, part time

5. Certifications or professional registrations

6. Current membership in professional organizations
   - American Chemical Society
   - Materials Research Society

7. Honors and awards
   - Peter J. Elich Teaching Award, WWU (Nomination)
   - Natural Sciences and Engineering Research Council of Canada, Postdoctoral Fellowship award
   - Izaak Walton Killam Memorial Postdoctoral Fellowship award
   - Dorothy J. Killam Memorial Postdoctoral Prize (awarded to top postdoctoral fellow)
   - Xerox Research Centre of Canada Graduate Award
   - Ontario Graduate Scholarship
   - Fluor Daniel Wright Engineering Scholarship

8. Service activities
   - AMSEC - Curriculum Committee Member
   - AMSEC - Laboratory (ES 123) Remodel Consultant
   - Dept Chemistry - Honors Thesis Committee (2010-2013)
   - Dept Chemistry - Graduate Thesis Committee member (x6)
   - Dept Chemistry - Growing the Graduate Program Task Force Member
   - College of Science and Technology - Sigma-Xi Scholar’s Week Judge
   - University and Community - Faculty Representative for 2011 Migrant Youth Leadership Conference
   - University and Community - Faculty Representative for 2014 Migrant Youth Leadership Conference

- College of Science and Technology - Corporate Alliance Program steering committee member
- University - RSP Creative Opportunities Grant for Undergraduates Committee Member
- Dept Chemistry - Web/Technology Committee Member
- Dept Chemistry - REU program co-organizer
- Dept Chemistry - Department Chair of Web/Technology Committee
- Dept Chemistry - Lab-Safety Committee Member
- Dept Chemistry – Inorganic Chemistry Search Committee
- Engineering Technology - Plastics Engineering Technology Search Committee
- University - Chair for RSP Creative Opportunities for Undergraduates
- AMSEC – Executive Committee Member
- AMSEC - Compass to Campus AMSEC Leader (1 of 2)
- Dept Chemistry – National Science Foundation - Research Experience for Undergraduates WWU Speaker
- Linus Pauling Symposium co-Chair

9. Briefly list the most important publications and presentations from the past five years – title, co-authors if any, where published and/or presented, date of publication or presentation
Hackler, R. A.;* Hollcraft, A. T.;* Kirkness, T. A.;* Larson N. S.; Hoekstra, N. L.; Rider, D. A. "Relief of Cure Stress in Prepreg Composites with Engineered Voids: A Solution to Warping in Composite Phenolic Resin/Fiberglass Laminates" *Ind. Eng. Chem. Res. (article ID: ie-2015-028525).*

   Taylor, A.;* Pilapil, B.; Zhang, X.; Engelhard, M. H.; Gates, B. D.; Rider, D. A., "Block Copolymer Templated Synthesis of PtIr Bimetallic Nanocatalysts for the Formic Acid Oxidation Reaction." *Chem. Mater. (article ID: cm-2015-03053q).*

   Mikkelsen, K.;* Cassidy, B.;* Hofstetter, N.;* Bergquist, L.;* Rider, D. A., Block Copolymer Templated Synthesis of Core-Shell PtAu Bimetallic Nanocatalysts for the Methanol Oxidation Reaction. *Chem. Mater*. 2014, 26, 6928–6940.

   Knowles, K. D.;* Hanson, C. C.;* Fogel, A. L.;* Warhol, B.;* Rider, D. A., "Layer-by-Layer Assembled Multilayers of Polyethylenimine-Stabilized Platinum Nanoparticles and PEDOT:PSS as Anodes for the Methanol Oxidation Reaction." *ACS Appl. Mater. Interf.* **2012**, *4*, 3575-3583.

10. Briefly list the most recent professional development activities
    - Attendance of ACS National Meetings (2013-present), MRS National Meetings (2013-present)
    - Attendance of regional meetings for undergraduate (UG) research (ACS Puget Sound UG Meeting; 2011-present)
    - Attendance of institutional meetings (Scholars Week 2011-present; NSF REU symposia, 2011-present)

1. Name: Tina Smilkstein

2. Education
    - Ph.D., Electrical Engineering, University of California Berkeley, 2007.
    - M.A., Electrical Engineering University of California – Berkeley, 2003.
    - B.S., Business Administration, Nanzan University, 1989.

3. Academic experience
    - Western Washington University, part-time
        - Instructor, 1/2022-present
    - California Polytechnic State University
        - Associate Professor, 2015-2021
        - Assistant Professor, 2009-2015
    - University of Missouri,
        - Assistant Professor, 2006-2009
    - University of California Berkeley
        - Teaching Assistant, part-time, 1998-2006

4. Non-academic experience
    - Fujitsu Artificial Intelligence Research Center, C-cube Software, 1992-1996
    - Hitachi Chubu Software – Programmer/SE/Translator, 1989-1992
    - Hitachi Chubu Software, Programmer, 1988-1989

5. Certifications or professional registrations

6. Current membership in professional organizations
    - IEEE Engineering in Medicine and Biology Society, current member
    - Society of Women Engineers, current member
    - Institute of Electrical and Electronics Engineers, current member
    - IEEE Solid State Circuits Society, current member
    - Women in Computer Science and Engineering, current member
    - IEEE Technology and Society, current member

7. Honors and awards

8. Service activities

9. Most important publications and presentations from the past five years:
    - T. Smilkstein, *Jitter Reduction on High-Speed Clock Signals*, Ph.D. Thesis, University
    - of California at Berkeley, 2007 (Advisor: Robert W. Brodersen). (100% contribution).

- T. Smilkstein, *Clocktree Generation for an Automated IC Design Flow*, Master's Thesis,
- University of California at Berkeley, May 2003 (Advisor: Robert W. Brodersen). (100% contribution).
- T. Smilkstein, "The Power of Visibility", 2020 American Society for Engineering Education Pacific Southwest (ASEE PSW) Conference, Conference rescheduled to 2021.
- T. Smilkstein, "Diversity, Equity, and Inclusion Project", 2020 American Society for Engineering Education Pacific Southwest (ASEE PSW) Conference, Conference rescheduled to 2021.
- T. Smilkstein. "A Fully Feedforward Jitter Removal Circuit for Low GHz Applications", in IEEE Dallas Circuits and Systems Conference, Dallas, Texas, October 12-13, 2014. Accepted but not presented.

10. Most recent professional development activities:
    - Intro to Equitable and Inclusive Teaching, 2021 (CalPoly)
    - TIDE (Teaching inclusivity, diversity, and equity), 2020 (CalPoly)

1. Name: Stephen D. Sandelin

2. Education
    - Bachelor of Science, Electrical Engineering, Washington State University, 1995.

3. Academic experience
    - Instructor, Engineering & Design Department, Western Washington University, 2012-present.

4. Non-academic experience
    - Product Definer, Maxim Integrated Products, Microcontroller Group, 2005-2012
    - Design Manager, Maxim Integrated Products, Microcontroller Group, 2003-2005
    - Engineer, Dallas Semiconductor, 1999-2000
    - Design Engineer, Dallas Semiconductor, 1997-2000
    - Design Engineer, Advanced Microelectronics, 1996-1997
    - Rifleman, Squad Leader, United States Army, 101^{st} Airborne Division, 1987-1991

5. Certifications or professional registrations

6. Current membership in professional organizations

7. Honors and awards

8. Service activities

9. Most important publications and presentations from the past five years:

10. Most recent professional development activities:

Appendix C
Equipment

Plastics & Composites Equipment List **Date Updated: 13 May 2022 Stephen James**

Room	Category	Equipment Name
ET 113 & 114	Thermoplastic Processing: Injection Molding	Toshiba EC85SXII injection Molding Machine and Hopper Dryer
		Sumitomo Injection Molding Machine and Hopper Dryer
		Newbury 50 ton/4 oz
		Arburg 221K Allrounder injection molder 28 ton
		Electric Injection Mold Heating System
	Thermoplastic Processing	Labtech Single Screw Extruder with Davis Standard Puller
		CR Clark Sheet Press
		Killion 1 inch single screw extruder (includes blown film line and compounding screw)
		Gravimetric Feeder
		Volumetric Feeders (2)
		Lab Tech twin screw extruder
		Leistritz twin screw extruder with Killion puller
		Formech Vacuum Thermoformer
		Hyrel and Intamsys High Temperature 3D Printers (2)
		Lulzbot Taz 5 & Taz 6 3D printer (2)
		Roto Sampler rotational molder
ET 124 & 164	Secondary Operations	Branson ultrasonic welders (2)
		Plastics welders and sealing equipment
		Powder fusion-coating unit
		Paint booth
		High Volume/Low Pressure Spray unit
		Gel Coating equipment
		Ovens and Vacuum Ovens (8)
		Granulators (3)
ET 110	Materials Anaylsis	Hardness testers: Rockwell, Barcol, Shore A, Durometer

		Moisture analysis unit - Metler LP16
		Viscometer
		Polariscope - Scott
		Precision balances: Metler PE3600, Metler AE100, Metler Toledo
		Brookfield RVTDV-II viscometer
		fluidized bed tool cleaner
		Shimadzu Universal Test Machine AGS-X, 10N-10kN
		Spectrophotometer - BYK Gardner
		Universal Test machine, 100 kN - MTS Insight
		Universal Test machine 5KIP - MTS
		Reaction Injection Molding machine - Graco
		TA Insturments Dynamic Mechanical Analyzer
		Landmark Fatigue Tester - MTS
		TA Instruments Q10 Differential Scanning Calorimeter
		Dynisco Melt Flow Indexer
ET 122	Soft Tooling Lab	Bandsaws (4)
		Drill Press
		Ipsco Pin Cutter and Grinder
		Delta Disk and Belt Sander
		Delta Table Saw
		Hand Tools
ET 112	Composites and Thermoset Processing	Wabash 120 ton heated compression molding press
		Wabash 30 ton heated compression molding press
		United McGill Mini-Bonder Autoclave
		Welch Vacuum Pumps (9)
		French 75 Ton Heated Column Press
		Gorton Tool and Cutter Grinder
		Composite layup stations with vacum and resin traps (18)
		Banko Pneumatic Ski Press

		300 ton isostatic press with tooling for superplastic forming
		High temp furnace
		Prepreg treater/manufacturing line
		Cheminstruments Hot Melt Coater/Laminator
		AMAR Reactor Vessel & Heat/Cool syustem

Appendix D

Institutional Summary

The Institution

a. Western Washington University
516 High Street
Bellingham, WA 98225

b. Dr. Sabah Randhawa, President

c. Prof. Nikki Larson, Program Director Manufacturing Engineering

d. Western Washington University is accredited by the Northwest Commission on Colleges and Universities (NWCCU), one of the eight agencies recognized by the U.S. Department of Education as a national accrediting body. The initial NWCCU accreditation was granted in 1921, and the accreditation status was last confirmed in 2017; the university is scheduled for its next evaluation by NWCCU during the 2024-2025 academic year.

Further information about the institution's national accreditation and other specialized program accreditation can be found at the following website: https://www.wwu.edu/accreditation/.

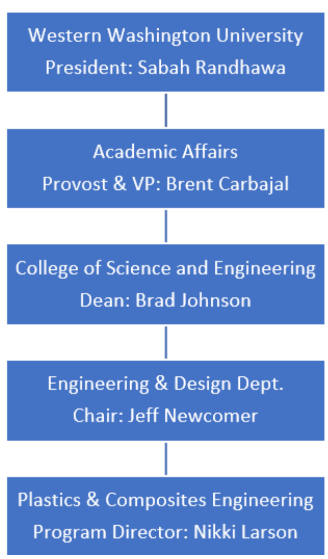
2. Type of Control

Western Washington University is a state, 4-year, comprehensive University.

3. Educational Unit

The Electrical & Computer Engineering program is one of four programs in the Engineering & Design Department. The other three programs are Manufacturing Engineering, Plastics and Composites Engineering, and Industrial Design.

The following chart shows the administrative chain of responsibility:



4. Academic Support Units

Chemistry
Chair, Dr. P. Clint Spiegel

Computer Science
Chair, Dr. Filip Jagodzinski

English
Chair, Dr. Kathryn Vulic

Mathematics
Chair, Dr. David Hartenstine

Physics & Astronomy
Chair: Dr. Janelle Leger

5. Non-academic Support Units

Western Libraries
Dean of Libraries: Mark Greenberg

University Information Technology
Vice Provost for Information Technology and Chief Information Officer: Chuck Lanham

College Information Technology
Director of Network Computer Services: Todd Epps

Career Services Center
Director: Effie Eisses

University Accreditation, Assessment, Faculty Development, Teaching and Learning Resources
Vice Provost for Undergraduate Education: Dr. Jack Herring

Office of Research and Sponsored Programs
Vice Provost for Research: Dr. David Patrick

Admissions Office
Dir. of Admissions: Cezar Mesquita

Registrar's Office
Interim Registrar: Shelli Soto

Disability Access Center
Dir. DAC and Dep. ADA Coordinator: Josef Mogharreban

Civil Rights and Title IX Compliance

Dir. of Civil Rights and Title IX Compliance: Daniel Records-Galbraith

6. Credit Unit

Western Washington University is on the quarter system. Each quarter is ten weeks excluding Finals week. All Engineering programs require courses in Fall, Winter, and Spring quarters. Summer quarter attendance is not required to meet program requirements.

In the Engineering and Design Department one quarter credit represents one class hour or two laboratory hours per week.

Table D-1. Program Enrollment and Degree Data

Plastics & Composites Engineering

	Academic Year		Enrollment Year 1st	2nd	3rd	4th	5th	Total Undergrad	Total Grad	Degrees Awarded Associates	Bachelors	Masters	Doctorates
Current 2021-22		FT	25	20	21	21		87			17		
		PT											
1 year prior to current 2020-21		FT	9	17	23	20		69			26		
		PT											
2 years prior to current 2019-20		FT	17	20	24	27		88			33		
		PT											
3 years prior to current 2018-19		FT	20	22	30	29		101			16		
		PT											
4 years prior to current 2017-18		FT	20	22	31	21		94			22		
		PT											

Give official fall term enrollment figures (head count) for the current and preceding four academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the on-site visit.

FT—full-time
PT—part-time

Table D-2. Personnel

Plastics & Composites Engineering

2021-2022

	HEAD COUNT		FTE[2]
	FT	PT	
Administrative[2]	0	2	.334
Faculty (tenure-track)[3]	4	1	4.163
Other Faculty (excluding student Assistants)	6	0	1.223
Student Teaching Assistants[4]	0	0	
Technicians/Specialists	4	0	2.50
Office/Clerical Employees	3	0	.75
Others[5]			

Appendix E
Templates and Samples

E.1

Outcome Rubrics

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.	Fails to identify one or more major principles which will prevent proper formulation of the problem.	Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	Correctly identifies all relevant principles needed to formate and solve the problem.
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.	Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	Correctly and clearly includes all required information in the visual abstraction needed for formulation.
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.	Fails to fully develop the mathematical equations needed for the formulation.	Develops fully the mathematical equations needed for the formulation though with minor errors.	Correctly and fully develops all mathematical equations needed for the formulation.
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.	Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.	Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.	Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (c), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**execute (C3) a logical and orderly design process to arrive at a solution.**	Fails to execute a logical and orderly design process.	Omits or improperly executes a major step of the design process.	Executes each step of the design process but improvements in the logic and order applied are possible.	Executes each step of the design process in a logical and orderly fashion.
2	**identify (C1) and quantify (C2) relevant customer requirements that include both performance targets and realistic constraints.**	Fails to identify and quantify relevant customer requirements.	Identifies most relevant customer requirements but does not adequately quantify the majority of these.	Identifies all relevant customer requirements but improvements are possible in how some have been quantified.	Identifies and meaningfully quantifies all relevant customer requirements .
3	**identify (C1) and attempt to integrate (C2) consideration of public health, safety and welfare into the final solution.**	Fails to identify any public health, safety and welfare considerations.	Identifies some important public health, safety and welfare considerations but does not integrate any into the final solution.	Identifies all important public health, safety and welfare considerations and integrates some of these into the final solution.	Identifies all important public health, safety and welfare considerations and broadly integrates these into the final solution.
4	**identify (C1) and attempt to integrate (C2) consideration of global, cultural, social, environmental and economic factors into the final solution.**	Fails to identify any global, cultural, social, environmental or economic considerations.	Identifies some important global, cultural, social, environmental or economic considerations but none are integrated into the final solution.	Identifies all important global, cultural, social, environmental or economic considerations and integrates some of these into the final solution.	Identifies all important global, cultural, social, environmental or economic considerations and broadly integrates these into the final solution.
5	**create (C3) a final solution that satisfies all requirements identified in formulating the design problem.**	Fails to create a final solution that meets any of the identified requirements.	Creates a final solution but does not meet several important requirements.	Creates a final solution that meets most of the important requirements that have been identified.	Creates a final solution that meets all of the important requirements that have been identified.

6	**justify (C3) decisionmaking through analysis (C3) of the solution (intermediate and final) using appropriate engineering and/or scientific principles.**	Fails to justify decisionmaking through appropriate analyses at any stage of the process.	Justifies decisionmaking but inconsistently and often through the use of inappropriate analyses.	Justifies decisionmaking through appropriateness analyses for most stages of the process.	Justifies decisionmaking at all stages of the process through the use of the most appropriate analyses.

Bloom's Taxonomy

C1 - Level 1 (Remember)

C2 - Level 2 (Understand)

C3 - Level 3 (Apply, Analyze, Evaluate, Create)

3. an ability to communicate effectively with a range of audiences (g)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.	Better methods and tools are available, or use of the ones selected is ineffective.	The choice of methods and tools is appropriate, but improvements are possible in their use.	Selection and use of methods and tools is highly effective.
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of conprehension.	Some structure. Weak in logic, brevity and ease of comprehension.	Small improvements in structure, logic, brevity and ease of comprehension are possible.	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherance to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards	Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.	Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inapproriate.	Either the content or style is inappropriate, but not both.	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	The content and style are ideally suited to engaging the target audience.

4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (f, h, j)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**recognize and articulate ethical and professional responsibilities in engineering situations**	Consistently fails to recognize or practice ethical and professional responsibilities	Recognizes and practices only the important ethical and professional responsibilities, and is unable to articulate the ethical reasoning that guides behavior.	Occasionally fails to recognize or practice an ethical and professional responsibilities, occasionally cannot articulate the proper ethical reasoning that guides behavior.	Recognizes and practices all ethical and professional responsibilities, can always clearly articulate the ethical reasoning that guides behavior.
2	**gather, validate and analyze information from multiple relevant sources, on the potential impact of an engineering solution**	Fails to gather meaningful information from any relevant sources.	Significant information sources have been overlooked, and the validation, analysis or both are missing or weak.	In-depth validation and analysis has been completed on some relevant sources, but other important sources have been overlooked.	Information has been gathered from a broad set of relevant sources, validation and analysis has been completed and is of a high quality.
3	**make informed judgements supported by analysis of the societal and global impact of engineering solutions**	Fails to offer any informed judgements of the societal and global impact.	Judgements are made but are either incorrect or poorly supported by the analysis provided.	Judgements are correct and to a large extent supported by the analysis, but the rationale presented could be stronger.	Judgements are correct and a strong rationale is presented that is clearly supported by the analysis.
4	**make informed judgements supported by analysis of the economic and environmental impact of engineering solutions**	Fails to offer any informed judgements of the economic and environmental impact.	Judgements are made but are either incorrect or poorly supported by the analysis provided.	Judgements are correct and to a large extent supported by the analysis, but the rationale presented could be stronger.	Judgements are correct and a strong rationale is presented that is clearly supported by the analysis.

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (d)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**function effectively in providing team leadership.**	Fails to demonstrate any leadership abilities.	Demonstrates leadership abilities only as part of a shared responsibility.	Demonstrates independent leadership skills.	Demonstrates both strong independent leadership skills and the ability to delegate responsibilities to others.
2	**promote a collaborative and inclusive environment that supports effective teamwork.**	Demonstrates attitudes that obstruct collaboration and that exclude contributions from other team members.	Demonstrates tendencies to want to work alone and is reluctant to accept contributions from other team members.	Willingly collaborates on assigned team activities and is receptive to the contributions of others.	Actively encourages collaboration and contributions from all team members across all team activities.
3	**share in planning and setting goals for the team.**	Lacks knowledge of the team's plan and goals.	Is knowledgeable of the plan and goals but contributes little to developing them.	Willingly participates in planning and goal setting.	Assumes responsibility for planning and goal setting.
4	**share in the work of the team.**	Always relies on others to do the work	Rarely does the assigned work – often needs reminding	Usually does the work assigned – rarely needs reminding	Always does the assigned work without having to be reminded
5	**complete assigned tasks in a timely fashion**	Fails to complete any assigned task on schedule.	Inconsistent in completing assigned tasks on schedule.	Completes most of the assigned tasks on schedule.	Completes all tasks on time or ahead of schedule.

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (b), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**select and operate appropriate process equipment and instruments to perform necessary experiments. (lab-based classes only)**	Unprepared for lab; does not operate instruments and process equipment properly; requires excessive supervision.	Generally follows proper lab procedures; requires significant supervision to operate instruments and process equipment.	Attentive to safety procedures and proper operation of instruments and process equipment; requires little supervision.	Very prepared and organized; attentive to safety procedures and proper operation of instruments and process equipment; requires minimal supervision.
2	**apply appropriate experimental design principles.**	Design of experiments is inadequate.	Planned experiments are not complete.	Experimental design is fairly complete.	Experimental design is complete.
3	**apply appropriate statistical analyses to produce professional quality technical work.**	Statistical analysis is incomplete or applied incorrectly.	Statistical analysis is fairly complete; Reporting of analysis is not professional quality.	Data analysis is fairly complete; professional presentation could be improved.	Statistical analysis of data is thorough; data are presented in a meaningful and professional manner.
4	**form conclusions based on empirical evidence and to compare these with researched information or theoretical models.**	Conclusions are incorrect or poorly justified. Presentation of data and results lacks depth and/or is not compared to researched literature.	Data and results are generally, interpreted correctly, but written descriptions lack sufficient depth and/or are not compared sufficiently with researched literature.	Conclusions are fairly well supported by empirical data; depth of data analysis is acceptable; results are compared to some literature.	Results are thoroughly and correctly interpreted and presented; conclusions are supported by appropriate literature sources.

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies (i)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**to identify relevant sources of new knowledge.**	Makes no effort to seek out relevant sources.	Conducts a background study but fails to identify and verify any relevant sources.	Background study identifies and verifies most but not all relevant sources.	Background study is comprehensive in identifying and verifying all relevant sources.
2	**use an approriate learning strategy to acquire new knowledge.**	Is unable to demonstrate learning from a verified source.	The adopted strategy leads to superficial or improper learning.	The adopted strategy leads to learning that is adequate for the need.	The adopted strategy leads to mastery of the new knowledge.
3	**apply newly acquired knowledge to problem solving.**	Is unable to apply newly acquired knowledge to problem solving.	The newly acquired knowledge is partially or incorrectly applied leading to erroneous results and conclusions.	The newly acquired knowledge is correctly applied, but veracity of results and conclusions need further verification.	The newly acquired knowledge is correctly applied and results and conclusions verified.

Current Language **EAC Criteria effective 2017-18 and 2018-19 Cycles**	**New Language** **Approved by the EAD October 20, 2017** **Applicable beginning in the 2019-20 cycle**
Criterion 3. Student Outcomes The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.	**Criterion 3. Student Outcomes** The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.
(a) an ability to apply knowledge of mathematics, science, and engineering (e) an ability to identify, formulate, and solve engineering problems	1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(b) an ability to design and conduct experiments, as well as to analyze and interpret data	6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
(d) an ability to function on multidisciplinary teams	5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
(f) an understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (j) a knowledge of contemporary issues	4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
(g) an ability to communicate effectively	3. an ability to communicate effectively with a range of audiences
(i) a recognition of the need for, and an ability to engage in life-long learning	7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	Implied in 1, 2, and 6

(a) an ability to apply knowledge of mathematics, science, and engineering to solving problems in manufacturing engineering

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**define the problem and outline a strategy to solve it**	Does not define the problem or outline a road map	Attempts to define the problem and solving strategy but not completely	Supplies a basic definition of the problem and a simple strategy to solve it	Defines the problem completely and lays out a complete road map to solve it
2	**include visual sketches to describe the physical situation given in the problem**	Does not include visual sketches/models or describe physical situation given in the problem	Visual sketches/models and description of the physical situation are incomplete	Visual sketches/models and description of the physical situation are complete most of the time	Complete visual sketches/models and description of the physical situation are always given
3	**develop appropriate equations required to solve problem**	Is incapable of developing required equations	Does list some of the required equations	Is able to develop necessary equations most of the time	Is always able to develop the equations and justify them
4	**use correct mathematical tools to solve the generated equations**	Is not able to solve the equations or use mathematical tools correctly	Uses correct mathematical tools but does not get correct answers usually	Solves the equations using appropriate mathematical tools and gets correct answer most of the time	Uses appropriate mathematical tools and gets correct answer every time
5	**use knowledge of engineering to verify solutions and/or discuss them**	Cannot verify solution and/or discuss it	Verifies and/or discusses part of the solution	Verifies the solution and/or discusses it logically most of the time	Always verifies the solution and/or has a valid explanation

(b) an ability to design and conduct experiments and to analyze and interpret data within a manufacturing context

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**select and operate appropriate process equipment and instruments to perform necessary experiments. (lab-based classes only)**	Unprepared for lab; does not operate instruments and process equipment properly; requires excessive supervision.	Generally follows proper lab procedures; requires significant supervision to operate instruments and process equipment.	Attentive to safety procedures and proper operation of instruments and process equipment; requires little supervision.	Very prepared and organized; attentive to safety procedures and proper operation of instruments and process equipment; requires minimal supervision.
2	**apply appropriate experimental design principles.**	Design of experiments is inadequate.	Planned experiments are not complete.	Experimental design is fairly complete.	Experimental design is complete.
3	**apply appropriate statistical analyses to produce professional quality technical work.**	Statistical analysis is incomplete or applied incorrectly.	Statistical analysis is fairly complete; Reporting of analysis is not professional quality.	Data analysis is fairly complete; professional presentation could be improved.	Statistical analysis of data is thorough; data are presented in a meaningful and professional manner.
4	**form conclusions based on empirical evidence and to compare these with researched information or theoretical models.**	Conclusions are incorrect or poorly justified. Presentation of data and results lacks depth and/or is not compared to researched literature.	Data and results are generally, interpreted correctly, but written descriptions lack sufficient depth and/or are not compared sufficiently with researched literature.	Conclusions are fairly well supported by empirical data; depth of data analysis is acceptable; results are compared to some literature.	Results are thoroughly and correctly interpreted and presented; conclusions are supported by appropriate literature sources.

(c) an ability to design products, and to design or select the processes, equipment, tooling, and systems necessary for their manufacture to desired specifications

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**identify and follow a logical and orderly design process.**	No discernable effort made to identify or follow a procedure. Haphazard approach taken.	Requires significant guidance in identifying, understanding and following a proper procedure.	Needs some minimal help in identifying the procedure, understanding steps and staying on track.	Works independently throughout. Correctly identifies the procedure, and executes with a high level of understanding.
2	**create quantified goals that include both targets and constraints.**	Cannot Develop a complete List of Objectives, Functions, or Constraints	Cannot Quantify Objectives, Functions, or Constraints into Specifications	Partially Quantifies Objectives, Functions, or Constraints into Specifications	Quantifies and Justifies Every Appropriate Objective, Function, and Constraint into a Specification
3	**systematically develop, compare and rank design alternatives to arrive at a final solution.**	Only considers one design option.	Several alternatives are developed. But a systematic comparison and ranking has not been attempted or is poorly justified.	A systematic comparison and ranking of alternatives has been performed. Some dispute about final solution may exist.	A systematic comparison and ranking of alternatives has been performed. Final solution is undisputed.
4	**create a final solution that satisfies all requirements and constraints identified in formulating the design problem.**	Identification of requirements and constraints in formulating the problem is missing or inadequate.	The final solution does not satisfy many of the design problem's requirements and constraints.	The final solution satisfies most though not all of the design problem's requirements and constraints.	The final solution satisfies all of the design problem's requirements and constraints.
5	**justify design decisions using analyses based on appropriate engineering and/or scientific principles.**	No analysis of design decisions performed.	Applies principles incompletely or incorrectly in many cases. Some decisions are not justified.	Applies principles correctly for major design decisions. One or two minor decisions may be overlooked.	Consistently applies the correct principles in justifying all decisions.

(d) an ability to function on multidisciplinary teams

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**negotiate and resolve differences with the other teammates to reach effective solutions**	Is a major contributor to indecision within the team and is unable to take steps to resolve differences.	Is not a major contributor to indecision, but has difficulties helping the team negotiate and resolve differences.	Is always a willing and compromising participant to efforts aimed at helping the team reach consensus.	Is willing to take the lead, and is extremely effective in guiding the team through negotiations that resolve differences.
2	**complete assigned duties in a timely fashion**	Fails to complete any assigned task on schedule.	Inconsistent in completing assigned tasks on schedule.	Completes most of the assigned tasks on schedule.	Completes all tasks on time or ahead of schedule.
3	**share in the work of the team**	Always relies on others to do the work	Rarely does the assigned work – often needs reminding	Usually does the work assigned – rarely needs reminding	Always does the assigned work without having to be reminded
4	**listen and contributing to other teammates**	Is always talking – never allows anyone else to speak	Usually doing most of the talking – rarely allows others to speak	Listens most of the time	Consistently listens and responds to others appropriately

(e) an ability to identify, formulate, and solve engineering problems

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**Identify problems with a quantifiable solution that can be approached systematically.**	Cannot identify any of the key problem elements	Identifies only some the key problem elements	Identifies the key problem elements	Identifies all of the problem elements
2	**Select appropriate methods and techniques for solving the problem.**	Selects a method/technique that is inappropriate for the problem	Selects a method/technique that is appropriate, but not optimal for the problem	Selects a method/technique that is appropriate and efficient for the problem	Considers multiple options and selects the method(s)/technique(s) that is optimal for the problem
3	**Correctly formulate the problem according to chosen solution method**	Cannot properly set up necessary equations and/or analyses	Properly sets up some, but not all necessary equations and/or analyses	Properly sets up necessary equations and/or analyses with minor errors	Properly sets up necessary equations and/or analyses without errors
4	**Select appropriate values, ranges and bounds for variables and correctly use these in the formulation to obtain a solution.**	Selects values, ranges, and bounds for variables that are unrelated to realistic conditions for the problem.	Selects values, ranges, and bounds for variables that are somewhat related to realistic conditions for the problem.	Selects values, ranges, and bounds for variables that are realistic conditions for the problem, but are not optimal.	Selects values, ranges, and bounds for variables that are optimal for a realistic analysis of the problem.

(f) an understanding of the professional and ethical responsibilities of an engineer

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**identify important information in an ethical dilemma**	Student Ignores Important Facts	Student Identifies Some Facts	Student Identifies all Important Facts	Student Identifies Unknown Facts and Uses their Own Expertise to Add Appropriate Information
2	**meaningfully participates in In-Class Discussions and Exercises on Ethics and Professionalism**	Student does not participate or complete exercises on ethics and professionalism	Student input into the discussion and exercises demonstrates a limited understanding.	Student input into the discussion and exercises demonstrates an adequate understanding.	Student input into the discussion and exercises demonstrates a full understanding.

(g) an ability to communicate effectively

	Performance Indicator (Student has the ability to communicate .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**making effective use of available methods and tools**	Fails to identify and make proper use of available methods and tools.	Better methods and tools are available, or use of the ones selected is ineffective.	The choice of methods and tools is appropriate, but improvements are possible in their use.	Selection and use of methods and tools is highly effective.
2	**in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of conprehension.	Some structure. Weak in logic, brevity and ease of comprehension.	Small improvements in structure, logic, brevity and ease of comprehension are possible.	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.
3	**with professionalism including grammar, spelling and usage**	Presentation lacks professionalism, and demonstrates weak language skills.	Either the presentation lacks professionalism, or weak language skills are evident, but not both.	Presentation is professional, but there is room for small improvements in language skills.	Highly professional in all aspects, with a strong command of the language skills.
4	**using content and style appropriate to the audience.**	Both content and style are highly inapproriate.	Either the content or style is inappropriate, but not both.	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	The content and style are ideally suited to engaging the target audience.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**Analyze an engineering solution to determine the global, societal, economic, and environmental impact**	Cannot analyze a solution to find any impact on the global, societal, economic, or environment	Can analyze an engineering solution to express impact to only one area of global,environmental,societal, or economic impact	Can analyze engineering solutions to express the impact on at least two areas (global, environmental, societal, economic)	Can analyze engineering solutions to show imact in all areas (global, environmental, societal, economic)
2	**Student Participates in In-Class Discussions and Exercises on the impact of engineering solutions in a global, economic, environmental, and societal context**	Student does not participate or complete exercises on the impact of engineering solutions in a global, economic, environmental, and societal context	Students participates in in-class discussions and completes exercises on the impact of engineering solutions in a global, economic, environmental, and societal context less than 50% of the time	Student participates often in in-class discussions and completes exercises on the impact of engineering solutions in a global, economic, environmental, and societal context correctly most of the time	Student always participates in In-class discussions and Completes the impact of engineering solutions in a global, economic, environmental, and societal context Correctly
3	**Perform well in humanity, social sciences and comparitive gender and multicultural studies courses to satisfy the general university requirements (based on GPA)**	under 1.5	1.5-2.5	2.5-3.5	Over 3.5

(i) a recognition of the need for, and an ability to engage in life-long learning

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**recognize the need to seek additional information.**	Does no background research.	Does background research for some major areas of the project.	Does background research for most major areas of the project.	Does background research for all major areas of the project.
2	**find relevant and useful additional information.**	Finds only unverified internet resources.	Finds verifiable and relevant internet resources.	Finds verifiable and relevant resources from multiple sources, including, but not limited to the internet.	Finds multiple verifiable and relevant sources for multiple parts of the project from multiple sources, including, but not limited to the internet.
3	**successfully integrate additional information.**	Is not able to use additional information found to inform project.	Is able to recognize new material as relevant to project, but does not fully integrate or synthesize new information.	Uses pieces of new information to inform project, but does not fully synthesize new information.	Synthesizes new information and uses it to inform project.

(j) a knowledge of contemporary issues

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**identifies valid contemporary issues**	Unable to identify a contemporary Issue	Able to acknowlege a contempory issue	Able to identify few contemporary issues	Able to identify many contemporary issues
2	**seeks multiple sources of information on the issue**	Only 1 source reviewed	Limited sources or types of resources used (3)	Adequate number of sources and types (5)	Extensive use of a variety of resources in a varity of formats
3	**discerns the credibility of the resources**	Cannot discern if the resource is credible	Discerns the credibility of a few resources	Discerns the credibility of many of the resources	Always discerns the credibility of the resource
4	**integrates the information into a nuanced argument**	Cannot integrate information into a nuanced argument (only black & white)	Can integrate a small amount of the information into a nuanced argument	Can integrate a portion of the information into a nuanced argument	Integrates all information into a nuanced argument

(k) an ability to use and practical experience with the techniques, skills, and modern engineering technologies necessary for manufacturing engineering practice

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Developing	Satisfactory	Exemplary
1	**apply technology in design.**	Demonstrates lack of preparation, ability, and understanding to use technology in the design process. Student requires significant supervision, models contain significant errors.	Understands basic use of technology for design; requires some supervision and assistance to create feasible product or process designs which may contain multiple minor errors.	Skillfully uses technology for design with little need for assistance or supervision, creates designs with few errors.	Uses capabilities technology to achieve superior design results; assists other students in the use of technology and is self-motivated in seeking and using advanced capabilities of the tools.
2	**apply technology in analysis or simulation.**	Analysis/simulation tools incorrectly applied, models may have significant errors and show lack of understanding, thought, or effort in evaluation of computational results.	Analysis/simulation planning and execution contain some errors but show application of basic understanding, thought, or effort in the evaluation of computational results.	Analysis/simulation planning and execution achieve meaningful results.	Analysis/simulation is utilized to achieve superior engineering solution with sufficient analysis of results to understand sensitivities and limitations.
3	**demonstrate use of technology in the realization of a product or process.**	Realized product or process does not demonstrate effective use of technology. Technology usage requires constant supervision or may not have been done safely.	Realized product or process shows some effectiveness to use of technology. Student generally follows proper procedures but may require significant supervision. Result is usable but has errors if not corrected by others beforehand.	Realized product or process demonstrates effective use of technology. Student is attentive to procedures, requires little supervision. Result is functional with few minor errors.	Realized product or process shows superior results demonstrating the use of technology. Student is very attentive to safety procedures, requires minimal supervision, helps other students, or conceives process improvements.
4	**demonstrate use of technology in measuring or evaluating the efficacy of the designed product or process to satisfy goals.**	Technology is not used and no plan is conceived for how technology might be used to measure of evaluate design efficacy.	Technology is proposed or implemented for measurement of design efficacy but technology selection is mismatched to the evaluation.	Appropriate technology is proposed for a measurement of design efficacy.	Appropriate technology is utilized to measure design efficacy resulting in meaningful evaluation of the design process and its results.

E.2

Sample Outcome Assessment Worksheet

Student Outcomes Assessment - Course Data Feedback Form

PROG:		**Instructor:**						
CRN:		**# Students:**						
TITLE:					**Term:**	**F18**		

Instructions: - Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

Target	Comments

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (c), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
											80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
1	**execute (C3) a logical and orderly design process to arrive at a solution.**	Fails to execute a logical and orderly design process.		Omits or improperly executes a major step of the design process.		Executes each step of the design process but improvements in the logic and order applied are possible.		Executes each step of the design process in a logical and orderly fashion.				
2	**identify (C1) and quantify (C2) relevant customer requirements that include both performance targets and realistic constraints.**	Fails to identify and quantify relevant customer requirements.		Identifies most relevant customer requirements but does not adequately quantify the majority of these.		Identifies all relevant customer requirements but improvements are possible in how some have been quantified.		Identifies and meaningfully quantifies all relevant customer requirements .				
3	**identify (C1) and attempt to integrate (C2) consideration of public health, safety and welfare into the final solution.**	Fails to identify any public health, safety and welfare considerations.		Identifies some important public health, safety and welfare considerations but does not integrate any into the final solution.		Identifies all important public health, safety and welfare considerations and integrates some of these into the final solution.		Identifies all important public health, safety and welfare considerations and broadly integrates these into the final solution.				
4	**identify (C1) and attempt to integrate (C2) consideration of global, cultural, social, environmental and economic factors into the final solution.**	Fails to identify any global, cultural, social, environmental or economic considerations.		Identifies some important global, cultural, social, environmental or economic considerations but none are integrated into the final solution.		Identifies all important global, cultural, social, environmental or economic considerations and integrates some of these into the final solution.		Identifies all important global, cultural, social, environmental or economic considerations and broadly integrates these into the final solution.				
5	**create (C3) a final solution that satisfies all requirements identified in formulating the design problem.**	Fails to create a final solution that meets any of the identified requirements.		Creates a final solution but does not meet several important requirements.		Creates a final solution that meets most of the important requirements that have been identified.		Creates a final solution that meets all of the important requirements that have been identified.				
6	**justify (C3) decisionmaking through analysis (C3) of the solution (intermediate and final) using appropriate engineering and/or scientific principles.**	Fails to justify decisionmaking through appropriate analyses at any stage of the process.		Justifies decisionmaking but inconsistently and often through the use of inappropriate analyses.		Justifies decisionmaking through appropriateness analyses for most stages of the process.		Justifies decisionmaking at all stages of the process through the use of the most appropriate analyses.				

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

E.3

Program Outcome Assessment

End of Year Summary

"CLOSING THE LOOP": IMPROVEMENT BRAINSTORMING SHEET

Type of Change	Example/Your Draft Improvements
Curricular	Change prerequisites or GE requirements; Add required courses; Replace existing courses with new ones; Change course sequence; Add internships, labs and other hands-on learning opportunities. **Your Improvements:**
Faculty Support	Increase number of TAs or peer mentors; Add specialized support to faculty (Library, Academic Technology, etc.); Increase support to promote dialogues and community among faculty. **Your Improvements:**
Faculty Development	Provide targeted professional development opportunities. **Your Improvements:**
Pedagogy	Change course assignments; Add more active-learning components to course design; Change textbooks; Increase opportunities for formative feedback and peer-assisted learning. **Your Improvements:**
Student Support	Increase tutors; Add more online resources; Improve advising to make sure students take the right courses; Provide resources to encourage community building among students and between students and faculty; Bring graduates back to discuss work opportunities related to the major. **Your Improvements:**
Resources	Change the course management system; Improve or expand lab spaces; Provide resources to support student independent research. **Your Improvements:**
Assessment Plan	Refine SLO statements; Change methods and/or measures; Change where (e.g. courses) the data are collected; Collect additional data; Improve data reporting and dissemination mechanisms. **Your Improvements**:

"Closing the Loop": Program Improvement Documentation Template

This year's assessment task is to document program improvements informed by SLO assessment and other forms of evidence. Use this form to document your improvements and the evidence and discussion that informed them.

Type of Change	SLOs Targeted	Description of Program Improvement	Rationale and Level of Faculty Involvement	Evidence that will demonstrate if this change improves student learning.
Curricular	f	Additional instruction on how to assess the information contained in ethical case studies was introduced.	Additional instruction and practice of how to assess information in ethical case studies gave additional time and experience to the students.	All performance indicators were met during the next course offering
Curricular	d	Since the rubrics for assessing program outcomes will be changing due to the new ABET outcomes, the program outcomes not achieved during this assessment round will be discussed as new program outcomes, rubrics, and assessment measures are developed.	Two or more faculty members will be involved in the development of the new rubric and assessment measures for teamwork activities. All program faculty will review, provide input, and ultimately approved each version as it is implemented.	The rubrics developed for the new ABET outcomes will be utilized in PCE 461 during AY 18-19.

BI-ANNUAL "CLOSING THE LOOP" PROGRAM IMPROVEMENT REPORT RUBRIC

The Accreditation and Assessment Advisory Committee (AAAC) will use this rubric in responding to the departmental CTL reports.

Criteria	At Standard	Developing	Unacceptable
Level of Faculty Participation	Broad faculty participation in both planning and implementation.	Select faculty participation with departmental discussion or dissemination.	Select faculty participation.
Relation to evidence and SLO assessment	Rationale meaningfully connects the improvement to a quantitative summary of SLO assessment results, and to supporting departmental discussion.	Rationale connects the improvement to SLO assessment.	Rationale does not connect the improvement to SLO assessment.
Stage of implementation	Improvement is largely implemented (e.g. proposed curriculum change was approved by the department and sent to the ACC).	Department has a plan for implementing the improvement.	Department has no plan for implementing the improvement.

Bi-Annual Assessment Report
Academic Year:_16-17________

Department/Progam: Engineering & Design/ Plastics and Composites Engineering
Assessment Coordinator/Program Director: Jeff Newcomer/ Nikki Larson
Departmental Mission: The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience we provide emphasizes teamwork, communication, critical thinking, and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context.

Program Student Learning Outcomes: Upon graduation, _PCE_______ Program majors will have:

a) an ability to apply knowledge of mathematics, science, and engineering.
b) an ability to design and conduct experiments, as well as to analyze and interpret data;
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d) an ability to function on multidisciplinary teams;
e) an ability to identify, formulate, and solve engineering problems;
f) an understanding of professional and ethical responsibility;
g) an ability to communicate effectively;
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i) a recognition of the need for, and an ability to engage in life-long learning;
j) a knowledge of contemporary issues; and
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

GUR Student Learning Outcomes

Student Learning Outcomes Assessed This Year

Assessment Measures	SLOs Assessed	Results
Students are able to define the problem, outline a strategy to solve it, complete visual sketches to describe the physical situation given in the problem, develop appropriate equations required to solve the problem, use correct mathematical tools to solve the generated equations, and use knowledge of engineering to verify solutions and/or discuss them	a	Students were able to meet all of the performance indicators with the exception of completing the visual sketches required to describe the physical situation. Assessment of all of these performance indicators come from a quiz and homework assignment in the Advanced

		Composites course (PCE 472).
Students are able to select and operate appropriate process equipment and instruments, apply appropriate experimental design principles, apply appropriate statistical analyses, and form conclusions based on empirical evidence.	**b**	All students were able to meet these performance indicators. Assessment was taken from the Advanced Materials and Processing course (PCE 431)
Students are able to follow the design process, create quanified goals, compare and rank potential solutions, and create a solution that satisfies all of the requirements of the project. Some students still struggle with justifying the design decisions based on engineering and scientific standards.	**c**	All students were able to meet these performance indicators. Assessment was taken from the final proposal in PCE 492.
Students are able to negotiate and resolve differences with the other teammates to reach effective solutions, complete assigned duties in a timely fashion, share in the work of the team, and listen and contributing to other teammates	**d**	Three of 4 of these performance indicators were met. Students were were just shy of the threshold for listening and contributing to their teammates. Assessment was taken from the Team Project in the Plastics Tooling course (PCE 461).
Students are able to identify problems with a quantifiable solution, select appropriate methods for solving these problems Students are able to correctly formulate the problem according to chosen solution method, and select appropriate values, ranges and bounds for variables and correctly use these in the formulation to obtain a solution.	**e**	The first 2 performance indicators are assessed in PCE 492 from the final proposal of their Sr. Project. The last 2 performance indicators are assessed from the final report of the implementation of their Sr. Project. All studnts are able to meet all 4 of these performance indicators.
Students participate in ethical discussions and are able to identify all of the important information that comes from an ethical case study.	**f**	½ of the performance indicators were met. Although students participate in ethical discussions, some are still struggling to be able to identify all of the important information that comes from an ethical case study.
Students are able to make effective use of available methods and tools, in an organized and concise manner, with professionalism, using content and style appropriate to the audience.	**g**	All students were able to meet these performance indicators. Assessment was taken from the final Sr. Project implementation report in PCE 493.
Students are able to analyze an engineering solution to determine the global, societal, economic, and environmental impact	**h**	All students were able to meet these performance indicators. Assessment was taken from the Contemporary Issues assignment in PCE 491.

Students are able to recognize the need to seek additional information that is relevant and useful and integrate it into their projects.	**I**	All studnts were able to meet these performance indicators. Assessment was taken from the Literature Review portion of the final Sr. Project proposal assignment in PCE 492.
Students are able to identify contemporary issues, analyze them using several sources, and discern if the sources are credible.	**J**	All students were able to meet these performance indicators. Assessment was taken from the Contemporary Issues assignment in PCE 491 .
Students are able to apply technology in design, analysis, or simulation, demonstrate an ability to use (and practical experience with) manufacturing processes for plastic and composite materials, and demonstrate the use of technology in characterizing the properties of the designed product, process, or material to satisfy goals.	**k**	All students were able to meet these performance indicators. Assessment was taken from the Comprehensive Project report in PCE 472.

Bi-Annual Assessment Report
Academic Year:_17-18_________

Department/Progam: Engineering & Design/ Plastics and Composites Engineering
Assessment Coordinator/Program Director: Jeff Newcomer/ Nikki Larson
Departmental Mission: The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience we provide emphasizes teamwork, communication, critical thinking, and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context.

Program Student Learning Outcomes: Upon graduation, _PCE_______ Program majors will have:

a) an ability to apply knowledge of mathematics, science, and engineering.
b) an ability to design and conduct experiments, as well as to analyze and interpret data;
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d) an ability to function on multidisciplinary teams;
e) an ability to identify, formulate, and solve engineering problems;
f) an understanding of professional and ethical responsibility;
g) an ability to communicate effectively;
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i) a recognition of the need for, and an ability to engage in life-long learning;
j) a knowledge of contemporary issues; and
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

GUR Student Learning Outcomes

Student Learning Outcomes Assessed This Year

Assessment Measures	SLOs Assessed	Results
Students are able to define the problem, outline a strategy to solve it, complete visual sketches to describe the physical situation given in the problem, develop appropriate equations required to solve the problem, use correct mathematical tools to solve the generated equations, and use knowledge of engineering to verify solutions and/or discuss them	a	Students were able to meet all of the performance indicators with the exception of completing the visual sketches required to describe the physical situation. Assessment of all of these performance indicators come from a quiz and homework assignment in the Advanced

		Composites course (PCE 472).
Students are able to select and operate appropriate process equipment and instruments, apply appropriate experimental design principles, apply appropriate statistical analyses, and form conclusions based on empirical evidence.	**b**	All students were able to meet these performance indicators. Assessment was taken from the Advanced Materials and Processing course (PCE 431)
Students are able to follow the design process, create quanified goals, compare and rank potential solutions, and create a solution that satisfies all of the requirements of the project. Some students still struggle with justifying the design decisions based on engineering and scientific standards.	**c**	Student were able to meet 2 of 5 of the performance indicators Students struggled with following the design process and creating a final solution that satisfies all requirements and constraints identified in formulating the design problem. Assessment was taken from the final proposal in PCE 492.
Students are able to negotiate and resolve differences with the other teammates to reach effective solutions, complete assigned duties in a timely fashion, share in the work of the team, and listen and contributing to other teammates	**d**	All of the performance indicator (4) thresholds were met. Last year the students were were just shy of the threshold for listening and contributing to their teammates. This year that threshold was met. Assessment was taken from the Team Project in the Plastics Tooling course (PCE 461).
Students are able to identify problems with a quantifiable solution, select appropriate methods for solving these problems Students are able to correctly formulate the problem according to chosen solution method, and select appropriate values, ranges and bounds for variables and correctly use these in the formulation to obtain a solution.	**e**	The first 2 performance indicators are assessed in PCE 492 from the final proposal of their Sr. Project. The last 2 performance indicators are assessed from the final report of the implementation of their Sr. Project. Students met 2 of the 4 PI successfully. They failed to meet the threshold of 80% (and only acheieved 71.4%) of the PI relating to selecting appropriate techniques and tools to solve their problems (assessed in PCE 492) and the PI relating to correctly formulating the problem for the chosen solution (we were at 79% instead of meeting the targeting 80%)

Students participate in ethical discussions and are able to identify all of the important information that comes from an ethical case study.	**f**	All of the performance indicators were met. Assessment was taken from an ethical case study assignment in PCE 491.
Students are able to make effective use of available methods and tools, in an organized and concise manner, with professionalism, using content and style appropriate to the audience.	**g**	All students were able to meet these performance indicators. Assessment was taken from the final Sr. Project implementation report in PCE 493.
Students are able to analyze an engineering solution to determine the global, societal, economic, and environmental impact	**h**	All students were able to meet these performance indicators. Assessment was taken from the Contemporary Issues assignment in PCE 491.
Students are able to recognize the need to seek additional information that is relevant and useful and integrate it into their projects.	**I**	All studnts were able to meet these performance indicators. Assessment was taken from the Literature Review portion of the final Sr. Project proposal assignment in PCE 492.
Students are able to identify contemporary issues, analyze them using several sources, and discern if the sources are credible.	**J**	All students were able to meet these performance indicators. Assessment was taken from the Contemporary Issues assignment in PCE 491 .
Students are able to apply technology in design, analysis, or simulation, demonstrate an ability to use (and practical experience with) manufacturing processes for plastic and composite materials, and demonstrate the use of technology in characterizing the properties of the designed product, process, or material to satisfy goals.	**k**	All students were able to meet these performance indicators. Assessment was taken from the Comprehensive Project report in PCE 472.

Bi-Annual Assessment Report
Academic Year:_18-19_________

Department/Progam: Engineering & Design/ Plastics and Composites Engineering
Assessment Coordinator/Program Director: Jeff Newcomer/ Nikki Larson
Departmental Mission: The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience we provide emphasizes teamwork, communication, critical thinking, and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context.

Program Student Learning Outcomes: Upon graduation, _PCE_______ Program majors will have:

a) an ability to apply knowledge of mathematics, science, and engineering.
b) an ability to design and conduct experiments, as well as to analyze and interpret data;
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d) an ability to function on multidisciplinary teams;
e) an ability to identify, formulate, and solve engineering problems;
f) (now 4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (f, h, j);
g) (now 3) an ability to communicate effectively with a range of audiences (g);
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i) a recognition of the need for, and an ability to engage in life-long learning;
j) a knowledge of contemporary issues; and
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

GUR Student Learning Outcomes

Student Learning Outcomes Assessed This Year

Assessment Measures	SLOs Assessed	Results
Students are able to define the problem, outline a strategy to solve it, complete visual sketches to describe the physical situation given in the problem, develop appropriate equations required to solve the problem, use correct mathematical tools to solve the generated equations, and use knowledge of engineering to verify solutions and/or discuss them	a	Unfortunately there is no assessment of this outcome for this year as the instructor did not gather any data. Typically this outcome is measured in PCE 472.

Students are able to select and operate appropriate process equipment and instruments, apply appropriate experimental design principles, apply appropriate statistical analyses, and form conclusions based on empirical evidence.	**b**	80% or more of the students were able to meet 3 of 4 performance indicators. Only 68% of students were able to meet the performance indicator of applying statistical analysis to produce professional quality work. Unfortunately two groups failed to follow instructions given to them. All PI's assessed in PCE 431.
Students are able to follow the design process, create quanified goals, compare and rank potential solutions, and create a solution that satisfies all of the requirements of the project. Some students still struggle with justifying the design decisions based on engineering and scientific standards.	**c**	Student were able to meet 2 of 5 of the performance indicators Students struggled with following the design process and creating a final solution that satisfies all requirements and constraints identified in formulating the design problem. Students have challenges with justifying their chosen solutions. Assessment was taken from the final proposal in PCE 492.
Students are able to negotiate and resolve differences with the other teammates to reach effective solutions, complete assigned duties in a timely fashion, share in the work of the team, and listen and contributing to other teammates	**d**	All of the performance indicator (4) thresholds were met. Assessment was taken from the Team Project in the Plastics Tooling course (PCE 461).
Students are able to identify problems with a quantifiable solution, select appropriate methods for solving these problems Students are able to correctly formulate the problem according to chosen solution method, and select appropriate values, ranges and bounds for variables and correctly use these in the formulation to obtain a solution.	**e**	Students met the threshold for 3 of the 4 performance indicators. Students are still struggling with selecting and justifying appropriate methods for solving the problem. Assessment is take in PCE 492.
Students participate in ethical discussions and are able to identify all of the important information that comes from an ethical case study.	**4**	All of the performance indicators were met. Assessment was taken from an ethical case study assignment in PCE 491.
Students are able to make effective use of available methods and tools, in an organized and concise manner, with professionalism, using content and style appropriate to the audience.	**3**	All students were able to meet these performance indicators. Assessment was taken from the final Sr. Project implementation report in PCE 493.
Students are able to analyze an engineering solution to determine the global, societal, economic, and environmental impact	**h**	N/A with new 1-7 criteria (see #4)

Students are able to recognize the need to seek additional information that is relevant and useful and integrate it into their projects.	**I**	All studnts were able to meet these performance indicators. Assessment was taken from the Literature Review portion of the final Sr. Project proposal assignment in PCE 492.
Students are able to identify contemporary issues, analyze them using several sources, and discern if the sources are credible.	**J**	N/A with new 1-7 criteria (see #4)
Students are able to apply technology in design, analysis, or simulation, demonstrate an ability to use (and practical experience with) manufacturing processes for plastic and composite materials, and demonstrate the use of technology in characterizing the properties of the designed product, process, or material to satisfy goals.	**k**	Assessment not taken due to the instructor not gathering data. Typically this outcome is assessed in PCE 472.

Bi-Annual Assessment Report
Academic Year:_18-19________

Department/Progam: Engineering & Design/ Plastics and Composites Engineering
Assessment Coordinator/Program Director: Jeff Newcomer/ Nikki Larson
Departmental Mission: The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience we provide emphasizes teamwork, communication, critical thinking, and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context.

Program Student Learning Outcomes: Upon graduation, _PCE_______ Program majors will have:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

GUR Student Learning Outcomes

Student Learning Outcomes Assessed This Year - Tyipcally all student outcomes are assessed each year. Due to COVID only the following were assessed for this year.

Student have an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	**7**	All of the performance indicators were met. Assessment was taken from their background and solution development sections of the final paper in PCE 492.

an ability to communicate effectively with a range of audiences	**3**	All students were able to meet these performance indicators. Assessment was taken from the final Sr. Project proposal report and presentation in PCE 492.
Students participate in ethical discussions and are able to identify all of the important information that comes from an ethical case study.	**4**	All of the performance indicators were met. Assessment was taken from an ethical case study assignment in PCE 491.

Rationale/Problem	Course or Program	Type of change	SLO targeted	Source of Info re problem	How to determine if change makes improvement	Follow Up & Person in charge
Moving assessment	From PCE 472 to PCE 431	Assessment	1	Content for this rubric is better assessed in PCE 431	Switch to PCE 461 for assessment.	N. Larson

Bi-Annual Assessment Report
Academic Year:_20-21________

Department/Progam: Engineering & Design/ Plastics and Composites Engineering
Assessment Coordinator/Program Director: Jeff Newcomer/ Nikki Larson
Departmental Mission: The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience we provide emphasizes teamwork, communication, critical thinking, and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context.

Program Student Learning Outcomes: Upon graduation, _PCE_______ Program majors will have:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

GUR Student Learning Outcomes

Student Learning Outcomes Assessed This Year

an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)	**1**	All 4 of the PI's for this outcome were met this year as we were able to have some lab work completed (unlike last year with COVID not allowing for any lab work). Assessment is taken from the final paper and presentation in PCE 493.

an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	**2**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for 5 of the 6 performance indicators. For the PI where the threshold was not met the PI should be changed. The majority of students were able to identify most of the important considerations and incorporate some of these into the final solution. This is not an option for this rubric so these students were scored at Developing. Often, incorporating these considerations into their project is outside of the project scope. Data is taken from the final paper in PCE 492.
an ability to communicate effectively with a range of audiences	**3**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all 4 performance indicators. Data is taken from the final paper and presentation in PCE 493.
an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	**4**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all 4 performance indicators. Data is taken from the ethics assignments/presentations in PCE 491.
an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	**5**	All of the PI were met with 80% or more of students scoring in the satisfactory or exemplary categories for this outcome. Assessment is taken from the Tooling course in their teammate evaluations.
an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	**6**	Students met the threshold of at least 80% of student in either the satisfactory or exemplary category for

		2 of the 4 PI's which were assessed in PCE 431. PI's that were missed were due to changes made due to COVID restrictions. PI's, **select and operate appropriate process equipment and instruments to perform necessary experiments. (lab-based classes only)**, and **form conclusions based on empirical evidence and to compare these with researched information or theoretical models** missed the mark because, due to COVID, lab access was restricted and students were not able to make decisions on their own.
Student have an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	**7**	The first PI is assessed in PCE 492 from the background assignment. The other 2 PI are assessed in PCE 493. All students were able to meet the threshold of at least 80% of students in either the satisfactory or exemplary category for PI 1. For the other 2 PI's assessed in PCE 493, both were met with an 80% or more students able to achieve a satisfactory or exemplary rating. Data for PI 2 & 3 was taken from the students' final reports, final presentations, and reflective statements.

Rationale/Problem	Course or Program	Type of change	SLO targeted	Source of Info re problem	How to determine if change makes improvement	Follow Up & Person in charge
Changed EE 351 course content	Course	Content change		Course was not providing any information that was used in	We will continue to work with our IAC to ensure that our graduates have the skills that they require	NL - Complete

				follow on courses. With the addition of MFGE 250 this course can add additional valuable information on PLC's and automation		
Added MFGE 250 as required course	Program	Course addition		Industrial advisory committee indicated a need for our students to know basic automation techniques		NL - Complete
Changing PI 4 in criteria 2		Rubric	2	The majority of students were able to identify <u>most</u> of the important considerations and incorporate <u>some</u> of these into the final solution. This is not an option for this rubric so these students were scored at Developing. Often, incorporating these considerations into their project is outside of the project scope.	Assessment at the end of the course should show if the change was appropriate.	NH - Complete

Changing location of assessment for criteria 7 PI 2 & 3 to PCE 493 from PCE 492.		Assessment location	7	Students need to adapt and change during implementation to be able to successfully complete it. PI 1 is about using new information to plan while 2 & 3 are around using the new information to change their implementation.	Assessment at the end of senior project will confirm the appropriate location to gather the data from	NH – Complete
Added ENGR 101 to program		Course Addition	4	Engineering ethics and professional responsibilities were only formally taught in the first capstaone course during a student's final year. Adding this course allows for these topics to be introduced at the early underclassman level so that it can then be referenced	Assessment of this SLO in the senior year should prove to show an even deeper understanding and commitment to these topics	JD - Complete

				throughout the curriculum.		

Bi-Annual Assessment Report
Academic Year:_21-22________

Department/Progam: Engineering & Design/ Plastics and Composites Engineering
Assessment Coordinator/Program Director: Jeff Newcomer/ Nikki Larson
Departmental Mission: The Engineering & Design department at Western Washington University serves current students, industry, the University, and the citizens of Washington State by developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning. The educational experience we provide emphasizes teamwork, communication, critical thinking, and an understanding of the impact of design, engineering, and manufacturing solutions in a global, economic, environmental, and societal context.

Program Student Learning Outcomes: Upon graduation, _PCE_______ Program majors will have:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

GUR Student Learning Outcomes

Student Learning Outcomes Assessed This Year

an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	**1**	3 of the 4 of the PI's for this outcome were met this year. PI 3's threshold of 80% was barely missed (78.9%). After discussion around this PI, it was determined that nothing should be changed as it was likely just a class anomaly as we were still unable to

		start the quarter normally due to continued COVID restrictions and, therefore, some instruction was lost. However, this PI will be monitored to ensure this is the case. Assessment is taken from the DOE & process Planning and Compounding Report for PI 1, the DOE & Process Planning Report for PI 2, and the Final Report for PI's 3 & 4.
an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	**2**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all performance indicators. Data is taken from the final paper in PCE 492.
an ability to communicate effectively with a range of audiences	**3**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all 4 performance indicators. Data is taken from the final paper, presentation, and poster in PCE 493.
an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	**4**	Students met the threshold of at least 80% of students in either the satisfactory or exemplary category for all 4 performance indicators. Data is taken from the ethics assignments/presentations in PCE 491.
an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	**5**	All of the PI were met with 80% or more of students scoring in the satisfactory or exemplary categories for this outcome. Assessment is taken from the Tooling course in their teammate evaluations and instructor observations.
an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	**6**	Students met the threshold of at least 80% of student in either the satisfactory or exemplary category for

		all 4 of the which were assessed in PCE 431.
Student have an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	**7**	The first PI is assessed in PCE 491 from the literature review assignment. The other 2 PI are assessed in PCE 493. All students were able to meet the threshold of at least 80% of students in either the satisfactory or exemplary category for PI 1. For the other 2 PI's, assessed in PCE 493, both were met with an 80% or more students able to achieve a satisfactory or exemplary rating. Data for PI 2 & 3 was taken from the students' final reports, final presentations, and reflective statements.

Rationale/Problem	**Course or Program**	**Type of change**	**SLO targeted**	**Source of Info re problem**	**How to determine if change makes improvement**	**Follow Up & Person in charge**
PCE Program Name Change	PCE to PME	Program		Plastics are seen with a negative connotation. Hopefully this change will remedy that	If we obtain more PME pre-majors	NL - Complete
PCE 331 not a prereq to PCE 491	PCE	Prereq		A student failed to successfully complete PCE 331 but was able to move on to senior project	Students should not be allowed to take PCE 491 without successfully completing PCE 331	NL - Complete

PCE 342 was a co-req not a pre-req to PCE 491	PCE	Prereq		Students that have not yet completed the DOE class can not use it in the sr. Project, which is a problem	All students will have the ability to complete DOE's in their senior projects if deemed necessary	NL - Complete
Moving assessment of 1 to PCE 431 from 493	PCE			Too much assessment is done in the senior project series and things get confounded	See if the assessment is appropriate after a few cycles	NL/JM - Complete
Remove PI 1 from outcome 4	PCE			The outcome does not require the assessment of the practice of ethical responsibilities	N/A	NH complete

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:	Peyron							
CRN:		# Students:	6							
TITLE:						Term:	S21			
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.									

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	4	Correctly identifies all relevant principles needed to formate and solve the problem.	2	100.0%		
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.		Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	4	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	2	100.0%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.		Develops fully the mathematical equations needed for the formulation though with minor errors.	3	Correctly and fully develops all mathematical equations needed for the formulation.	3	100.0%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.		Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	3	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	3	100.0%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	4	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	2	100.0%		

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Misasi				
CRN:		# Students:	7				
TITLE:	Senior Project Implementation					Term:	S21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	5	Correctly identifies all relevant principles needed to formate and solve the problem.	2	100.0%		
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	2	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	4	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	3	77.8%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.		Develops fully the mathematical equations needed for the formulation though with minor errors.	4	Correctly and fully develops all mathematical equations needed for the formulation.	3	100.0%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.		Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	4	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	3	100.0%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	4	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	3			

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:	Hoekstra						
CRN:		# Students:	7						
TITLE:					Term:	S21			

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	Will, Anna, Josh, Eli, Kai, Evan	Correctly identifies all relevant principles needed to formate and solve the problem.	Kevin			
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.		Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	Will, Anna, Josh, Eli, Kai, Evan	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	Kevin			
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.		Develops fully the mathematical equations needed for the formulation though with minor errors.	Will, Anna, Josh, Eli, Kai, Evan	Correctly and fully develops all mathematical equations needed for the formulation.	Kevin			
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.		Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.		Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	Will, Anna, Josh, Eli, Kai, Evan, Kevin			
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	Will, Anna, Josh, Eli, Kai, Evan	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	Kevin			

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	Instructor:	combined				
CRN:		# Students:	26				
TITLE:						Term:	S21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	18	Correctly identifies all relevant principles needed to formate and solve the problem.	8	100.0%	All assessment taken is from the final presentation and paper	
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	3	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	14	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	12	89.7%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.	1	Develops fully the mathematical equations needed for the formulation though with minor errors.	15	Correctly and fully develops all mathematical equations needed for the formulation.	10	96.2%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	3	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	9	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	16	89.3%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	17	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	9	100.0%		

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	Instructor:	Larson		
CRN:		# Students:	5		
TITLE:				Term:	S21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	3	Correctly identifies all relevant principles needed to formate and solve the problem.	3	100.0%	All assessment taken is from the final presentation and paper	
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	1	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.		Correctly and clearly includes all required information in the visual abstraction needed for formulation.	6	85.7%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.	1	Develops fully the mathematical equations needed for the formulation though with minor errors.	2	Correctly and fully develops all mathematical equations needed for the formulation.	3	83.3%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	1	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	2	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	3	83.3%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	3	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	3			

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Hoekstra**
CRN:	493	**# Students:**	**20**
TITLE:	Plastics Senior Project Implementation	**Term:**	**S22**

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.	0	Fails to identify one or more major principles which will prevent proper formulation of the problem.	0	Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	11	Correctly identifies all relevant principles needed to formate and solve the problem.	9	100.0%	PCE 493 Final Report	Move to PCE 492 to assess this PI
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.	0	Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	0	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	16	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	4	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.	0	Fails to fully develop the mathematical equations needed for the formulation.	0	Develops fully the mathematical equations needed for the formulation though with minor errors.	14	Correctly and fully develops all mathematical equations needed for the formulation.	6	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.	0	Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	0	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	0	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	20	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.	0	Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.	0	Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	12	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	8	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Outcome 1

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:	Peyron							
CRN:		# Students:	6							
TITLE:						Term:	S21			
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.									

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	4	Correctly identifies all relevant principles needed to formate and solve the problem.	2	100.0%		
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.		Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	4	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	2	100.0%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.		Develops fully the mathematical equations needed for the formulation though with minor errors.	3	Correctly and fully develops all mathematical equations needed for the formulation.	3	100.0%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.		Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	3	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	3	100.0%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	4	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	2	100.0%		

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)

C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Misasi
CRN:		# Students:	7
TITLE:	Senior Project Implementation	Term:	S21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	5	Correctly identifies all relevant principles needed to formate and solve the problem.	2	100.0%		
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	2	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	4	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	3	77.8%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.		Develops fully the mathematical equations needed for the formulation though with minor errors.	4	Correctly and fully develops all mathematical equations needed for the formulation.	3	100.0%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.		Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	4	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	3	100.0%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	4	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	3			

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:	Hoekstra								
CRN:		# Students:	7								
TITLE:						Term:	S21				

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	Will, Anna, Josh, Eli, Kai, Evan	Correctly identifies all relevant principles needed to formate and solve the problem.	Kevin			
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.		Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	Will, Anna, Josh, Eli, Kai, Evan	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	Kevin			
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.		Develops fully the mathematical equations needed for the formulation though with minor errors.	Will, Anna, Josh, Eli, Kai, Evan	Correctly and fully develops all mathematical equations needed for the formulation.	Kevin			
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.		Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.		Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	Will, Anna, Josh, Eli, Kai, Evan, Kevin			
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	Will, Anna, Josh, Eli, Kai, Evan	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	Kevin			

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	Instructor:	combined		
CRN:		# Students:	26		
TITLE:				Term:	S21
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
											80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	18	Correctly identifies all relevant principles needed to formate and solve the problem.	8	100.0%	All assessment taken is from the final presentation and paper	
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	3	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	14	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	12	89.7%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.	1	Develops fully the mathematical equations needed for the formulation though with minor errors.	15	Correctly and fully develops all mathematical equations needed for the formulation.	10	96.2%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	3	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	9	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	16	89.3%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	17	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	9	100.0%		

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	**Instructor:**	**Larson**		
CRN:		**# Students:**	5		
TITLE:				**Term:**	**S21**
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.		Fails to identify one or more major principles which will prevent proper formulation of the problem.		Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	3	Correctly identifies all relevant principles needed to formate and solve the problem.	3	100.0%	All assessment taken is from the final presentation and paper	
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.		Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	1	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.		Correctly and clearly includes all required information in the visual abstraction needed for formulation.	6	85.7%		
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.		Fails to fully develop the mathematical equations needed for the formulation.	1	Develops fully the mathematical equations needed for the formulation though with minor errors.	2	Correctly and fully develops all mathematical equations needed for the formulation.	3	83.3%		
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.		Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	1	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	2	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	3	83.3%		
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.		Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.		Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	3	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	3			

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Hoekstra**		
CRN:	493	**# Students:**	**20**		
TITLE:	Plastics Senior Project Implementation			**Term:**	**S22**
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify (C1) appropriate principles of engineering, science and mathematics needed to solve a complex engineering problem.**	Fails to identify any principles that are revelant to the problem.	0	Fails to identify one or more major principles which will prevent proper formulation of the problem.	0	Identifies all major principles, though a minor misinterpretation will result in an incorrect solution to the problem.	11	Correctly identifies all relevant principles needed to formate and solve the problem.	9	100.0%	PCE 493 Final Report	Move to PCE 492 to assess this PI
2	**formulate (C2) a complex engineering problem using appropriate visual abstractions that capture the physical situation.**	Fails to include a visual abstraction needed for the formulation.	0	Fails to include important details or provide sufficient clarity in the visual abstraction needed for the formulation.	0	Includes required information though clarity can be improved in the visual abstraction needed for the formulation.	16	Correctly and clearly includes all required information in the visual abstraction needed for formulation.	4	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.
3	**formulate (C2) a complex engineering problem using appropriate mathematical equations that capture the physical situation.**	Fails to develop any mathematical equations needed for the formulation.	0	Fails to fully develop the mathematical equations needed for the formulation.	0	Develops fully the mathematical equations needed for the formulation though with minor errors.	14	Correctly and fully develops all mathematical equations needed for the formulation.	6	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.
4	**solve (C3) a complex engineering problem utilizing appropriate mathematical methods and available technologies.**	Fails to apply any method or available technology to solve the problem.	0	Fails to utilize the most approriate mathematical methods and available technologies arriving at an incorrect solution.	0	Utilizes an appropriate mathematical method or available technology but does not arrive at the correct solution.	0	Correctly utilizes the most appropriate mathematical method or available technology to arrive at the correct solution.	20	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.
5	**evaluate (C3) a derived solution to verify its veracity and explain inconsistencies and discrepancies when they occur.**	Fails to perform any evaluation of a derived solution for veracity.	0	Fails to provide any explanations for inconsistencies and discrepancies found when evaluating a solution.	0	Verifies the veracity of a solution but explanations for inconsistencies and discrepancies need to be better articulated.	12	Correctly verifies the solution and provides clear and accurate expanations for any inconsistencies and discrepancies that have occurred.	8	100.0%	PCE 493 Final Report	Not all projects involve the development or verificaion of equations or methods. Consider alternative assignments for assessing this PI or consider rewriting the PI to better reflect the application of engineering/science/mathematics in the capstone project.

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Outcome 2

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:			
CRN:		# Students:			
TITLE:				Term:	F18

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (c), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**<u>execute (C3)</u> a logical and orderly design process to arrive at a solution.**	Fails to execute a logical and orderly design process.		Omits or improperly executes a major step of the design process.		Executes each step of the design process but improvements in the logic and order applied are possible.	13	Executes each step of the design process in a logical and orderly fashion.	13	100.0%	Final proposal for PCE 492	
2	**<u>identify (C1)</u> and <u>quantify (C2)</u> relevant customer requirements that include both performance targets and realistic constraints.**	Fails to identify and quantify relevant customer requirements.		Identifies most relevant customer requirements but does not adequately quantify the majority of these.		Identifies all relevant customer requirements but improvements are possible in how some have been quantified.	8	Identifies and meaningfully quantifies all relevant customer requirements .	18	100.0%	Final proposal for PCE 492	
3	**<u>identify (C1)</u> and attempt to <u>integrate (C2)</u> consideration of public health, safety and welfare into the final solution.**	Fails to identify any public health, safety and welfare considerations.	1	Identifies some important public health, safety and welfare considerations but does not integrate any into the final solution.		Identifies all important public health, safety and welfare considerations and integrates some of these into the final solution.	17	Identifies all important public health, safety and welfare considerations and broadly integrates these into the final solution.	8	96.2%	Final proposal for PCE 492	
4	**<u>identify (C1)</u> and attempt to <u>integrate (C2)</u> consideration of global, cultural, social, environmental and economic factors into the final solution.**	Fails to identify any global, cultural, social, environmental or economic considerations.	1	Identifies some important global, cultural, social, environmental or economic considerations but none are integrated into the final solution.	14	Identifies all important global, cultural, social, environmental or economic considerations and integrates some of these into the final solution.	11	Identifies all important global, cultural, social, environmental or economic considerations and broadly integrates these into the final solution.	0	42.3%	Final proposal for PCE 492	The majority of students were able to identify <u>most</u> of the important considerations and incorporate <u>some</u> of these into the final solution. This is not an option for this rubric so these students were scored at Developing. Often, incorporating these considerations into their project is outside of the project scope.
5	**<u>create (C3)</u> a final solution that satisfies all requirements identified in formulating the design problem.**	Fails to create a final solution that meets any of the identified requirements.		Creates a final solution but does not meet several important requirements.	2	Creates a final solution that meets most of the important requirements that have been identified.	8	Creates a final solution that meets all of the important requirements that have been identified.	16	92.3%	Final proposal for PCE 492	
6	**<u>justify (C3)</u> decisionmaking through <u>analysis (C3)</u> of the solution (intermediate and final) using appropriate engineering and/or scientific principles.**	Fails to justify decisionmaking through appropriate analyses at any stage of the process.		Justifies decisionmaking but inconsistently and often through the use of inappropriate analyses.		Justifies decisionmaking through appropriateness analyses for most stages of the process.	13	Justifies decisionmaking at all stages of the process through the use of the most appropriate analyses.	13	100.0%	Final proposal for PCE 492	

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Hoekstra						
CRN:	492	# Students:	21						
TITLE:	Plastics Capstone Proposal					Term:	W22		
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.								

RUBRIC

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (c), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**execute (C3) a logical and orderly design process to arrive at a solution.**	Fails to execute a logical and orderly design process.	0	Omits or improperly executes a major step of the design process.	0	Executes each step of the design process but improvements in the logic and order applied are possible.	3	Executes each step of the design process in a logical and orderly fashion.	18	100.0%	Final proposal for PCE 492 - project plan section	
2	**identify (C1) and quantify (C2) relevant customer requirements that include both performance targets and realistic constraints.**	Fails to identify and quantify relevant customer requirements.	0	Identifies most relevant customer requirements but does not adequately quantify the majority of these.	0	Identifies all relevant customer requirements but improvements are possible in how some have been quantified.	7	Identifies and meaningfully quantifies all relevant customer requirements .	14	100.0%	Final proposal for PCE 492 - specifications section	
3	**identify (C1) and attempt to integrate (C2) consideration of public health, safety and welfare into the final solution.**	Fails to identify any public health, safety and welfare considerations.	2	Identifies some important public health, safety and welfare considerations but does not integrate any into the final solution.	0	Identifies all important public health, safety and welfare considerations and integrates some of these into the final solution.	3	Identifies all important public health, safety and welfare considerations and broadly integrates these into the final solution.	16	90.5%	Final proposal for PCE 492 - ethical impacts section	
4	**identify (C1) and attempt to integrate (C2) consideration of global, cultural, social, environmental and economic factors into the final solution.**	Fails to identify any global, cultural, social, environmental or economic considerations.	2	Identifies some important global, cultural, social, environmental or economic considerations but none are integrated into the final solution.	0	Identifies all important global, cultural, social, environmental or economic considerations and integrates some of these into the final solution.	3	Identifies all important global, cultural, social, environmental or economic considerations and broadly integrates these into the final solution.	16	90.5%	Final proposal for PCE 492 - ethical impacts section	The majority of students were able to identify all of the important considerations and incorporate some of these into the final solution. This is not an option for this rubric. Often, incorporating these considerations into their project is outside of the project scope.
5	**create (C3) a final solution that satisfies all requirements identified in formulating the design problem.**	Fails to create a final solution that meets any of the identified requirements.	0	Creates a final solution but does not meet several important requirements.	0	Creates a final solution that meets most of the important requirements that have been identified.	3	Creates a final solution that meets all of the important requirements that have been identified.	18	100.0%	Final proposal for PCE 492 - project plan section	
6	**justify (C3) decisionmaking through analysis (C3) of the solution (intermediate and final) using appropriate engineering and/or scientific principles.**	Fails to justify decisionmaking through appropriate analyses at any stage of the process.	0	Justifies decisionmaking but inconsistently and often through the use of inappropriate analyses.	0	Justifies decisionmaking through appropriateness analyses for most stages of the process.	7	Justifies decisionmaking at all stages of the process through the use of the most appropriate analyses.	14	100.0%	Final proposal for PCE 492 - decision matrices section	

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	Hoekstra
CRN:	492	**# Students:**	21
TITLE:	Plastics Capstone Proposal	**Term:**	W22

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (c), (k implied)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**execute (C3) a logical and orderly design process to arrive at a solution.**	Fails to execute a logical and orderly design process.		Omits or improperly executes a major step of the design process.		Executes each step of the design process but improvements in the logic and order applied are possible.	Ben Derek Will	Executes each step of the design process in a logical and orderly fashion.	Jake Tanner Alec Juliana Keegan Jason David Justin Sander Keaton Bradley Kyle Chris Hadrian Zeke Jon Travis Kole		Final proposal for PCE 492 - project plan section	
2	**identify (C1) and quantify (C2) relevant customer requirements that include both performance targets and realistic constraints.**	Fails to identify and quantify relevant customer requirements.		Identifies most relevant customer requirements but does not adequately quantify the majority of these.		Identifies all relevant customer requirements but improvements are possible in how some have been quantified.	Keegan Zeke Jason David Ben Derek Will	Identifies and meaningfully quantifies all relevant customer requirements .	Jake Tanner Alec Kyle Juliana Chris Bradley Hadrian Jon Travis Kole Justin Keaton Sander		Final proposal for PCE 492 - specifications section	
3	**identify (C1) and attempt to integrate (C2) consideration of public health, safety and welfare into the final solution.**	Fails to identify any public health, safety and welfare considerations.	Derek Ben	Identifies some important public health, safety and welfare considerations but does not integrate any into the final solution.		Identifies all important public health, safety and welfare considerations and integrates some of these into the final solution.	Sander Justin Keaton	Identifies all important public health, safety and welfare considerations and broadly integrates these into the final solution.	Jake Tanner Alec Juliana Keegan Jason David Bradley Kyle Chris Hadrian Zeke Jon Travis Kole Will		Final proposal for PCE 492 - ethical impacts section	
4	**identify (C1) and attempt to integrate (C2) consideration of global, cultural, social, environmental and economic factors into the final solution.**	Fails to identify any global, cultural, social, environmental or economic considerations.	Derek Ben	Identifies some important global, cultural, social, environmental or economic considerations but none are integrated into the final solution.		Identifies all important global, cultural, social, environmental or economic considerations and integrates some of these into the final solution.	Sander Justin Keaton	Identifies all important global, cultural, social, environmental or economic considerations and broadly integrates these into the final solution.	Jake Tanner Alec Juliana Keegan Jason David Bradley Kyle Chris Hadrian Zeke Jon Travis Kole Will		Final proposal for PCE 492 - ethical impacts section	The majority of students were able to identify all of the important considerations and incorporate some of these into the final solution. This is not an option for this rubric. Often, incorporating these considerations into their project is outside of the project scope.
5	**create (C3) a final solution that satisfies all requirements identified in formulating the design problem.**	Fails to create a final solution that meets any of the identified requirements.		Creates a final solution but does not meet several important requirements.		Creates a final solution that meets most of the important requirements that have been identified.	Ben Derek Will	Creates a final solution that meets all of the important requirements that have been identified.	Jake Tanner Alec Juliana Keegan Jason David Justin Sander Keaton Bradley Kyle Chris Hadrian Zeke Jon Travis Kole		Final proposal for PCE 492 - project plan section	
6	**justify (C3) decisionmaking through analysis (C3) of the solution (intermediate and final) using appropriate engineering and/or scientific principles.**	Fails to justify decisionmaking through appropriate analyses at any stage of the process.		Justifies decisionmaking but inconsistently and often through the use of inappropriate analyses.		Justifies decisionmaking through appropriateness analyses for most stages of the process.	Keegan Zeke Jason David Ben Derek Will	Justifies decisionmaking at all stages of the process through the use of the most appropriate analyses.	Jake Tanner Alec Kyle Juliana Chris Bradley Hadrian Jon Travis Kole Justin Keaton Sander		Final proposal for PCE 492 - decision matrices section	

Bloom's Taxonomy
C1 - Level 1 (Remember)
C2 - Level 2 (Understand)
C3 - Level 3 (Apply, Analyze, Evaluate, Create)

Outcome 3

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:	Peyron		
CRN:		# Students:	6		
TITLE:				Term:	S21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

3. an ability to communicate effectively with a range of audiences (g)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	make effective use of available communication methods and tools	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.		The choice of methods and tools is appropriate, but improvements are possible in their use.	4	Selection and use of methods and tools is highly effective.	2	100.0%		
2	communicate in an organized and concise manner	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.	1	Small improvements in structure, logic, brevity and ease of comprehension are possible.	4	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	1	83.3%		
3	communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	4	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	2	100.0%		
4	communicate using content and style appropriate to the audience.	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.		Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	5	The content and style are ideally suited to engaging the target audience.	1	100.0%		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Misasi			
CRN:		# Students:	7			
TITLE:	Senior Project Implementation			Term:	S21	
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.					

RUBRIC

3. an ability to communicate effectively with a range of audiences (g)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
											80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report and final presentation
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.	2	The choice of methods and tools is appropriate, but improvements are possible in their use.	2	Selection and use of methods and tools is highly effective.	3	71.4%		
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.	2	Small improvements in structure, logic, brevity and ease of comprehension are possible.	5	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.		71.4%		
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	5	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	2	100.0%		
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.	2	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	2	The content and style are ideally suited to engaging the target audience.	3	71.4%		

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:	Hoekstra									
CRN:		# Students:	7									
TITLE:						Term:	S21					
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.											

RUBRIC

	3. an ability to communicate effectively with a range of audiences (g)										80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.		The choice of methods and tools is appropriate, but improvements are possible in their use.		Selection and use of methods and tools is highly effective.	Will, Anna, Josh, Eli, Kai, Evan, Kevin			
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.		Small improvements in structure, logic, brevity and ease of comprehension are possible.	Will, Anna, Josh, Eli, Kai, Evan	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	Kevin			
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.	Eli	Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	Will, Anna, Josh, Kai, Evan	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	Kevin			
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.	Eli	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	Will, Anna, Josh, Kai, Evan	The content and style are ideally suited to engaging the target audience.	Kevin			

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Hoekstra		
CRN:	23477	# Students:	6		
TITLE:	Plastics Capstone Project - Implementation			Term:	S19
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

3. an ability to communicate effectively with a range of audiences (g)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.		The choice of methods and tools is appropriate, but improvements are possible in their use.	3	Selection and use of methods and tools is highly effective.	3	100.0%		
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.		Small improvements in structure, logic, brevity and ease of comprehension are possible.	3	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	3	100.0%		
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	3	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	3	100.0%		
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.		Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	3	The content and style are ideally suited to engaging the target audience.	3	100.0%		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Larson		
CRN:		# Students:	8		
TITLE:	PCE 493 - Senior Project Implementation			Term:	F18
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

3. an ability to communicate effectively with a range of audiences (g)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.	2	The choice of methods and tools is appropriate, but improvements are possible in their use.	9	Selection and use of methods and tools is highly effective.	8	89.5%		
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.	2	Small improvements in structure, logic, brevity and ease of comprehension are possible.	9	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	8	89.5%		
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	11	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	7	100.0%		
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.	1	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	10	The content and style are ideally suited to engaging the target audience.	7	94.4%		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Larson**		
CRN:		**# Students:**	**8**		
TITLE:	PCE 493 - Senior Project Implementation			**Term:**	**F18**
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

	3. an ability to communicate effectively with a range of audiences (g)										80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
	Performance Indicator (Student has the ability to .....)	**Unsatisfactory**	**Result**	**Developing**	**Result**	**Satisfactory**	**Result**	**Exemplary**	**Result**	**Overall Result**	**Description of Assessment Methodology and Student Samples to be Collected**	**Describe Any Mitigating Factors Impacting the Overall Result**
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.	2	The choice of methods and tools is appropriate, but improvements are possible in their use.	9	Selection and use of methods and tools is highly effective.	8	**89.5%**		
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.	2	Small improvements in structure, logic, brevity and ease of comprehension are possible.	9	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	8	**89.5%**		
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	11	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	7	**100.0%**		
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.	1	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	10	The content and style are ideally suited to engaging the target audience.	7	**94.4%**		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	Instructor:	Combined						
CRN:		# Students:	26						
TITLE:					Term:	S21			
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.								

RUBRIC

											80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
	3. an ability to communicate effectively with a range of audiences (g)											
	Performance Indicator (Student has the ability to .....)	**Unsatisfactory**	**Result**	**Developing**	**Result**	**Satisfactory**	**Result**	**Exemplary**	**Result**	**Overall Result**	**Description of Assessment Methodology and Student Samples to be Collected**	**Describe Any Mitigating Factors Impacting the Overall Result**
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.	2	The choice of methods and tools is appropriate, but improvements are possible in their use.	9	Selection and use of methods and tools is highly effective.	15	92.3%	Final presentation, report, and virtual poster were used for all assessment.	
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.	3	Small improvements in structure, logic, brevity and ease of comprehension are possible.	18	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	5	88.5%		
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	18	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	8	100.0%		
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.	2	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	16	The content and style are ideally suited to engaging the target audience.	8	92.3%		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	Instructor:	Larson	
CRN:		# Students:	5	
TITLE:				Term: S21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

3. an ability to communicate effectively with a range of audiences (g)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.		The choice of methods and tools is appropriate, but improvements are possible in their use.	3	Selection and use of methods and tools is highly effective.	3	100.0%	Final presentation, report, and virtual poster were used for all assessment.	
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.		Small improvements in structure, logic, brevity and ease of comprehension are possible.	3	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	3	100.0%		
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	3	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	3	100.0%		
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.		Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	3	The content and style are ideally suited to engaging the target audience.	3	100.0%		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 492	Instructor:	Hoekstra		
CRN:		# Students:	27		
TITLE:	Plastics Capstone Project Proposal			Term:	F18
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

3. an ability to communicate effectively with a range of audiences (g)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.		The choice of methods and tools is appropriate, but improvements are possible in their use.	14	Selection and use of methods and tools is highly effective.	13	100.0%	Final Proposal and Final Presentation	
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.		Small improvements in structure, logic, brevity and ease of comprehension are possible.	14	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	13	100.0%	Final Proposal and Final Presentation	
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.	2	Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	12	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	13	92.6%	Final Proposal and Final Presentation	
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.	2	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	12	The content and style are ideally suited to engaging the target audience.	13	92.6%	Final Proposal and Final Presentation	

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Hoekstra									
CRN:	493	# Students:	20									
TITLE:	Plastics Capstone Implementation					Term:	S22					
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.											

RUBRIC

3. an ability to communicate effectively with a range of audiences (g)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
											80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.	0	Better methods and tools are available, or use of the ones selected is ineffective.	0	The choice of methods and tools is appropriate, but improvements are possible in their use.	9	Selection and use of methods and tools is highly effective.	11	100.0%	PCE 493 Final Report, Final Presentation, Poster	
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.	0	Some structure. Weak in logic, brevity and ease of comprehension.	0	Small improvements in structure, logic, brevity and ease of comprehension are possible.	10	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	10	100.0%	PCE 493 Final Report, Final Presentation, Poster	
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards	0	Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.	0	Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	9	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	11	100.0%	PCE 493 Final Report, Final Presentation, Poster	
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.	0	Either the content or style is inappropriate, but not both.	0	Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	15	The content and style are ideally suited to engaging the target audience.	5	100.0%	PCE 493 Final Report, Final Presentation, Poster	

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Hoekstra					
CRN:	493	# Students:	20					
TITLE:	Plastics Capstone Implementation				Term:	S22		
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.							

RUBRIC

	3. an ability to communicate effectively with a range of audiences (g)										80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**make effective use of available communication methods and tools**	Fails to identify and make proper use of available methods and tools.		Better methods and tools are available, or use of the ones selected is ineffective.		The choice of methods and tools is appropriate, but improvements are possible in their use.	Chris Kyle Ben Derek Bradley Hadrian Travis Kole Jon	Selection and use of methods and tools is highly effective.	Tanner Jake Juliana Alec Keaton Sander Justin David Jason Keegan Will		PCE 493 Final Report, Final Presentation, Poster	
2	**communicate in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of comprehension.		Some structure. Weak in logic, brevity and ease of comprehension.		Small improvements in structure, logic, brevity and ease of comprehension are possible.	Chris Kyle Ben Derek Bradley Hadrian Will Travis Kole Jon	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	Tanner Jake Juliana Alec Keaton Sander Justin David Jason Keegan		PCE 493 Final Report, Final Presentation, Poster	
3	**communicate with professionalism including, proper usage of grammar, correct spelling, and adherence to relevant standards.**	Lacks professionalism and demonstrates poor grammar and spelling; Ignores all relevant standards		Lacks professionalism, or demonstrates poor grammar and spelling, but not both; Usage of relevant standards is incomplete and with major errors.		Professionalism is adequate, but there is room for small improvements in grammar and spelling; All relevant standards have been used with some minor errors present.	Chris Kyle Will Keaton Samder Justin Travis Kole Jon	Highly professional in all aspects, with a strong command of grammar and spelling; All relevant standards are applied without error.	Bradley Hadrian Ben Derek Tanner Jake Alec Juliana David Jason Keegan		PCE 493 Final Report, Final Presentation, Poster	
4	**communicate using content and style appropriate to the audience.**	Both content and style are highly inappropriate.		Either the content or style is inappropriate, but not both.		Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	Chris Kyle Ben Derek Bradley Hadrian Tanner Jake Will Travis Kole Jon David Jason Keegan	The content and style are ideally suited to engaging the target audience.	Juliana Alec Keaton Sander Justin		PCE 493 Final Report, Final Presentation, Poster	

Outcome 4

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 491	**Instructor:**	**Larson**			
CRN:		**# Students:**	**20**			
TITLE:			**Term:**	**Fall 2018**		

Instructions: - Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (f, h, j)	Target	Comments
	80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**recognize and articulate ethical and professional responsibilities in engineering situations**	Consistently fails to recognize or practice ethical and professional responsibilities		Recognizes and practices only the important ethical and professional responsibilities, and is unable to articulate the ethical reasoning that guides behavior.		Occasionally fails to recognize or practice an ethical and professional responsibilities, occasionally cannot articulate the proper ethical reasoning that guides behavior.	14	Recognizes and practices all ethical and professional responsibilities, can always clearly articulate the ethical reasoning that guides behavior.	6	100.0%	Ethics Presentation for all PI	
2	**gather, validate and analyze information from multiple relevant sources, on the potential impact of an engineering solution**	Fails to gather meaningful information from any relevant sources.		Significant information sources have been overlooked, and the validation, analysis or both are missing or weak.	1	In-depth validation and analysis has been completed on some relevant sources, but other important sources have been overlooked.	13	Information has been gathered from a broad set of relevant sources, validation and analysis has been completed and is of a high quality.	6	95.0%		
3	**make informed judgements supported by analysis of the societal and global impact of engineering solutions**	Fails to offer any informed judgements of the societal and global impact.		Judgements are made but are either incorrect or poorly supported by the analysis provided.	4	Judgements are correct and to a large extent supported by the analysis, but the rationale presented could be stronger.	11	Judgements are correct and a strong rationale is presented that is clearly supported by the analysis.	5	80.0%		
4	**make informed judgements supported by analysis of the economic and environmental impact of engineering solutions**	Fails to offer any informed judgements of the economic and environmental impact.	2	Judgements are made but are either incorrect or poorly supported by the analysis provided.	2	Judgements are correct and to a large extent supported by the analysis, but the rationale presented could be stronger.	10	Judgements are correct and a strong rationale is presented that is clearly supported by the analysis.	6	80.0%		

Outcome 5

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Hoekstra**
CRN:	461	**# Students:**	**25**
TITLE:	Tooling for Plastics Processing	**Term:**	**S21**
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.		

RUBRIC

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (d)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**function effectively in providing team leadership.**	Fails to demonstrate any leadership abilities.	Molly, Nik	Demonstrates leadership abilities only as part of a shared responsibility.	Chris, Evan	Demonstrates independent leadership skills.	16	Demonstrates both strong independent leadership skills and the ability to delegate responsibilities to others.	Ellsion, Kevin, Josh, Jacob, Mac	84.0%	Teamwork evaluation form from students along with weekly observations by instructor	
2	**promote a collaborative and inclusive environment that supports effective teamwork.**	Demonstrates attitudes that obstruct collaboration and that exclude contributions from other team members.	Molly	Demonstrates tendencies to want to work alone and is reluctant to accept contributions from other team members.	Nik	Willingly collaborates on assigned team activities and is receptive to the contributions of others.	18	Actively encourages collaboration and contributions from all team members across all team activities.	Ellsion, Kevin, Josh, Jacob, Mac	92.0%	Teamwork evaluation form from students along with weekly observations by instructor	
3	**share in planning and setting goals for the team.**	Lacks knowledge of the team's plan and goals.	Molly, Nik	Is knowledgeable of the plan and goals but contributes little to developing them.	Chris, Evan	Willingly participates in planning and goal setting.	14	Assumes responsibility for planning and goal setting.	Ellsion, Kevin, Josh, Jacob, Mac	84.0%	Teamwork evaluation form from students along with weekly observations by instructor	
4	**share in the work of the team.**	Always relies on others to do the work		Rarely does the assigned work – often needs reminding	Molly	Usually does the work assigned – rarely needs reminding	19	Always does the assigned work without having to be reminded	Ellsion, Kevin, Josh, Jacob, Mac	96.0%	Teamwork evaluation form from students along with weekly observations by instructor	
5	**complete assigned tasks in a timely fashion**	Fails to complete any assigned task on schedule.	Molly	Inconsistent in completing assigned tasks on schedule.	Robbie, Kai, Eli	Completes most of the assigned tasks on schedule.	16	Completes all tasks on time or ahead of schedule.	Ellsion, Kevin, Josh, Jacob, Mac	84.0%	Teamwork evaluation form from students along with weekly observations by instructor	

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Hoekstra		
CRN:	461	# Students:	20		
TITLE:	Tooling for Plastics Processing			Term:	S22
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (d)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**function effectively in providing team leadership.**	Fails to demonstrate any leadership abilities.	0	Demonstrates leadership abilities only as part of a shared responsibility.	3	Demonstrates independent leadership skills.	8	Demonstrates both strong independent leadership skills and the ability to delegate responsibilities to others.	9	85.0%	Teamwork evaluation form from students along with weekly observations by instructor	
2	**promote a collaborative and inclusive environment that supports effective teamwork.**	Demonstrates attitudes that obstruct collaboration and that exclude contributions from other team members.	0	Demonstrates tendencies to want to work alone and is reluctant to accept contributions from other team members.	3	Willingly collaborates on assigned team activities and is receptive to the contributions of others.	8	Actively encourages collaboration and contributions from all team members across all team activities.	9	85.0%	Teamwork evaluation form from students along with weekly observations by instructor	
3	**share in planning and setting goals for the team.**	Lacks knowledge of the team's plan and goals.	0	Is knowledgeable of the plan and goals but contributes little to developing them.	3	Willingly participates in planning and goal setting.	8	Assumes responsibility for planning and goal setting.	9	85.0%	Teamwork evaluation form from students along with weekly observations by instructor	
4	**share in the work of the team.**	Always relies on others to do the work	0	Rarely does the assigned work – often needs reminding	2	Usually does the work assigned – rarely needs reminding	9	Always does the assigned work without having to be reminded	9	90.0%	Teamwork evaluation form from students along with weekly observations by instructor	
5	**complete assigned tasks in a timely fashion**	Fails to complete any assigned task on schedule.	0	Inconsistent in completing assigned tasks on schedule.	3	Completes most of the assigned tasks on schedule.	8	Completes all tasks on time or ahead of schedule.	9	85.0%	Teamwork evaluation form from students along with weekly observations by instructor	

Outcome 6

Student Outcomes Assessment - Course Data Feedback Form

PROG:		Instructor:					
CRN:		# Students:	25				
TITLE:					Term:	W21	

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

Target	Comments

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (b), (k implied)

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
										80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	all data taken from final report
1	**select and operate appropriate process equipment and instruments to perform necessary experiments. (lab-based classes only)**	Unprepared for lab; does not operate instruments and process equipment properly; requires excessive supervision.	3	Generally follows proper lab procedures; requires significant supervision to operate instruments and process equipment.	7	Attentive to safety procedures and proper operation of instruments and process equipment; requires little supervision.	6	Very prepared and organized; attentive to safety procedures and proper operation of instruments and process equipment; requires minimal supervision.	9	60.0%	Process Plan	Covid 19 made this outcome challenging to assess - lab access was restricted and students were not able to make these decisions on their own
2	**apply appropriate experimental design principles.**	Design of experiments is inadequate.	3	Planned experiments are not complete.	2	Experimental design is fairly complete.	11	Experimental design is complete.	9	80.0%	DOE plan and Final report	
3	**apply appropriate statistical analyses to produce professional quality technical work.**	Statistical analysis is incomplete or applied incorrectly.	0	Statistical analysis is fairly complete; Reporting of analysis is not professional quality.	3	Data analysis is fairly complete; professional presentation could be improved.	19	Statistical analysis of data is thorough; data are presented in a meaningful and professional manner.	3	88.0%	Final Report	
4	**form conclusions based on empirical evidence and to compare these with researched information or theoretical models.**	Conclusions are incorrect or poorly justified. Presentation of data and results lacks depth and/or is not compared to researched literature.	3	Data and results are generally, interpreted correctly, but written descriptions lack sufficient depth and/or are not compared sufficiently with researched literature.	3	Conclusions are fairly well supported by empirical data; depth of data analysis is acceptable; results are compared to some literature.	16	Results are thoroughly and correctly interpreted and presented; conclusions are supported by appropriate literature sources.	3	76.0%	Final Report	Covid 19 - instrcutor thoroghness may have been lacking

Outcome 7

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	Instructor:	Hoekstra		
CRN:		# Students:	27		
TITLE:	Plastics Capstone Project Proposal			Term:	W21

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.

RUBRIC

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies (i)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**to identify relevant sources of new knowledge.**	Makes no effort to seek out relevant sources.		Conducts a background study but fails to identify and verify any relevant sources.		Background study identifies and verifies most but not all relevant sources.	14	Background study is comprehensive in identifying and verifying all relevant sources.	13	100.0%	Background of Project Proposal	
2	**use an approriate learning strategy to acquire new knowledge.**	Is unable to demonstrate learning from a verified source.		The adopted strategy leads to superficial or improper learning.		The adopted strategy leads to learning that is adequate for the need.		The adopted strategy leads to mastery of the new knowledge.			This has to be accessed in PCE 493	
3	**apply newly acquired knowledge to problem solving.**	Is unable to apply newly acquired knowledge to problem solving.		The newly acquired knowledge is partially or incorrectly applied leading to erroneous results and conclusions.		The newly acquired knowledge is correctly applied, but veracity of results and conclusions need further verification.		The newly acquired knowledge is correctly applied and results and conclusions verified.			This has to be accessed in PCE 493	

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 493	Instructor:	Combined		
CRN:		# Students:	26		
TITLE:				Term:	S21
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold.				

RUBRIC

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies (i)

80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

all data taken from final report

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**to identify relevant sources of new knowledge.**	Makes no effort to seek out relevant sources.		Conducts a background study but fails to identify and verify any relevant sources.		Background study identifies and verifies most but not all relevant sources.		Background study is comprehensive in identifying and verifying all relevant sources.				
2	**use an approriate learning strategy to acquire new knowledge.**	Is unable to demonstrate learning from a verified source.		The adopted strategy leads to superficial or improper learning.		The adopted strategy leads to learning that is adequate for the need.	16	The adopted strategy leads to mastery of the new knowledge.	10	100.0%	Assessment taken from final report, final presentation, and reflective statement	
3	**apply newly acquired knowledge to problem solving.**	Is unable to apply newly acquired knowledge to problem solving.		The newly acquired knowledge is partially or incorrectly applied leading to erroneous results and conclusions.	1	The newly acquired knowledge is correctly applied, but veracity of results and conclusions need further verification.	15	The newly acquired knowledge is correctly applied and results and conclusions verified.	10	96.2%	Assessment taken from final report, final presentation, and reflective statement	

Outcome a

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Tanveer Singh Chawla**	
CRN:	42259	**# Students:**	**21**	
TITLE:	PCE 472	**Term:**	**Fall 2017**	

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.
- Include a description of the Assessment Methodology used for each performance indicator.
- Student samples of work showing high, middle and low scores need to be collected.

RUBRIC

(a) an ability to apply knowledge of mathematics, science, and engineering

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**define the problem and outline a strategy to solve it**	Does not define the problem or outline a road map		Attempts to define the problem and solving strategy but not completely		Supplies a basic definition of the problem and a simple strategy to solve it	18	Defines the problem completely and lays out a complete road map to solve it	3		100.0%	Assessed from Final Exam, Quiz 2 and a HW.	
2	**include visual sketches to describe the physical situation given in the problem**	Does not include visual sketches/models or describe physical situation given in the problem		Visual sketches/models and description of the physical situation are incomplete	3	Visual sketches/models and description of the physical situation are complete most of the time	15	Complete visual sketches/models and description of the physical situation are always given	3		85.7%	Assessed from Final Exam.	
3	**develop appropriate equations required to solve problem**	Is incapable of developing required equations		Does list some of the required equations	2	Is able to develop necessary equations most of the time	15	Is always able to develop the equations and justify them	4		90.5%	Assessed from Final Exam and Quiz 2.	
4	**use correct mathematical tools to solve the generated equations**	Is not able to solve the equations or use mathematical tools correctly		Uses correct mathematical tools but does not get correct answers usually	2	Solves the equations using appropriate mathematical tools and gets correct answer most of the time	15	Uses appropriate mathematical tools and gets correct answer every time	4		90.5%	Assessed from Final Exam and Quiz 2.	
5	**use knowledge of engineering to verify solutions and/or discuss them**	Cannot verify solution and/or discuss it		Verifies and/or discusses part of the solution	2	Verifies the solution and/or discusses it logically most of the time	17	Always verifies the solution and/or has a valid explanation	2		90.5%	Assessed from Final Exam, Quiz 2 and a HW.	

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome b

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 431	**Instructor:**	Misasi		
CRN:		**# Students:**	22		
TITLE:	Advanced Materials and Processes		**Term:**	Winter 2018	
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold. - Include a description of the Assessment Methodology used for each performance indicator. - Student samples of work showing high, middle and low scores need to be collected.				

RUBRIC

(b) an ability to design and conduct experiments and to analyze and interpret data

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**select and operate appropriate process equipment and instruments to perform necessary experiments. (lab-based classes only)**	Unprepared for lab; does not operate instruments and process equipment properly; requires excessive supervision.	0	Generally follows proper lab procedures; requires significant supervision to operate instruments and process equipment.	3	Attentive to safety procedures and proper operation of instruments and process equipment; requires little supervision.	3	Very prepared and organized; attentive to safety procedures and proper operation of instruments and process equipment; requires minimal supervision.	13		84.2%	Control and Processing Procedures and Results (from the quarter long materials and process development project)	Group-based project where students were graded in 2-3 person teams, not individually
2	**apply appropriate experimental design principles.**	Design of experiments is inadequate.	0	Planned experiments are not complete.	3	Experimental design is fairly complete.	8	Experimental design is complete.	8		84.2%	DOE Set-Up and Plan (from the quarter long materials and process development project)	Group-based project where students were graded in 2-3 person teams, not individually
3	**apply appropriate statistical analyses to produce professional quality technical work.**	Statistical analysis is incomplete or applied incorrectly.	0	Statistical analysis is fairly complete; Reporting of analysis is not professional quality.	6	Data analysis is fairly complete; professional presentation could be improved.	5	Statistical analysis of data is thorough; data are presented in a meaningful and professional manner.	8		68.4%	Final Project Report (from the quarter long materials and process development project)	Group-based project where students were graded in 2-3 person teams, not individually
4	**form conclusions based on empirical evidence and to compare these with researched information or theoretical models.**	Conclusions are incorrect or poorly justified. Presentation of data and results lacks depth and/or is not compared to researched literature.	0	Data and results are generally, interpreted correctly, but written descriptions lack sufficient depth and/or are not compared sufficiently with researched literature.	3	Conclusions are fairly well supported by empirical data; depth of data analysis is acceptable; results are compared to some literature.	8	Results are thoroughly and correctly interpreted and presented; conclusions are supported by appropriate literature sources.	8		84.2%	Final Project Report (from the quarter long materials and process development project)	Group-based project where students were graded in 2-3 person teams, not individually

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome c

Student Outcomes Assessment - Course Data Feedback Form

PROG:		**Instructor:**	**Larson**
CRN:		**# Students:**	**28**
TITLE:		**Term:**	W20

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.
- Include a description of the Assessment Methodology used for each performance indicator.
- Student samples of work showing high, middle and low scores need to be collected.

RUBRIC

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identify and follow a logical and orderly design process.**	No discernable effort made to identify or follow a procedure. Haphazard approach taken.	1	Requires significant guidance in identifying, understanding and following a proper procedure.	4	Needs some minimal help in identifying the procedure, understanding steps and staying on track.	21	Works independently throughout. Correctly identifies the procedure, and executes with a high level of understanding.	2		82.1%	final proposal report grade	
2	**create quantified goals that include both targets and constraints.**	Cannot Develop a complete List of Objectives, Functions, or Constraints		Cannot Quantify Objectives, Functions, or Constraints into Specifications	0	Partially Quantifies Objectives, Functions, or Constraints into Specifications	8	Quantifies and Justifies Every Appropriate Objective, Function, and Constraint into a Specification	20		100.0%	final problem development grade	
3	**systematically develop, compare and rank design alternatives to arrive at a final solution.**	Only considers one design option.		Several alternatives are developed. But a systematic comparison and ranking has not been attempted or is poorly justified.	3	A systematic comparison and ranking of alternatives has been performed. Some dispute about final solution may exist.	13	A systematic comparison and ranking of alternatives has been performed. Final solution is undisputed.	12		89.3%	final approach grade	
4	**create a final solution that satisfies all requirements and constraints identified in formulating the design problem.**	Identification of requirements and constraints in formulating the problem is missing or inadequate.	4	The final solution does not satisfy many of the design problem's requirements and constraints.	2	The final solution satisfies most though not all of the design problem's requirements and constraints.	17	The final solution satisfies all of the design problem's requirements and constraints.	5		78.6%	analyze proposed solution section of proposal report	
5	**justify design decisions using analyses based on appropriate engineering and/or scientific principles.**	No analysis of design decisions performed.		Applies principles incompletely or incorrectly in many cases. Some decisions are not justified.	3	Applies principles correctly for major design decisions. One or two minor decisions may be overlooked.	13	Consistently applies the correct principles in justifying all decisions.	12		89.3%	final approach grade	

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

7.1%	75.0%	14.3%	3.6%	100.0%
71.4%	28.6%	0.0%	0.0%	100.0%
42.9%	46.4%	10.7%	0.0%	100.0%
17.9%	60.7%	7.1%	14.3%	100.0%

Outcome d

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Misasi**
CRN:		**# Students:**	
TITLE:	PCE 461	**Term:**	**Spring 2018**

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.
- Include a description of the Assessment Methodology used for each performance indicator.
- Student samples of work showing high, middle and low scores need to be collected.

RUBRIC

(d) an ability to function on multidisciplinary teams

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**negotiate and resolve differences with the other teammates to reach effective solutions**	Is a major contributor to indecision within the team and is unable to take steps to resolve differences.	0	Is not a major contributor to indecision, but has difficulties helping the team negotiate and resolve differences.	1	Is always a willing and compromising participant to efforts aimed at helping the team reach consensus.	9	Is willing to take the lead, and is extremely effective in guiding the team through negotiations that resolve differences.	10		95.0%	Peer Evaluations and Team Assessment	
2	**complete assigned duties in a timely fashion**	Fails to complete any assigned task on schedule.	0	Inconsistent in completing assigned tasks on schedule.	1	Completes most of the assigned tasks on schedule.	9	Completes all tasks on time or ahead of schedule.	10		95.0%	Peer Evaluations and Team Assessment	
3	**share in the work of the team**	Always relies on others to do the work	0	Rarely does the assigned work – often needs reminding	1	Usually does the work assigned – rarely needs reminding	9	Always does the assigned work without having to be reminded	10		95.0%	Peer Evaluations and Team Assessment	
4	**listen and contributing to other teammates**	Is always talking – never allows anyone else to speak	1	Usually doing most of the talking – rarely allows others to speak	1	Listens most of the time	9	Consistently listens and responds to others appropriately	9		90.0%	Team Assessment	Bias during meeting times

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	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome e

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 492	**Instructor:**	**Larson**
CRN:		**# Students:**	**21**
TITLE:		**Term:**	**W18**

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.
- Include a description of the Assessment Methodology used for each performance indicator.
- Student samples of work showing high, middle and low scores need to be collected.

RUBRIC

(e) an ability to identify, formulate, and solve engineering problems

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result					
1	**Identify problems with a quantifiable solution that can be approached systematically.**	Cannot identify any of the key problem elements		Identifies only some the key problem elements	4	Identifies the key problem elements	11	Identifies all of the problem elements	6		81.0%	problem development in final proposal		28.6%	52.4%	19.0%	0.0%	100.0%
2	**Select appropriate methods and techniques for solving the problem.**	Selects a method/technique that is inappropriate for the problem		Selects a method/technique that is appropriate, but not optimal for the problem	6	Selects a method/technique that is appropriate and efficient for the problem	12	Considers multiple options and selects the method(s)/technique(s) that is optimal for the problem	3		71.4%	analyzed proposed solution		14.3%	57.1%	28.6%	0.0%	100.0%
3	**Correctly formulate the problem according to chosen solution method**	Cannot properly set up necessary equations and/or analyses		Properly sets up some, but not all necessary equations and/or analyses	4	Properly sets up necessary equations and/or analyses with minor errors	15	Properly sets up necessary equations and/or analyses without errors	2		81.0%	propose appropriate tools to solve problem		9.5%	71.4%	19.0%	0.0%	100.0%
4	**Select appropriate values, ranges and bounds for variables and correctly use these in the formulation to obtain a solution.**	Selects values, ranges, and bounds for variables that are unrelated to realistic conditions for the problem.		Selects values, ranges, and bounds for variables that are somewhat related to realistic conditions for the problem.	4	Selects values, ranges, and bounds for variables that are realistic conditions for the problem, but are not optimal.	16	Selects values, ranges, and bounds for variables that are optimal for a realistic analysis of the problem.	1		81.0%	propose appropriate testing to evaluate performance		4.8%	76.2%	19.0%	0.0%	100.0%

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 492	**Instructor:**	**Larson**
CRN:		**# Students:**	**20**
TITLE:		**Term:**	**W19**

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.
- Include a description of the Assessment Methodology used for each performance indicator.
- Student samples of work showing high, middle and low scores need to be collected.

RUBRIC

(e) an ability to identify, formulate, and solve engineering problems

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result					
1	**Identify problems with a quantifiable solution that can be approached systematically.**	Cannot identify any of the key problem elements		Identifies only some the key problem elements	4	Identifies the key problem elements	8	Identifies all of the problem elements	8		80.0%	problem development in final proposal		40.0%	40.0%	20.0%	0.0%	100.0%
2	**Select appropriate methods and techniques for solving the problem.**	Selects a method/technique that is inappropriate for the problem		Selects a method/technique that is appropriate, but not optimal for the problem	6	Selects a method/technique that is appropriate and efficient for the problem	10	Considers multiple options and selects the method(s)/technique(s) that is optimal for the problem	4		70.0%	analyzed proposed solution		20.0%	50.0%	30.0%	0.0%	100.0%
3	**Correctly formulate the problem according to chosen solution method**	Cannot properly set up necessary equations and/or analyses		Properly sets up some, but not all necessary equations and/or analyses	4	Properly sets up necessary equations and/or analyses with minor errors	13	Properly sets up necessary equations and/or analyses without errors	3		80.0%	propose appropriate tools to solve problem		15.0%	65.0%	20.0%	0.0%	100.0%
4	**Select appropriate values, ranges and bounds for variables and correctly use these in the formulation to obtain a solution.**	Selects values, ranges, and bounds for variables that are unrelated to realistic conditions for the problem.		Selects values, ranges, and bounds for variables that are somewhat related to realistic conditions for the problem.	4	Selects values, ranges, and bounds for variables that are realistic conditions for the problem, but are not optimal.	14	Selects values, ranges, and bounds for variables that are optimal for a realistic analysis of the problem.	2		80.0%	propose appropriate testing to evaluate performance		10.0%	70.0%	20.0%	0.0%	100.0%

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome f

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 491	**Instructor:**	**Larson**		
CRN:		**# Students:**	**20**		
TITLE:		**Term:**	F17		
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold. - Include a description of the Assessment Methodology used for each performance indicator. - Student samples of work showing high, middle and low scores need to be collected.				

RUBRIC

(f) an understanding of the professional and ethical responsibilities of an engineer

	Performance Indicator (Student has the ability to …..)	**Unsatisfactory**	**Result**	**Developing**	**Result**	**Satisfactory**	**Result**	**Exemplary**	**Result**	**Level**	**Overall Result**	**Description of Assessment Methodology and Student Samples to be Collected**	**Describe Any Mitigating Factors Impacting the Overall Result**
1	**identify important information in an ethical dilemma**	Student Ignores Important Facts		Student Identifies Some Facts		Student Identifies all Important Facts	14	Student Identifies Unknown Facts and Uses their Own Expertise to Add Appropriate Information	6		100.0%		
2	**meaningfully participates in In-Class Discussions and Exercises on Ethics and Professionalism**	Student does not participate or complete exercises on ethics and professionalism		Student input into the discussion and exercises demonstrates a limited understanding.		Student input into the discussion and exercises demonstrates an adequate understanding.		Student input into the discussion and exercises demonstrates a full understanding.					

Target	**Comments**	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome g

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Larson**
CRN:		**# Students:**	**4**
TITLE:	PCE 493	**Term:**	**S18**
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold. - Include a description of the Assessment Methodology used for each performance indicator. - Student samples of work showing high, middle and low scores need to be collected.		

RUBRIC

(g) an ability to communicate effectively

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**making effective use of available methods and tools**	Fails to identify and make proper use of available methods and tools.	1.00	Better methods and tools are available, or use of the ones selected is ineffective.	1	The choice of methods and tools is appropriate, but improvements are possible in their use.	11	Selection and use of methods and tools is highly effective.	8		90.5%	493 final report for all PI	
2	**in an organized and concise manner**	Haphazard and random. Lacks brevity and ease of conprehension.	2	Some structure. Weak in logic, brevity and ease of comprehension.	2	Small improvements in structure, logic, brevity and ease of comprehension are possible.	11	Structure enhances readers understanding. Logic is highly sound. To the point and easy to comprehend.	6		81.0%		
3	**with professionalism including grammar, spelling and usage**	Presentation lacks professionalism, and demonstrates weak language skills.		Either the presentation lacks professionalism, or weak language skills are evident, but not both.	2	Presentation is professional, but there is room for small improvements in language skills.	13	Highly professional in all aspects, with a strong command of the language skills.	6		90.5%		
4	**using content and style appropriate to the audience.**	Both content and style are highly inapproriate.		Either the content or style is inappropriate, but not both.		Both the content and style are appropriate, but improvements are needed to improve the connection with the audience.	11	The content and style are ideally suited to engaging the target audience.	10		100.0%		

(yellow)	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
(green)	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
(blue)	Mastery		

Outcome h

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 491	**Instructor:**	**Larson**
CRN:		**# Students:**	**20**
TITLE:		**Term:**	F17
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold. - Include a description of the Assessment Methodology used for each performance indicator. - Student samples of work showing high, middle and low scores need to be collected.		

RUBRIC

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**Analyze an engineering solution to determine the global, societal, economic, and environmental impact**	Cannot analyze a solution to find any impact on the global, societal, economic, or environment	2	Can analyze an engineering solution to express impact to only one area of global,environmental,societal, or economic impact	2	Can analyze engineering solutions to express the impact on at least two areas (global, environmental, societal, economic)	20	Can analyze engineering solutions to show imact in all areas (global, environmental, societal, economic)	12		88.9%	2 sets of responses	
2	**Student Participates in In-Class Discussions and Exercises on the impact of engineering solutions in a global, economic, environmental, and societal context**	Student does not participate or complete exercises on the impact of engineering solutions in a global, economic, environmental, and societal context	2	Students participates in in-class discussions and completes exercises on the impact of engineering solutions in a global, economic, environmental, and societal context less than 50% of the time	2	Student participates often in in-class discussions and completes exercises on the impact of engineering solutions in a global, economic, environmental, and societal context correctly most of the time	20	Student always participates in In-class discussions and Completes the impact of engineering solutions in a global, economic, environmental, and societal context Correctly	12		88.9%		
3	**Perform well in humanity, social sciences and comparitive gender and multicultural studies courses to satisfy the general university requirements (based on GPA)**	under 1.5		1.5-2.5		2.5-3.5		Over 3.5					

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome i

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 492	**Instructor:**	**Larson**		
CRN:		**# Students:**	**20**		
TITLE:		**Term:**	W19		
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold. - Include a description of the Assessment Methodology used for each performance indicator. - Student samples of work showing high, middle and low scores need to be collected.				

RUBRIC

(i) a recognition of the need for, and an ability to engage in life-long learning

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to .....)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**recognize the need to seek additional information.**	Does no background research.		Does background research for some major areas of the project.	4	Does background research for most major areas of the project.	7	Does background research for all major areas of the project.	9		80.0%	lit review of final proposal paper	
2	**find relevant and useful additional information.**	Finds only unverified internet resources.		Finds verifiable and relevant internet resources.	4	Finds verifiable and relevant resources from multiple sources, including, but not limited to the internet.	7	Finds multiple verifiable and relevant sources for multiple parts of the project from multiple sources, including, but not limited to the internet.	9		80.0%	lit review of final proposal paper	
3	**successfully integrate additional information.**	Is not able to use additional information found to inform project.		Is able to recognize new material as relevant to project, but does not fully integrate or synthesize new information.	4	Uses pieces of new information to inform project, but does not fully synthesize new information.	9	Synthesizes new information and uses it to inform project.	7		80.0%	lit review of final proposal paper	

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

Outcome j

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE 491	Instructor:	Larson
CRN:		# Students:	20
TITLE:		Term:	F17

Instructions:
- Only evaluate Performance Indicators that are have an assessment level indicated in column K.
- In the Results column for each level of learning indicate the number of students that attained that threshold.
- Include a description of the Assessment Methodology used for each performance indicator.
- Student samples of work showing high, middle and low scores need to be collected.

RUBRIC

(j) a knowledge of contemporary issues

Target	Comments
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**identifies valid contemporary issues**	Unable to identify a contemporary Issue		Able to acknowlege a contempory issue	1	Able to identify few contemporary issues	3	Able to identify many contemporary issues	16		95.0%		
2	**seeks multiple sources of information on the issue**	Only 1 source reviewed		Limited sources or types of resources used (3)		Adequate number of sources and types (5)	5	Extensive use of a variety of resources in a varity of formats	15		100.0%		
3	**discerns the credibility of the resources**	Cannot discern if the resource is credible		Discerns the credibility of a few resources		Discerns the credibility of many of the resources	17	Always discerns the credibility of the resource	3		100.0%		
4	**integrates the information into a nuanced argument**	Cannot integrate information into a nuanced argument (only black & white)		Can integrate a small amount of the information into a nuanced argument	2	Can integrate a portion of the information into a nuanced argument	12	Integrates all information into a nuanced argument	6		90.0%		

(yellow)	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
(green)	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
(blue)	Mastery		

Outcome k

Student Outcomes Assessment - Course Data Feedback Form

PROG:	PCE	**Instructor:**	**Tanveer Singh Chawla**		
CRN:	42259	**# Students:**	**21**		
TITLE:	PCE 472	**Term:**	**Fall 2017**		
Instructions:	- Only evaluate Performance Indicators that are have an assessment level indicated in column K. - In the Results column for each level of learning indicate the number of students that attained that threshold. - Include a description of the Assessment Methodology used for each performance indicator. - Student samples of work showing high, middle and low scores need to be collected.				

RUBRIC

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Target	Comments	
80%	80% of the students should score either a satisfactory or exemplary rating for each indicatory that is assessed.	

	Performance Indicator (Student has the ability to …..)	Unsatisfactory	Result	Developing	Result	Satisfactory	Result	Exemplary	Result	Level	Overall Result	Description of Assessment Methodology and Student Samples to be Collected	Describe Any Mitigating Factors Impacting the Overall Result
1	**apply technology in design.**	Demonstrates lack of preparation, ability, and understanding to use technology in the design process. Student requires significant supervision, models contain significant errors.		Understands basic use of technology for design; requires some supervision and assistance to create feasible product or process designs which may contain multiple minor errors.	3	Skillfully uses technology for design with little need for assistance or supervision, creates designs with few errors.	12	Uses capabilities technology to achieve superior design results; assists other students in the use of technology and is self-motivated in seeking and using advanced capabilities of the tools.	6		85.7%	Comprehensive project report	
2	**apply technology in analysis or simulation.**	Analysis/simulation tools incorrectly applied, models may have significant errors and show lack of understanding, thought, or effort in evaluation of computational results.		Analysis/simulation planning and execution contain some errors but show application of basic understanding, thought, or effort in the evaluation of computational results.		Analysis/simulation planning and execution achieve meaningful results.	15	Analysis/simulation is utilized to achieve superior engineering solution with sufficient analysis of results to understand sensitivities and limitations.	6		100.0%	Comprehensive project report	
3	**Demonstrates ability to use (and practical experience with) manufacturing processes for plastic and composite materials**	Manufacturing process usage requires constant supervision or may not have been done safely.		Student generally follows proper procedures but may require significant supervision. Procedure is usable but has errors if not corrected by others beforehand.	3	Student is attentive to procedures, requires little supervision. Procedure is functional with few minor errors.	15	Student is very attentive to safety procedures, requires minimal supervision, helps other students, or conceives process improvements.	3		85.7%	Comprehensive project report	
4	**Demonstrates use of technology in characterizing the properties of the designed product, process, or material to satisfy goals.**	Technology is not used and no plan is conceived for how technology might be used to measure of evaluate design efficacy.		Technology is proposed or implemented for measurement of design efficacy but technology selection is mismatched to the evaluation.		Appropriate technology is proposed for a measurement of design efficacy.	18	Appropriate technology is utilized to measure design efficacy resulting in meaningful evaluation of the design process and its results.	3		100.0%	Comprehensive project report	

	Introductory	1	Primary to the purpose of the course. Course contains significant instruction and opportunities for practice.
	Reinforcement	2	Secondary to the purpose of the course. Course contains limited instruction and opportunities for practice.
	Mastery		

E.4

Sample Course Outcome 3-Year Review

PCE 431 Course Review

4/30/21

Last Offering: *Winter 2021, John Misasi*

Course Topics

Mixing & Solubility Theory

- Mixing mechanisms
- Distributive mixing theory
- Dispersive mixing theory
- Calculating & quantifying mixing
- Blends and alloys
- Thermodynamics of mixing
- Free energy of mixing
- Solubility parameters

Polymer Mixing Processes

- Batch mixing
- Continuous mixing
- Single screw extrusion
- Twin screw extrusion
- Residence time & mixing
- Shear & mixing
- Predicting/calculating mixing process quality

Polymer Additives & Modifiers

- Antioxidants
- UV stabilizers
- Quantifying performance
- Flame retardants
- Plasticizers
- Lubricants
- Colorants
- Compatibilizers
- Other (nanomaterials, recycling additives, etc.)

Are students entering the class deficient in any of the prerequisite outcomes, and if so which ones?

True Prerequisites

- **PCE 471**
- **PCE 342**

Pre-Prerequisite

- **PCE 331**

- No deficiencies in prerequisite outcomes
- Cancelling of PCE 331 labs due to COVID led to challenges with some fundamental concepts and practical knowledge of polymers and processing

WESTERN WASHINGTON UNIVERSITY

Are students meeting the course learning outcomes, and what is the evidence?

Active Minds Changing Lives

	PCE 431 Course Outcomes	ABET Outcomes
1	Develop proficiency in the advanced characterization of polymers and composite materials	6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
2	Develop proficiency in designing and conducting experiments in addition to analyzing and interpreting data	1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
3	To develop an understanding of the principles of compound design, including compatibility and compound properties	1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
4	To enhance awareness of the ingredients used in polymer compounds and their functions	
5	Gain experience presenting and writing a technical paper	
6	Enhance the understanding of manufacturing processes used in compounding	6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Are students meeting the course learning outcomes, and what is the evidence?

Active Minds Changing Lives

Course Outcomes	
1	Develop proficiency in the advanced characterization of polymers and composite materials

Meeting Outcome?
No (Experimental)

Evidence

- **DOE, Processing, & Analysis Plans: 72% of students performed 80% or higher on O1 related questions/requirements**
- ***NOTE: this assignment was impacted due to COVID; students were unable to run their own experiments in AMSEC***

Meeting Outcome?
Yes (Analysis)

Evidence

- **Final Paper: 88% of students performed 80% or higher on the culminating technical paper with questions related to O1**

Are students meeting the course learning outcomes, and what is the evidence?

Course Outcomes	
2	Develop proficiency in designing and conducting experiments in addition to analyzing and interpreting data

Meeting Outcome?
Yes

Evidence

- **DOE, Processing, & Analysis Plans: 88% of students performed 80% or higher on O2 related questions**
- ***NOTE: this assignment was modified due to COVID; modification made it less rigorous***

Are students meeting the course learning outcomes, and what is the evidence?

Course Outcomes	
3	To develop an understanding of the principles of compound design, including compatibility and compound properties

Meeting Outcome?
Yes

Evidence

- Quiz 1: 90% answered questions related to O3 correctly
- Homework 1: 84% of students performed 80% or higher on O3 related questions

Are students meeting the course learning outcomes, and what is the evidence?

Course Outcomes	
4	To enhance awareness of the ingredients used in polymer compounds and their functions.

Meeting Outcome?
Yes

Evidence

- Project Literature Review: 70% received an 80% or higher on finding, describing, analyzing literature based on compounds for their project
- **Homework 3: 92% of students performed 80% or higher on O4 related questions**
- **Final Paper: 88% of students performed 80% or higher on the culminating technical paper**

Are students meeting the course learning outcomes, and what is the evidence?

Course Outcomes	
5	Gain experience presenting and writing a technical paper

Meeting Outcome?
Yes (Writing)

Evidence

- **Final Paper: 88% of students performed 80% or higher on the culminating technical paper**

Meeting Outcome?
No (Presenting)

Evidence

- **Presentations were cancelled due to COVID related circumstances**

Are students meeting the course learning outcomes, and what is the evidence?

Course Outcomes	
6	Enhance the understanding of manufacturing processes used in compounding

Meeting Outcome?
No (almost)

Evidence

- **Quiz 1: 84% answered questions related to O6 correctly**
- Quiz 2: 65% answered questions related to O6 correctly
- **Homework 2: 92% of students performed 80% or higher on O6 related questions**
- Compounding Report: 70% performed 80% or higher on the overall understanding of the twin screw extrusion process

Approx. 77% of students meet the outcome

If not, what changes would you recommend to improve student learning?

- Approx. half of learning outcomes met
- Other outcomes not met mainly due to COVID circumstances
  - Designing and running characterization experiments
  - Hands-on experiences with compounding equipment
  - Final presentation

- No recommendations for changes due to this year's circumstances

Are there other changes that you would recommend be made to the course and/or its learning outcomes, and if so, why?

- **Design Project**
  - Hard to have a lot of small teams due to equipment logistics
  - Created 3 projects this year, teams of 6-8
  - Sub-teams were responsible for specific runs of a DOE
    - Pro – fewer projects to manage, practice with larger teams, more repeats per DOE run, sharing data easier now with OneDrive
    - Con – students have a hard time coordinating this, I had to organize, introducing error into experiment, idea fails if one subteam doesn't contribute
- **Scheduled lab times**
  - Having specific times for lab will allow for:
    - Universal training
    - Class times not being impacted by training
    - Easier instructor access (I'll know when they are running equipment)
    - Scheduled meeting times for activities other than lab (group planning meetings)

Recommendations of PCE faculty based upon this review

E.5

IAC Meeting Minutes and Agendas

WESTERN
WASHINGTON UNIVERSITY

Engineering and Design
ET 204 - MS 9086
516 High Street, Bellingham, Washington 98225
(360) 650-3380
wwu.edu/engd

WWU IAC Member Responsibilities

As a member of the WWU PCE Industrial Advisory Committee we expect you to:

1. Realistically assess the labor market demand for program graduates and advise the program to ensure it produces graduates with the skills required to meet employment needs.
2. Be informed about the program, its students, curriculum, services/supports, and activities through two (2) of the following activities:
   - Hire program graduates
   - Serve as an ambassador and advocate to the program(s) providing a connection to and ongoing exchange of information and ideas with practitioners in the field and other external contacts.
   - Identify and present opportunities for students and/or host students for capstone projects or course projects.
3. Advise on curricular matters
4. Share developments in the field
5. Provide support and advice to program, assist in the development of new programs, and identify best practice standards
6. Realistically assess the labor market demand for program graduates and advise the program to ensure it produces graduates with the skills required to meet employment needs.
7. Attend the annual meeting in Spring
8. Assist in identification and acquisition (when appropriate) of external funding and resources to support the students and program (e.g. scholarships, program materials, other resources)

PCE IAC Meeting

June 11, 2019

9:30-11:30 a.m.

ET 216

Meeting Facilitator: Nikki Larson

In attendance: Nicole Hoekstra, Cece Grubb, Nikki Larson, Nicole Miller, John Misasi, and Mark Peyron.

Elliot Banko (Hexcel), Damon Call (Toray), Sarah Cornwell (R & D Plastics), Celeste Davis (Hexcel Corp), Andrew Hollcraft (Hexcel), John James (Pacific Research), Bill Karman (Airtech), Jordan Kiesser (PACCAR), Bryan Kraft (Nike), Kacey Loyd (IDEX Health & Science), Eben Sarver (Fluke), Luke Shulock (Fabriform), Nathan Slesinger (Janicki).

Announcements:

Open House 1-4 p.m. today. PCE and EE projects. MFGE senior projects. RAM Mounts project.

Meeting at Twin Sisters Brewery at 4:30 p.m.

Agenda:

Packet. Agenda. Handouts. Announcements. Updates on where we are. Papers presented. Student accolades.

Introductions:

If Alumni. What year graduated.

Andrew Hollcraft. Two and a half years ago. PCE.

John James. PCE. 1990.

Luke Shulock. 1997.

Bryan Kraft. 2000.

John Misasi. 2011.

Sarah Cornwell. PCE. 2008.

David Call. PTE. 2010.

Eben Sarver. PTE. 2015.

Nathan Slesinger. PTE. 2006.

Celeste Davis. PTE. Four years ago.

Bill Karman.

Jordan Kiesser. PTE. 2004.

Kacey Loyd. Three years ago.

Cece Grubb. Chemistry. 2013

Nicole Hoekstra.

Mark Peyron.

Discuss and question future state of PCE program. Trying to formalize process. Expectations of IAC. Formalize expectations.

Second document under agenda. Expectations that you will be informed about program and its students. Hiring. Advocacy. Exchange ideas in field. Capstone projects. Advice on curricular matters and advice to program. Identify best practice, identify labor markets, attend meeting in spring, and share information that will support students and the program.

How do you feel about agreement?

Typically board have them sign up for particular time period. Bill Karman.

One thing we've done is have a company represented. Not necessarily person. Want to make sure that the company is continued to be represented. Adverse to time limit because wouldn't want company to be rotated out. Nicole Hoekstra.

Understand that it's a time commitment.

Has there been a discussion about maximum of alumni? Came up with OSU. Capped at 50. Bryan Kraft.

Think if not an alumni may be more objective. If hiring graduates and have a good feel about needs of industry able to give input that we need. Value of having someone on the committee that wasn't in the program. Have the manger roles. Diversity critical. Nicole Hoekstra.

Did data mining of what others have put out. University of Wisconsin has 15-page document. It varies.

Any other thoughts? Will definitely look into this.

Main things to discuss. PCE changes or not. Look to group to advise. Should we expand. Curriculum. Looking to future. Opportunity over next five years to stay the course or introduce new elements into the program. Things we could change if we wanted to. Have search that is coming out. Think late summer. Dr. Chawla did not receive tenure. Doing a search to replace him. If you know of anyone that would be a good fit. Attached position description. In past specific to what is needed. Like thermoplastics. Composites data analysis. Jack of all trades. Thinking we'd have a broad search. Can we find the best fit? John Misasi. That's the way the job description written. That's what we'd like input on. Is that a good way to go or are we missing something? Do we need a specialist in additive?

Even if we do a broad search will not get a chance to meet again until we make this decision. Nicole Hoekstra.

Would be nice to have a champion for additive for proposed master's program. Andrew Hollcraft.

Other thoughts?

Do you feel like you have a hole somewhere? John James.

Automation. Relied on MFGE faculty. Don't want students to have stand alone class. Different ways of learning. I'm teaching injection molding. Don't know about automation. Don't have that skill within the four of us. Will have them take within MFGE. Tarek developing a series of automation classes. Challenging to have them developed within our labs. Nicole Hoekstra.

Seems like a good fit overall. Only way to fill the gap is with automation. Still want to find someone who has a good general background. John James.

Agree with that. Automation focus. Kacey Loyd.

Hole in my education too. Sarah Cornwell.

Creating stand alone class that can be taken.

At Janicki have bought a lot of robots in the last few years. Nathan Slesinger. Sarah Cornwell and Eben Sarver said the same.

Is it better to throw bodies or robots at it? Cost. Nathan Slesinger.

Collaborative robots. People wouldn't have thought to work side by side with robots years ago. John James.

New MFGE in with robots. How does the human interact with robots?

Way to leverage activities into the labs. Filament mining. Project to automate that. So students can plug in parameters. Bill Karman.

Have had discussions with the MFGE faculty. Overwhelmed with getting things going. Demand too high. Developed within major. Nicole Hoekstra.

Doesn't have to be centered on robots. Expand. Control theory. Can apply to a lot of other areas. John Misasi.

Started brief discussions that EE class could have processing theory. Suitable. Mark Peyron.

All coursework. Back to person. Familiar with automation and control theory. As long as they have skill sets.

Required or preferred qualifications. Something missed or not appropriate.

Discussion where possible adjunct where masters not required? Bill Karman.

Not for tenured track person. Nicole H. Have had people been able to come in and teach from industry. Nicole Hoekstra.

Any consideration of requiring industry experience. Eben Sarver.

Challenge to find PhD with industry experience. Bonus points. Harder than industry job and a lot less money.

Required for masters and not PhD. John James.

Been nice to have people with more industry experience. Creates a nice blend. Nicole Hoekstra.

Anything else?

Committed to hands on approach?

Very helpful.

Any final thoughts?

Any discussion about engineer that is out in industry and would like to teach but has MBA. Might want to discuss internally. Bill Karman.

Hadn't considered. Right now has to be a technical degree.

Feel like it would require supply chain management. All they do and all they know. Maybe you could crossover course work. Nathan Slesinger.

There are technical electives. They learn to do supply chain and project management. Take some course within the department. Material Science. CAD course. Part of college of decision. More of a technical management degree program. Can take operations management course.

Increasingly hard to get into. Students struggle to fill technical electives. Need to try to get in as juniors. Capacity problem at Western. Nicole Hoekstra.

Now about 15,000 students. Mark Peyron.

One thing I'm not seeing. Capacity to maintain funding. Damon Call.

Not a requirement. How you do that does not require you to get funding. Do not have to write grants.

With someone like me it could be beneficial. Damon Call.

See your point. Required to find scholarly activity. May be low budget. May not need outside funding. Requirement for department can maintain scholarly activity.

Are we ok with both or did you want to focus on one? Are you applying for grants? Do you not have experience? Has experience and capability. Damon Call.

Shied away from requiring this as a job requirement. At Western want to teach, work with students, and work with industry. Did not want that requirement. Nicole Hoekstra.

Decision Package Proposal

Creates GUR course. Gives four faculty line shared between. Would not have master's program within this department. Would have access to those students. AMSEC master's and minor. Concentration in sustainable plastics through ENGD. Tech and one half between two.

Do you think good idea or bad idea? Is expansion good?

Background in sustainable plastics. A lot of students focusing on sustainable plastics and materials. Knee jerk reaction to the word plastic. Thinking of ways to increase diversity pool.

How to expand program if people cannot get into classes. Nathan Slesinger.

Would have to add classes. Need more space. Unless we offer a night tech. Cannot put more bodies into labs. This proposal would allow additional space. Faculty and tech to support additional space.

Where would the space be? Sarah Cornwell.

Probably VHCL.

Or take classroom space to turn into labs. Nicole Hoekstra.

Proposal for EE. Likely moving out of the building. Theoretically way to create more lab space. John Misasi.

What is the timeline? Sarah Cornwell.

EE timeline four years. Nicole Hoekstra.

For full proposal due February 2020. Moves forwarded. Would be funded 2023 biennium.

What's the hiring rate for graduates? Sarah Cornwell.

Don't know exact numbers. If they are looking for jobs will have one.

More positions offered than we have graduates. If we expand are they going to get hired? Assess market and give input about whether or not this should happen. Nicole Hoekstra.

You bring market knowledge. What we can't see. Need you to tell us. Would this be something that your company would value.

From Hexcel we are getting flowed down. Not a lot in garbage. By 2024 seems late. Celeste Davis.

Should we make this a part of the core curriculum now? Nicole Hoekstra.

What you do now is great. Don't see that you would need a focus with this. If interested could research hard to recycle plastics materials. If research projects could help students. Faculty support. Celeste Davis.

Mark Peyron has offered sustainable course as an elective.

Offered about one elective per year. Teaching a class in the fall for honors program on topic. Mark Peyron.

Other reason. Not a program like that within our region. Interest to get more focus on this. If, there are goals to reduce waste by 2020. John Misasi.

Still a need by 2024?

I think so. Celeste Davis.

Would see interest. Nathan Slesinger.

Cost effective. Andrew Hollcraft.

Looking at manufacturing and processing ability. Initiatives to look at packaging. Needs to be understood from a student perspective. Bill Karman.

Cost effective to recycle. As opposed to commodity recycling. Andrew Hollcraft.

Example. Replacement for airtech tubes. Corrugated. Completely recyclable. Switching the manufacturing process. Bill Karman.

Seems like a pretty good win. Northwest known for this. On their own will start to create jobs and opportunities. Initiatives by companies to be more sustainable. Plastic garbage patch in ocean. Problems plastics industry has created. Program to help solve those problems. Great way to expand program. John James.

Interest level shows up in 170. Gone from composite bike frames and compostable cups. Now it's PLA stuff. Nathan Slesinger.

Has the PCE program ever considered buying any machinery to recycle materials here? Celeste Davis.

Yes. One of the reasons to move proposal forward. Need space to buy new equipment. Funding in proposal for equipment. For recycling and separation. John Misai.

John Misasi got funding for ocean plastics. A couple of poster presentations address this.

Hard to imagine job shortage in engineering. Can't imagine it in 20 years. People retiring. John James.

Think Western would have a great marketing pitch that they recycle all materials internally. Celeste Davis.

Great step. Has to go in this direction. In my industry experience would have to come from a cost saving perspective. Eben Sarver.

With aerospace we are required. Celeste Davis.

A lot of RFQ's being written. Bill Karman.

Any other thoughts? Access to master's students in proposals? PCE degree with material science minor. Do an extra year to get the master's. Any thoughts and feelings?

The job I applied for was a master's in materials science. Got the job anyway. Think it would be a great fit. Andrew Hollcraft.

Is the plus one thesis based? Nathan Slesinger.

Undergraduate research would continue. Mark Peyron.

Where does the coursework come from? Nathan Slesinger.

We have to make it.

It would be collaborative. John Misasi.

Will have a senior level class co-listed. Their project is elevated. Nicole Hoekstra.

Think you'd get just as many chemistry as engineering. Andrew Hollcraft.

Combining undergrad and master's is very helpful. Nicole Hoekstra.

Do you see value in having these students come out of the master's program? John Misasi.

Absolutely. UW has their master's. PCE competing with these. Master's gives advantage. Other questions. For thesis and research project? Where is it coming from? Research or industry? Similar to senior project? Jordan Kiesser.

All of the above.

Challenge of such a large scale project. Students become really capable and then they graduate. A graduate student would be a better fit. There are a number of things the students get to do that other undergrads don't get to do. Think it would be kept small and targeted. Nicole Hoekstra.

More intricate and technically challenging.

If student working with company that would fund master's. Might be value oriented for company and make sense for students. Mark Peyron.

Day program. If you've been working you'd have to take a leave from your work life. Nicole Hoekstra.

At least for the class requirements. Not necessarily for thesis work. Mark Peyron.

How does accreditation work? Nathan Slesinger.

Master's not accredited. Mark Peyron.

Would want to focus on chemistry and recyclability. Be sure additive manufacturing would accompany all. Damon Call.

Any other thoughts?

Curriculum Core

Last year taught technical elective in additive MFGE. This year Jeff Newcomer teaching intro to automation. PCE specific. Last year heard loudly that automation and additive were really important to you. With the way you see things coming should we move from technical elective to core? Keep in mind if you move something in you have to move something out. If you do want to make core classes what would you remove?

Do you have a list you are thinking of replacing? Nathan Slesinger.

Let's start with do you think courses in automation and additive should be part of core or kept technical elective?

Core.

Right now we don't have additive anywhere in curriculum. Single day module. About two hours of instruction. Nicole Hoekstra.

For tooling.

Students have a general understanding. Able to utilize those printers. Nicole Hoekstra.

Is it something that could be rolled into on 3 D print scale? Bryan Karman.

Number of times where students have access. Lego project. Develop thermo plastic based. Nicole Hoekstra.

Again FDM with basic. Extrude filament. Test with it. Mark Peyron.

In composites have them do composite tooling. Dissolvable tool.

Another question are those small modules dispersed enough or should we have a core or kept as technical elective? Is that enough? John Misasi.

Maybe not the best to speak at this. Get tools that are additive. Celeste Davis.

Not as many companies need major focus. Sarah Cornwell.

Going to get more students that do this as a hobby. People have 3 D printers at home. Will get exposed a lot. Nathan Slesinger.

Customers that have designers on staff. Don't understand the process. Cannot mold this. Have to teach them how to understand draft. John James.

Designers have really enjoyed the additive world.

Maybe someday won't be limited. John James.

At Nike we use 3 D printers everywhere. Have an additive group. Would say to keep it as an elective. As long as they are exposed to it. Bryan Kraft.

I would say core. Eben Sarver.

We don't get a whole lot of electives to offer on a regular basis. What is more important?

Sustainable. Sarah Cornwell.

Better way to go. Elliot Banko.

Are you covering materials in other classes? Jordan Kiesser.

Sprinkled in. Opportunities to expand on. Nicole Hoekstra.

Mark and John both do research in sustainable world.

Additive an area that will continue to grow. Need in industry. Vote for additive. Jordan Kiesser.

Both fill up. Don't have enough humans to teach. Other thing to keep in mind. Every other year for classes with electives. Making sure you'll have the chance to take it. Two year cycle for technical electives. Have syllabus for manufacturing to automation course. Taught for the first time this winter. Do you feel this topic is worthy, once gets flushed out, to get into our core?

Yes. It will eventually. Inevitable.

Will it be focused on PCE or MFGE? Jordan Kiesser.

Way it's configured is automation in general. What we heard form you is that automation is important. Intro to automation that Jeff Newcomer would teach. Higher level that Tarek

Algeddawy would teach. If an intro course would you be willing to have it as a tech elective? Specific offering for our students. First time in winter to see how things go.

Design process in syllabus. Excited about starting point. Based on input from last year. Don't want to wait to get input. Input on additional faculty members. Nicole Hoekstra.

Is MFGE 261 a core class? Celeste Davis.

Yes.

Does it need to be more PCE focused?

Having a design project covers that. Sarah Cornwell.

Hits all the really good foundation points. Eban Sarver.

Don't see tooling on there. Bryan Kraft.

Tooling goes in the next level up.

Will find out. Subject to change. Would think would be in there. Loading and unloading machines. Nicole Hoekstra.

Different teams do different projects. Jordan Kiesser.

Really heavy in pneumatics. Coming out of school if had more experience in programming and theory would be able to do more. Comes down to being able to program it and be able to do it. Luke Shulock.

Is the computer science for engineers still required? Damon Call.

Yes.

What learned may not be applicable. Damon Call.

What MFGE has done is removed computer science component. Doing own numerical method. Additional math requirements that we don't have. Do you have thoughts on numerical methods?

When I'm hearing numerical methods I'm hearing VA? Nathan S.

MATLAB. Macro in Excel. Teach at Whatcom Community College without differential as a prerequisite.

Took numerical methods in order to determine and factor. Programs that can do that. Bill Karman.

Sounds like we need to get a syllabus. Nicole Hoekstra.

Are MATLAB classes on campus? Not understanding why math requirement if there is a program.

Talking of removing. What about circuits?

Is circuits a part of automation? John James.

Part of EE.

Typical engineer purchasing a card. Need to know the requirements to be able to order it. At a bit of a disadvantage if I didn't go to your EE class. Bill Karman.

For the people that are manufacturing engineers are you finding that you are using the information from the EE class? Nicole Hoekstra.

Fundamental circuits. John Misasi.

Not integrated into curriculum. Stand alone. Want students to be able to utilize it well. Students not liking the course. Mark Peyron.

Sounds like you want to be rid of it. Elliot Banko.

Just get concepts. Don't have opportunity to see how it applies. Hear about that they have no idea why they are taking this class. Do need to understand a circuits diagram. Nicole Hoekstra.

Working with automation engineer or troubleshoot came in handy to be able to talk intelligently. Can find the basics. Was pretty handy. John James.

Students don't have that now. Concern with talking something out. What ramifications it would have. Potential to remove for automation. Could be challenges downstream. Concepts they may not know but have applied a lot. Nicole Hoekstra.

Good to understand does that address the basic knowledge? Does it cover that? Jordan Kiesser.

More applicable to working on project. Luke Shulock.

If you understand how the component works and gets signal. Good information to know. Bill Karman.

How about PID controllers?

Yes. Kacey Loyd.

Going to add. Has to go in compounding. John Misasi.

One option. Have 13 credits of technical electives. If we don't remove anything and add could go down to nine technical electives. Reduce ability to take additives.

Like leaving the technical electives open. Opportunities to talk about what you're passionate about in interviews. Nine is low. Bryan Kraft.

Want to make sure you have fundamentals. Technology changes. Fundamentals allow learning of new technology. Look at it as fundamental knowledge? Or is it a gap? The sustainability piece if you don't get a chance to look at may not ever. John James.

Can you throw out other courses you'd like to remove? Eben Sarver.

EE 351. CSCI 141. Both high on list. Or technical electives. Will take other programming classes.

Out of classes I took computer science least valuable. Spent hours doing programs that weren't valuable in the end. Luke Shulock.

Computer Science another that builds fundamentals. John James.

Already may have experience. Luke Shulock.

Thinking about putting in Intro to ENGR using an Arduino.

Technical electives minimum four credits. Up to nine could be research. Could you have a one credit class in programming controllers? Could you fit it into a quarter? Maybe one day a week? Mark Peyron.

Like the idea. Like the foundational thing. But not specific to program and industry. Like the intro to programming and the logic. Hours of work didn't help. Eben Sarver.

Could you make five and add more programming? Circuits. Luke Shulock.

I don't know. Could talk with them.

Hard to make sure have all of the credits. Like the idea of a one credit class. Could they take something online or hybrid? Celeste Davis.

Like an independent sort of thing. Nathan Slesinger.

What about structuring like a tooling class? Partnering with a student with more experience. Learned quite a bit that way. Damon Call.

Could make more sense to be a two part series. Logistically five is a challenge. Nicole Hoekstra.

Other thoughts?

Any other directions the program should be going in?

What is the status of the VHCL program? Nathan Slesinger.

Have three proposals that have been written. AMSEC, MFGE, and VHCL.

Lease for tech center not renewed? John James.

Contract ends this year. If we want to stay in space would have to pay fair market value. About $10,0000 a month. One challenge is logistics. Challenging for students to get back and forth. Struggle to find projects. Think BTC will take part of the space. Good fit for them. Set up for composites work.

Will the equipment be kept? Damon Call.

There are things that they use that we own. Will sell to them directly. All things happen this summer. Nicole Hoekstra.

Relationship with Whatcom improving all the time. Adding additional faculty to do partnerships. Didn't have enough other than to teach. Have staff person that focuses on outreach. Goes to outreach events. Nicole H. BTC moving in the opposite direction. Difficult for students to transfer from two year technical to four year school. Don't have the correct pre-requisites. Not a lot coming from tech transferring to engineering.

Are you able to get a lot of pre major stuff done at WCC?

Nicole H. No. Have people to let you know how to do that. If students can't get in here let them know that they can take it at Whatcom and transfer it.

Faculty doing research. John M. Big NSF grant. Helping to develop research projects.

Hosted 20 students. Mark P.

Anything else?

Any documentation on potential projects. Eben S.

You talk to us. Fluke sponsored projects. Loading of inserts PCE wouldn't be able to do that right now. Students couldn't interpret the 2 D molds. In general if you have a potential project for next year please come talk to us.

Do you have a shortage of projects? John K.

We have an abundance of students.

What is the ratio of projects that are 1/3 to 2/3 industry/faculty. We try to mitigate If we have a student that might not be stellar on an industry project would steer them to faculty project.

How many students next year? 28?

Yes.

From your perspective is there a

To explain a paired agreement. If a company is going to sponsor a project. Will cover consumables. High impact on equipment and staff. Water jet great example. Charge to that fee rather than the company charging for garnet. Amount of   Two research staff that are paid for with these fees. Some are impossible. Rely on research fees.

Damon C. If I had a

All about duration. All start in the fall and end in June regardless of your needs. Would figure out if there is a way to do it in 10 weeks. Huge spectrum of ways we can do these projects depending on time. Cece works on project planning. Nicole H.

Nice to have a variety of different projects. Cece.

Fourteen or fifteen students over summer. Mark P.

Like the module of building on projects in the year. John M.

Thank you

Hope you stick around for the open house.

Send an email if you have other thoughts.

4:30 at Twin Sisters.

To be approved by IAC

WESTERN
WASHINGTON UNIVERSITY

Industrial Advisory Committee (IAC)
Meeting Minutes of 5 June 2020

Attendees: Nicole Larson, Bryan Kraft, Nicole Hoekstra, Steve Dillman, Bill Karman, Cecile Grubb, Mark Peyron, Andrew Hollcraft, John Misasi, David Frye, Jordan Kiesser, Scott McLean, Sean Ryan, Nathan Slesinger, Eban Sarver, Surendra Rajpal, Andrew Hollcraft, Kevin Bussard, Damon Call, Elliot Banko, John James, Russ Chiupka, Ron Knowlton, Michael Standiford

Call to Order: Nicole Larson called the meeting to order at 3:05 PM

Approval of Minutes: N/A

Nicole Larson opened up with introductions
Started with introducing Sean Ryan, the new PCE lab tech.

Nicole Larson gave a reminder to all members to fill out the WWU PCE IAC agreement
Nicole Larson also thanked those members who had already submitted their agreement form.

Nicole Larson welcomed both new research staff and the new Director of First Year Programs
Sean Ryan and Jill Davishahl respectively.

Nicole Larson updated the committee on the status of the search for a new PCE faculty member
An offer was extended to one candidate who turned down the offer.
All three candidates were deemed acceptable, but a hiring freeze put in place by Western meant that no more offers were able to be extended to the remaining two candidates.

Nicole Larson gave a quick overview of funding activity
PCE/MFGE decision package to add Sustainable materials track was not approved by the University as it does not benefit the entire university, this proposal is currently on hold.

Nicole Larson lead an update/question forum about Fall planning
First quarter for new PCE majors has been online
Mark Peyron: noted it has been tough without lab time.
A 1 credit lab course has been created in the Fall for both intro to plastics students and the injection molding students. Action for this was taken at the start of the quarter and is still very fluid as regulations on campus change and evolve.

Summer quarter updates:
Courses are online
Research teams are reduced to 9 students, down 15+ students last summer. Lab time will be reduced and analyzing data will be done off campus. Cleaning measures and PPE measures will be extensive. Work done here is a test bed for the fall. Lab sections in the fall will be reduced, roughly groups of 5 students. After work has concluded, an hour long cleaning session is required. Room occupancies will be strictly enforced.
Bill Karman: asked a question regarding how to optimize the amount of students can be in a lab space in one time.
Nicole Larson: responded with many ideas, including the use of ET 106 (which will not be used in the fall) to expand lab size. Nicole Larson is hopeful for an ideal outcome. Though the situation is fluid, including the potential to pivot to all online classes/lab sessions.
Russ Chiupka: asked about student hours commitment for 1 credit lab course
Nicole Larson: responded with 2 full days total in the lab space. Comfort level is the lab space is critical for the new students and upcoming seniors.
John James: commented on of having lab students record the labs for other students, filling in for the missing opportunity

to have students asked each other questions as to what they are doing.
John Misasi: added a comment about initial recording trials that have been taken this quarter with the help of David Frye. He noted the difficulties of how to properly record and edit videos.
Mark Peyron: added comments about the long run benefits of videos, but the short term inconvenience of recording videos.
Russ Chiupka: asked about the potential of prolonging graduation because of taking extra time to get through the material.
Damon Call: added a question about how industry partners can help out WWU.
Nicole Hoekstra: added a comment about how preexisting materials that are up to university standards that faculty can forward/present to the students would be helpful.
Nicole Larson: agrees with this, including potential industry training materials that could be used for students learning.
Russ Chiupka: asked about previous industry help that outside sources have helped/provided to WWU.
Nathan Slesinger: asked about a time frame of when that was needed. Nathan has a contact that may be able to help out.
Nicole Larson: responded with Fall quarter.
Mark Peyron: added a comment about how external resources would be helpful in the long run for students.
Bill Karman: asked WWU faculty about what other universities are doing in this situation.
Nicole Larson: responded with they have not heard of much, only that they mirror what WWU has been doing with videos.
Bill Karman: provided information that having industry guest speaker give a lecture about how their company applies the topics that are taught at WWU.
Scott McLean: added how there are resources that companies have for new engineers that may apply to the students at WWU.
John Misasi: inquired about what types of software are used out in industry that would benefit WWU.
Surendra Rajpal: asked about what work Boeing has been doing with WWU.
Nicole Larson: responded with a strong “I do not believe so”
Surendra Rajpal: said he will look into what Boeing could do to help out.
Mark Peyron: asked Nicole Larson to provide a course list of what classes will be held in the fall to help industry partners identify what they can help with.
WWU faculty gave a brief description of what classes they will be teaching in the fall.
Mark’s characterization class, John’s intro to plastics processing, Nicole Hoekstra’s will have the initial senior project study a focus on ethics.
Russ Chiupka: requested a class list for review for fall.

Nicole Larson brought up ABET accreditation requirements for review
First point:
success in their chosen profession as evidenced by:

- career satisfaction,
- career advancement (e.g. promotion/raises, new jobs/positions, professional license),
- life-long learning (e.g. continued education, technical training, professional development),
- professional visibility (e.g. publications, presentations, patents, inventions, awards, involvement in professional societies), and/or entrepreneurial activities.

Scott McLean: asked for clarification if this is the same list generated from the last meeting
A question was asked what defines success, e.g. hit 50% of points, 75%, etc.
Jordan Kiesser: asked how students 5 years later are meeting these goals.
Nicole Larson: responded that ABET requirements no longer require the collection of data to measure the definition of success. The data was not effectively measurable.
Surendra Rajpal: asked about if the first point of career satisfaction is specific to the topic that was degree specific.
Nicole Larson: mentioned that the requirement is not degree specific.

Larson: Chat suggestion about videos on website. We'll post the current video.

Larson: Reminder, we will need help going forward with ABET review and the search for adjuncts.

Larson: Any other questions.

Hollcraft: Take a look at Akron U for ideas.

Kraft: Have there been efforts to increase diversity.

Larson: Yes. Efforts have been made and are on-going.

Kraft: This is something that our company is working towards.

Banko: What is the time commitment for time adjunct work

Slesingger: First year is hard, smooth sailing afterward. A couple hours twice a week. ENGR 170 was 2 hours of lecture twice a week. The other time sink is grading. Canvas can do somethings automatically. If you are enthusiastic, it can be fun. Keeps you on your toes and is rewarding in its own right.

Larson: Thank you for your feedback. We'll meet again in December and give updates. Thank you.

Everyone: Thank you.

Meeting ended

Next meeting – to be scheduled in December
Adjourn - meeting adjourned at 4:50 PM

Respectfully submitted by: Michael Standiford, 2020-2021 SAMPE/SPE President

To be approved by IAC

WESTERN WASHINGTON UNIVERSITY

Industrial Advisory Committee (IAC)

Meeting Minutes of 9 June 2020

Attendees: Nicole Larson, Bill Karman, Bryan Kraft, Nicole Hoekstra, Mark Peyron, John Misasi, Jordan Kiesser, Scott McLean, Sean Ryan, Eban Sarver, Andrew Hollcraft, Damon Call, Elliot Banko, John James, Michael Standiford, Peter Quinn, Marcnin, Jordan Birkland, Celeste Davis, Marceen Raviacha? ,Sarah Cornwll, Rob Kearney, Kacey Loyd, Nathan Slesinger

Call to Order: Nicole Larson called the meeting to order at 3:03 PM

Approval of Minutes: N/A

Nicole Larson opened up with introductions

Nicole Larson mentioned that future IAC meetings will be hybrid model (better turn out with virtual meetings)

Meetings are going to twice a year instead of once a year, more input and more updates. Late fall, late spring.

Larson mentioned that students will be 100% back in the lab starting this fall. (vaccinations required)

Larson asked for general questions

John James: Asked about the budget cut situation that is holding up the new faculty search (department wide, university wide)?

Larson: Offer was made and then offer was put on hold. Candidate backed out. Current push is for: guaranteed money**,** who has demand. University has less students coming in (college is fine). This number is low into our programs and the fear has to do with PCE name. **Other programs have more demand at the moment**. The position is still being held, but is on hold. The odds are the search will not continue next year. Faculty are struggling due to high work load.

Larson: Starting discussion about being down a person due to PCE name

- Faculty are highly hands on with students
- No faculty can take time off at the moment (sabbatical)
- Hard time finding adjacent faculty (like Nathan Slesinger)

Larson: Asked who might be able to help teach intro technical courses. Classes can be hybrid, but in person is preferred. Need the most help with Catia Surfaces and FEA world, same with plastic specific courses. Winter quarter need.

John James: What are the educational requirements for adjuncts?

Larson: Bachelors. Adjunct pool information is on Western's website for the resume fill in person.

Rob Kerney: What specific classes are in scope for adjuncts?

Larson: Anything with PCE in front

Larson: Other classes that need help are also mechanics of materials

Andrew Hollcraft: Can you use PCE as more of a solution to gain interest. Noted environmental science programs have good turn out with poster sessions.

Nate: What about Whatcom Community College?

Larson: Lisa Ochs has reached out to them.

Larson: Changing topic to the topic of "should we change our name or stay the course"
Noted a lot of pressure from administration, chair, and dean.
Hoekstra: Her thoughts
Lisa meets up with all pre majors. Students only know major engineering programs. Students do not like to "be a part of the problem" of plastics. Only discussions about how to be a part of the problem bring interest to students. On paper, the program is hard to sell to students where conversations cannot be had. Suggestion is made to make the program more appealing on paper.

Larson: Changing our name WILL have consequences from ABET. Certain names in programs have specific criteria that needs to be met. Right now no criteria is present due to "plastics and composites" name. Others such as polymer or cermics will have new criteria.

These program criteria apply to engineering programs including "materials," "metallurgical," "ceramics," "glass", "polymer," "biomaterials," and similar modifiers in their titles.

§ 1. Curriculum The curriculum must prepare graduates to apply advanced science (such as chemistry, biology and physics), computational techniques and engineering principles to materials systems implied by the program modifier, e.g., ceramics, metals, polymers, biomaterials, composite materials; to integrate the understanding of the scientific and engineering principles underlying the four major elements of the field: structure, properties, processing, and performance related to material systems appropriate to the field; to apply and integrate knowledge from each of the above four elements of the field using experimental, computational and statistical methods to solve materials problems including selection and design consistent with the program educational objectives.

§ 2. Faculty The faculty expertise for the professional area must encompass the four major elements of the field.

Larson: We do the curriculum piece right now, we just do not document it now. It would not be the end of the world if we go this route, but we want others opinions about this potential change. Pros/cons, industrial impacts,

Kearny: Is there really any proof that is will help?
Larson: No, maybe

Karman: Would revising the paragraphs of descriptions to more friendly terms?
James: Sounds like more of a marketing problem than a name problem. You want to attract people who have a cause they want to fight for. We need those kinds of people.

Celeste: I agree. Use the students to help market (beach clean ups)

James: Agreed, use the voice of the students.

Kearny: Agreed. There was a stigma with the name. Graduates understand there is more than what the name suggests. Changing the name to polymer composites would be more of a sell.

Mclean: Have you talked with your peers at other universities? They must have similar problems.

Kraft: There are a lot of plastics engineering programs out there,

Mclean: Maybe they are also going to have that issue.

Karman: Polymer used to mean you need a chemist for the job.

James: We should have people who want to solve these issues. Example: those who want to solve the issue of ocean plastics. The message should be more powerful than the name.

???: Landing page of the website should be more impactful. Highlight who and where you can go work for.

Larson: What if we did both? Change name and message?

Call: isn't there risk of losing the legacy of the program?

Larson: yep.

James: Emphasize what the program outcomes can do for the world.

Hoekstra: A reminder that back when we transferred to an engineering program (from engineering tech), we had similar discussions and that the move was a good move. We must do the research and should not allow legacy and reputation to hold us back.

Banko: We shouldn't be afraid of losing legacy. It is hard to explain the program name to others.

Kraft: Where are your bosses getting their information coming from?

Larson: Data that the dean is coming from is coming from incoming student information. Not many students put down PCE.

Misasi: We've done some digging into freshman interest level. Numbers from pre majors and majors.

Larson: Mentioned about adding a sustainability concentration is currently on hold due to work load. Asking for help for creative solutions (funding and/or resources). There is no money or resources to develop the sustainability concentration. We want to go down that route, but cannot get there.

Hollcraft: What about the intro to materials courses?

Slesinger: Not much feedback from there. Does the current info take into account the pandemic year?

Larson: MSCI and AMSEC students are primarily PCE students. Interest numbers are the problem. Currently there are students who want to fill the spots. Should we change to materials just because the name is popular?

Hoekstra: We would see an increase at the high school student level. Students there might only be familiar with chemistry. Administration is concerned mostly about the student flow coming in.

Larson: Thinking of your employers, would it be easier to hire a grad from a polymer and composites engineering.

Various people : Yes. Polymer vs plastics. 5 yes answers.

Karman: Two part question: Has word gotten around how hard the program is to get into. Does that affect enrollment?

Larson: General idea is that there is a myth that the program is hard to get into.

Celeste: Sustainability would attract interest, but are there a lot of demand for jobs in sustainability? How many jobs have been filled?

Kraft: Most of our customers do have people dedicated to sustainability (mostly hired internally)

Several people: Agree with Kraft.

Misasi: Updating our marketing would indeed help.

Larson: Katrina has background experience with marketing. She made a video and our dean alone didn't understand the content. This pressure is not going to go away from administration. Gut feeling: changing the name of the program would open the position.

James: How much work would be needed to change the name and to deal with the consequences.

Larson: Some. A couple extra hours once it gets going.

Misasi: When in the ABET cycle would that have to happen?

Larson: We can change whenever. The work will fall into the next cycle regardless. It can happen mid cycle without too much issue.

James: People who are getting into EE have a long goal such as improving lithium ion batteries for EV's. I'd change the name and put a lot of effort into messaging. **MATERIALS SCIENCE AND ENGINEERING.**

Larson: Will that change what the student will expect from the program?

Kiesser: You will need to put great emphasis on what to expect from the program

James: Tell more stories about what the program can do.

Hollcraft: What about the name change and then have specific tracks.

Karman: Browser searches and better marketing would be the most helpful.

James: Must have relevant content out there for others to see and want to see.

Call: Being specific in the title is helpful from an employer, **MSE** would be very broad and generic.

Kraft: **Materials engineering** would be a pretty broad experience.

?: How educated is the dean on the program. We all on this call can talk about how well the program has prepped them for industry and tell the stories of where the program can take people.

Larson: We've sent a package to the dean to help educate him what we can and will do. Lisa was just asking for headshots and profiles about what you can do in industry.

?: Can the name be MCE with a composites/plastics focus

Larson: At what point do people stop listening in a title?

James: Make the marketing such that google search hits yield more interest.

Celeste: What again is the problem statement here?

Larson: The university is putting us on the back burner and the faculty search is on hold as a result. Our numbers are small, and administration uses student interest to make decisions where to allocate money.

James: How much has the program been marketed to more political and state figures? That will help convince the university administration to help the program. Maybe take that approach with administration.

Kearny: Can we take this moment to pivot the program to longer term goals, such as more concentrations and tracks that can increase interest for all parties, students to admin.

Hollcraft: Change the program to draw in more chemist with more specific chemistry based programs.

Misasi: Here is the 10 year timeline for those who are interested.

Second point:
success in continued studies as evidenced by:

- satisfaction with the decision to further their education,
- graduate and professional degrees earned, and/or
- academic credits earned.

No questions or comments.
Approved by committee.

Nicole Larson brought up courses and special courses at WWU, including faculty research
Nicole Larson: asked about the thoughts of a variable topic tech credit course that falls in line with faculty research
Nicole Larson and John Misasi: added how only 1 PCE tech elective course is required/offered per year.
John James: likes the idea of having a special topics course that is based on faculty research.
Nicole Larson: mentioned how hard it is to get technical electives that are not required on the books.
John Misasi: explained what industry 4.0 is/would be. The students would learn how to integrate systems that are PCE related that utilize big data and real time data. Gave an example of monitoring extrusion molding to make sure quality always remains in spec. Mentions how simulation tools can benefit industry, including the tooling course where students design a part in Catia, run moldflow, use vericut to predict machining capability.
Russ Chiupka: asked if WWU has the composite vericut workbench.
Nathan Slesinger: will look into his company's safety solutions to machining carbon fiber can be shared with WWU.
Bryan Kraft: asked about modeling courses at Western as a part of Industry 4.0
Mark Peyron: responded with how a plan was in work before the hiring freeze including modeling at the molecular level on up with focus on composites.
Nicole Larson: asked if lowering the tech credit limit is ok with the instruction of a special topics course. Again, asked recent grads about this potential change.
Damon Call: asked if classes can be more ATL geared processes (automated tape laying)
Eban Sarver: mentioned how prevalent industry 4.0 was in industry.
General agreement that adding more tech credits would be a good idea.
Nicole Larson: mentioned that WWU will be reaching out to everyone for help with new industry tech practices.

Nicole Larson opened up the floor for general questions
Ron Knowlton: at R&D mentioned that they will still support a Portland trip, and that October may not be the best time to do so.
Nicole Larson: generally asked about job opportunities for graduating seniors
Bryan Kraft: asked about what WWU is doing for diversity.
Nicole Hoekstra: mentions that WWU is targeting methods to increase diversity and how those topics intertwine with PCE topics. For instance, the mousetrap car project is generally liked, but WWU is looking to open the door to projects that may be more environmentally friendly. Last year students designed an energy generating system that uses the downspout of a house. A great alternative to the traditional project. WWU can reach a broader audience by creating graduates that are not just process engineers. Plans are in the works to make that happen.
John James wanted to thank WWU faculty. Internet cut out.
Damon Call: asked about structured internships for credits.
Nicole Larson: mentioned that students can do an internship for credit. Though doing it over the summer is much more expensive for the students. WWU encourages students to do internships and if companies will work with the students, a syllabus is created prior.

Nicole Larson thanked all attendees for their time and dedication
Meeting ended

Next meeting – to be scheduled [DATE]
Adjourn - meeting adjourned at 4:35 PM

Respectfully submitted by: Michael Standiford, 2020-2021 SAMPE/SPE President

Plastics and Composites Engineering: Industrial Advisory Committee - Announcements

Announcements:

- Funding activity
  - Applied Did Not Receive
    - Army - Materials for Printed Overmold Tooling
    - JCDREAM - Ocean Plastics Recycling Research
  - Pending
    - Proposal to WWU to develop a PCE concentration and Materials Science Master's program - "Establishing WWU as a Center of Excellence in the Science and Engineering of Sustainable Materials"
    - Vartega/DOE - Recycled Thermoset Matrix Materials for Automotive Composites
    - TUI/NASA - Resin Additive Manufacturing Processed Thermal Protection Systems
    - Office of Naval Research - pH-Responsive Polymers for Composite Repair
  - Received
    - JCATI – "Modified Epoxy Prepreg System for Improved Out Life" (Partner: Hexcel)
    - Student Technology Fee (Internal Funding) - "Mechanical Testing Equipment – Universal Test Stand"
    - Student Technology Fee (Internal Funding) – "Digital Microscopes for Engineering Courses and Applications"
    - KAI/NASA – "Low density ULTEM formulations for thermal protection"
    - URSCA (Internal Funding) – "Ocean Plastics Recycling"
    - URSCA (Internal Funding) – "Application of thermal analysis and advanced cure kinetics modeling for high-performance resins"
    - AMSEC Seed Grant (Internal Funding) – "Ocean Plastics Recycling Research"
    - Jarvis Summer Research Fellowship (Internal Funding) – "Ocean Plastics Recycling Research"
    - Jarvis Summer Research Fellowship (Internal Funding) – "Modified Epoxy Prepreg System for Improved Out Life" (Partner: Hexcel)
- Student Presentations/Posters
  - Papers
    - A. Watts and M. Peyron, "Combinatorial Isoconversional Analysis Applied to Benzoxazine Resin Cure Kinetics" Thermochemica Acta, (2019).
    - L. Ghanbari, C. Grubb, C. Croshaw, J. Misasi, "Influence of Continuous Reactor B-Staging on Rheological and Thermomechanical Behavior of a Benzoxazine Matrix" (1st Place Paper), Waterborne Symposium, (2019)

        - N. Manos, P. Smith, N. Hoekstra, "The Influence of Melt Flow Rate and Nozzle Temperature in Fused Filament Fabrication", *Proceedings*, The Society of Plastics Engineers' ANTEC, (2018)
        - S. Lew, N. Hoekstra, J. Misasi, F. Perkins, "Improving the Electrical Conductivity of PC/ABS Printing Filament for Fused Filament Fabrication using Carbon Nanostructures", *Proceedings*, The Society of Plastics Engineers' ANTEC, (2018)
    - Posters
        - Development of a Benzoxazine-Based Nanocomposite Molding Compound (2nd Place Poster), Waterborne Symposium
        - Demonstration of Benzoxazine Prepregs for Aircraft Interior Composites (1st Place Poster), JCATI Symposium
- New Equipment
    - KRUSS Contact Surface Angle instrument
    - Lab Scale Hot-Melt Filmer
    - Thermoformer
    - Falling Dart Impact Tester
    - High throughput powder XRD - AMSEC (for crystallization characterization)
    - SLS 3D printer (nylons and TPU) - AMSEC
    - 3 new TAZ printers for student use
    - Climbing drum peel fixture
    - Quick switch fixtures for MTS
- Technology Development Center
    - Lease was not renewed
- Elective/New Courses
    - Additive Manufacturing – Hoekstra, W20
    - Automation – Newcomer, W20
    - Honors Course in Sustainable Plastics and Composites Materials – Peyron, F19

Plastics and Composites Engineering: Industrial Advisory Committee - Announcements

Announcements:

- New Research Staff
    - Welcome Sean Ryan!
- New Director of First Year Programs
    - Welcome Jill Davishahl
- PCE Faculty Search –on hold
    - Extended 1 offer but were turned down
    - All three finalists were deemed acceptable but due to the hiring freeze we are unable to extend offers to any others
- PCE classes will be a hybrid format for next year
    - Lectures will be online but labs are being planned to run
- Actions Taken From Previous Year's Discussions
    - Intro to Automation will become a required class
    - Changes to Electronics for Engineering (see syllabus with changes)
        - Curriculum forms aren't due until Sept. so if you have feedback on the content please share!
        - Include Intro to PLC's and Microcontrollers
        - Removal of Digital Circuit Logic (Boolean, Combinatorial, Sequential Logic)
    - IAC member agreement rolled out
        - Please remember to get it back to us before the meeting)
- Introductory Course Sequence Updated
    - 2 new courses will replace the current 1. (The first is not currently required)
    - Engineering, Design, & Society (3 credits): Introduces students to field of engineering and design and explores the relationship between engineering, design, technology, and society.
    - Engineering, Innovation & Design (4 credits): A project-based course that introduces students to the engineering design process and explores the role of creativity, teamwork, and communication in innovative design.
- Funding activity
    - Applied Did Not Receive
        - NSF – Engineering the elimination of end-of-use plastics (co app with OSU)
    - In preparation
        - NSF Future Manufacturing Seed Grant ($250,000 for 2 years) in cooperation with Whatcom Community College

- Received
    - JCATI – “Integrating Combinatorial, “Model-Free” Cure Kinetics with Composites Simulation Products” Partner: Convergent Manufacturing Technologies 2020-2021
    - JCATI “Modified epoxy prepreg system for improved out life” ($95,000) Partner: Hexcel 2019-2020
    - NASA – “Resin Additive Manufacturing Processed Thermal Protection Systems (RAMP TPS) - In-situ Curing of Thermoset Resin Mixtures” (Partner: Tethers Unlimited, Inc) ($53,000)
    - Society of Plastics Engineers – “Development of Advanced Materials and Manufacturing using High-Temperature FFF Printing at Western Washington University” ($3700)
    - Vartega - Recycled Thermoset Matrix Materials Characterization ($6000)
    - JCDREAM - Recycling of Aerospace Thermoplastic Composites ($28,700)
    - HP – Recycling Rigids & Ropes (R3) Ocean Plastics ($48,011)
    - Jarvis Summer Research Fellowship (Internal Funding) – “Ocean Plastics Recycling Research” (two different students)
    - SAMPE Student Chapter Grant ($2000)

- Student Presentations/Posters
  - Papers
    - N. Manos, C. Alindayu, M. Peyron, “Influence of Void Content on the Dielectric Permittivity of 3D Printed Parts”, CAMX (The Composites and Advanced Materials Expo), Anaheim, CA, September, (2019).
    - E. Smith*, C. Grubb, J. Misasi, N. Larson; “Developing a Procedure for Prepreg Tack Characterization,” Composites and Advanced Materials Expo, September (2019)
    - A. Watts, M. Peyron, “MATLAB-Based Combinatorial Isoconversional Analysis Techniques for Characterizing Thermoset Cure Kinetics”, SAMPE – Seattle (2020). *Paper reviewed and accepted; to be presented in 2021*.
    - Davis, Charles; Antonson, Jordan; Smith, Paul; Kaas, Ben; Misasi, John. Characterization of POSS-ULTEM nanocomposites and their FFF printed-part properties. Technical Paper. CAMX. (2019)
    - L. Hamernik, C. Grubb, J. Misasi "Synthesis & Characterization of a High-Performance Reversible Epoxy Curative". Society for the Advancement of Material and Process Engineering, Conference Proceedings. 2021. *Paper reviewed and accepted; to be presented in 2021*
    - C. Grubb, C. Dojan, K. Hjelstrom, L. Ghanbari, J. Misasi "Direct Ink Writing of Benzoxazine Nanocomposites". Society for the Advancement of Material and Process Engineering, Conference Proceedings. 2021. *Paper reviewed and accepted; to be presented in 2021*
    -
  - Posters

        - Derek Ciampi, John Misasi; Cecile Grubb. Properties of Epoxy Matrix Materials after Chemical Recycling of Carbon Fiber Prepreg. CAMX (2019) (1st Place Poster)
        - Carter Dojan, Kevin Hjelstrom, Lina Ghanbari, Cecile Grubb, John Misasi. Direct Ink Writing of Benzoxazine Nanocomposites. CAMX (2019)
- New Equipment
    - High temperature FDM printer – Intamsys Funmat HT
    - Melt pump for Killion extruder
    - Side feeder for LabTech Twin Screw Extruder
    - Compression molder with JCDREAM funding (on order)
    - Bruker MALDI-TOF Imaging system
    - Malvern Viscotek triple-sensor GPC system
    - Agilent Q-TOF LCMS system
    - Powder XRD (AMSEC)
    - SpeedMixer dual action centrifugal mixer
    - MultiDrive mill for polymer milling
    - Shimadzu Universal Test Stand (2500 lb load cell)

- PCE/MFGE Decision Package to Add Sustainable Materials
    - Due to the economic crisis produced by COVID 19, the university has decided to not put forward any proposals to the state that do not benefit the entire university. Therefore, our proposal is on-hold at this time and we may be able to try again in the next biennium
- Elective/New Courses
    - Automation – Newcomer, W20 (will be added permanently)
    - Additive Manufacturing – Hoekstra, W20
    - Honors Course in Sustainable Plastics and Composites Materials – Peyron, F19

Plastics and Composites Engineering: Industrial Advisory Committee - Announcements

Announcements:

Meeting Frequency Change

- We will be moving to 2 IAC meetings/year (late fall quarter and late spring quarter)
    - Allows for additional input during this period of multiple changes

Personnel Changes

- Research Associate Cecile Grubb went to graduate school at UTK
- PCE Faculty Search –on hold
    - Enrollment decreases in the University caused funding

ABET

- Next year we will write our Self-Study
    - May need input from you
- On-Site visit F22

Curriculum & Actions Taken From Previous Year's Discussions

- Adjunct Faculty willing to teach FEA, PCE, and ENGR courses needed!
- PCE classes will return to "normal" in the Fall
    - Student, Staff, Faculty vaccinations required
    - Full labs and on-campus lectures
- Altair's simulation package will replace using CATIA's Composite FEA software in Advanced Composites in the Fall
- Altair's mold flow simulation software will replace MoldFlow in Injection Molding in Spring
- Intro to Automation is a required class
    - Reducing technical electives from 13 to 9
    - New majors will take it their first quarter in the program
- Changes to Electronics for Engineering (see syllabus with changes)
    - New content begins this year
        - Includes Intro to PLC's and Microcontrollers
        - Removes Digital Circuit Logic (Boolean, Combinatorial, Sequential Logic)
    - Course moved to Winter Jr. (from spring sr. yr) year to better utilize the content
        - New automation course is a prereq

- PCE/MFGE Decision Package to Add Sustainable Materials
    - Still on hold due to economic constraints brought on by COVID and no new faculty member
- Electives
    - None offered from PCE this year or next as faculty struggle to keep our heads above water with remote teaching and being down a faculty member.

Funding activity

- Applied Did Not Receive
    - WWU & Tethers Unlimited - white paper for DARPA's NOM4D program "High-Performance SpiderFab Structures: Integration of Advanced CFRTP Materials into the SpiderFab In-Space Manufacturing Architecture". ($1,827,000 total base funding)
    - WWU & KUI submitted a NASA SBIR/STTR Phase 1 proposal "Thermoset Extrusion Additive Manufacturing (TEAM)"
- Received
    - SOLVAY, Continuous Twin Screw Reactor Development - $40,000
    - HP, Recycling of Ocean Plastic and Characterization of Recycled Plastics - $55,000
    - JCATI, Chemical Recycling Demonstration of Carbon Fiber-Epoxy Composites - $101,024 (pending funding from the legislature)
    - JCATI, Automating the Preparation and Maintenance of Layup Tooling for Composite Aerostructures and Parts – $56,711 (pending funding from the legislature)
    - 2020 – RSP Pilot Grant - "Development of Additive Manufacturing for Advanced Applications" - $5000 (ends 3/2/22)

Faculty/Student Papers

- Misasi, John; Dao, Buu; Dell'Olio, Carmelo; Swan, Sam; Issadazeh, Salumeh; Wiggins, Jeffrey; Varley, Russell. Polyaryletherketone (PAEK) thermoplastic composites via in-situ ring opening polymerization. Composites Science and Technology, Volume 201, 2021, 108534, ISSN 0266-3538. (50%)
- Owen, Christofer; Grubb, Cecile; Misasi, John. Impacts of degraded surface removal on mechanical recycled marine debris. Technical Paper. ANTEC. 2021. (60%)
- Covarrubias, Juliana; sOwen, Christofer; Impink, sEvan; sHouse, Molly; Grubb, Cecile; Hokestra, Nicole; Misasi, John. Some properties of 100% recycled ocean plastic olefins. Technical Paper. ANTEC. 2021. (60%)

- Dojan, Carter; Hjelstrom, Kevin; Grubb, Cecile; Misasi, John. Direct ink writing of benzoxazine nanocomposites. Technical Paper. SAMPE. 2021. (50%)
- Hamernik, Levi; Grubb, Cecile; Misasi, John. Synthesis & characterization of a high-performance reversible epoxy curative. Technical Paper. SAMPE. 2021. (40%)
- M. Standiford*, C. Grubb, N. Larson, "Development of Unidirectional Carbon Prepreg Using a Solvent Dip Process," Society for the Advancement of Materials and Process Engineering, May 2021 #$
-

* New Equipment
  - Thermal conductivity instrument and circulating chiller
  - DMA fixtures (3-pt bend, compression, CTE)
  - Lab convection oven
  - CR Clarke R30 Sheet Press

Senior Projects for 20/21

- Industry Sponsored
  - Development of a Characterization Technique to Quantify Recycled Content Concentrations in Virgin/Recycled Polymer Blends - HP, Ocean Plastics Recovery
  - Design, Manufacturing, and Testing of a Dual Shaft Shear Shredder for Plastics and Composites Recycling - HP- Ocean Plastics Recovery
  - Design and Testing of a PLA Depolymerization Reactor to Improve Composting Rates - Ovenell Farms
  - Cure Kinetics of Thermoset Resins for RAVEN Composites Modeling Software - Convergent
  - Design of a transfer system for cadmium-coated fasteners - Boeing
  - Development of a Mechanical Recycling Solution for Blended Polyester/Polyolefin Ropes and Lines - Net your Problem, HP - Ocean Plastics Recovery
  - Core surface finish correlation to adhesion with face sheet - Hexcel
  - Characterizing Properties of Novel Vitrimer Materials - Mallinda
  - Characterizing Engineering Thermoplastic Prepreg for Composite Tooling Applications - Janicki
- Program Sponsored
  - Qualifying Thermal Diffusivity Instrument for Materials Characterization - PCE Program

- Process optimization of PCE’s new extrusion melt pump - PCE Program
- Accumulator Housing - WWU FSAE
- Design compression mold tooling and process optimization - PCE Program
- Additive Manufacturing of Thermally Cured Thermoset Polymer - PCE Program

E.6

Sample Course Change Form

PCE - 492 - Course Revision

Status	completed
Hierarchy Entities	Engineering and Design
Approval Process Name	z(Archived) 2020-2021 01. Request for Course Revision
Current Step	Catalog Integration
Originator	Nicole Larson
Created	10/03/2019 09:13AM
Launched	10/03/2019 09:16AM
Form	
Submitter	
Type of Proposal	Course Revision
Prefix:	PCE
Course Number:	492
Academic Department:	Engineering and Design
Course Type	Plastics and Composite Engineering
Rationale for Revision:	Add a credit's worth of project management instruction to this course. Material was previously included in PCE 491; see that proposal for details.
Please check all that will be changed:	Credits
Course Details	
Course Title:	Plastics Capstone Project Proposal
New Transcript Title:	Plastics Capstone Proposal
Credits:	3
Grade Mode	Letter
Course Description:	The second course in the capstone project sequence. Takes project specifications defined in the first course and furthers the planning and design work necessary to support project implementation in the final course. Experience culminates in the writing of a formal project proposal that clearly defines expected project results, resource requirements and project milestones.
Prerequisite(s):	MFGE 342; PCE 471; PCE 491
Prerequisite(s) with concurrency:	
Corequisite(s):	
For acceptable MATH or other course prereqs (e.g. HNRS) listed above as 'higher' or 'equivalent' please provide a complete list of these courses for prereq checking and Registration purposes:	

Is this proposal a teacher education certification or endorsement course offering?	No
Are prereqs Banner enforced?	Yes
Minimum Grade:	C-
Collegial Communication/Impact on Resources	
Have faculty in the Department/ Program been notified and approve of this change?	Yes
Are departments within the college and/or departments outside the college in agreement?	N/A
Comments	
Does the course revision impact other courses or programs?	No. The course revision is not a prereq nor appears in programs of study.
Copy/paste the impact report results into this field.	
Graduate Level Course Information	
Will this course be stacked with an undergraduate course?	No
If yes, explain the different expectations for graduate students:	**Note: While PCE 491 (changing from 4 to 3 credits) is a requirement in the Plastics and Composites Engineering, BS the total credits will not change due to a credit revision to PCE 492 (2 to 3 credits).** Impact Report for PCE 492 Source: 2020-2021 Working Catalog Prerequisites & Notes: PCE 493 - Plastics Capstone Project Implementation Programs Plastics and Composites Engineering, BS
Attached Syllabus	
Syllabus attached?	Yes, syllabus is attached
Does syllabus include class times or length and frequency of classroom sessions?	Yes
Steps	
Originator	
Nicole Larson	
Department/Program review	
Jeff Newcomer	
Lisa Ochs	
Amy Lazzell	
Derek Yip-Hoi	

Todd Morton		
Nicole Larson		
Jason Morris		
Eric Leonhardt		
Andy Klein		
Jamie Lawson		
Department/Program review		
Jeff Newcomer		
Lisa Ochs		
Amy Lazzell		
Derek Yip-Hoi		
Nicole Larson		
Jason Morris		
Eric Leonhardt		
Andy Klein		
College Curriculum Committee		
Courianne Willard		
Jackie Caplan-Auerbach		
Academic Coordinating Commission		
Lizzy Ramhorst		
Jamie Lawson		
Sheila Webb		
Catalog Integration		
Jamie Lawson		

PCE - 492 - Course Revision	
Status	completed
Hierarchy Entities	Engineering and Design
Approval Process Name	z(Archived) 2021-2022 01. Request for Course Revision
Current Step	Catalog Integration
Originator	Nicole Larson
Created	10/12/2020 01:06PM
Launched	10/12/2020 01:08PM
Form	
Submitter	
Type of Proposal	Course Revision
Prefix:	PCE
Course Number:	492
Academic Department:	Engineering and Design
Course Type	Plastics and Composite Engineering

Rationale for Revision:	Change prefix on MFGE 342 (cancelled) to PCE 342 (new equivalent course).
Please check all that will be changed:	Prerequisites
Course Details	
Course Title:	Plastics Capstone Project Proposal
New Transcript Title:	
Credits:	3
Grade Mode	Letter
Course Description:	The second course in the capstone project sequence. Takes project specifications defined in the first course and furthers the planning and design work necessary to support project implementation in the final course. Experience culminates in the writing of a formal project proposal that clearly defines expected project results, resource requirements and project milestones.
Prerequisite(s):	PCE 342; PCE 471; PCE 491
Prerequisite(s) with concurrency:	
Corequisite(s):	
For acceptable MATH or other course prereqs (e.g. HNRS) listed above as 'higher' or 'equivalent' please provide a complete list of these courses for prereq checking and Registration purposes:	
Is this proposal a teacher education certification or endorsement course offering?	No
Are prereqs Banner enforced?	Yes
Minimum Grade:	C-
Collegial Communication/Impact on Resources	
Have faculty in the Department/ Program been notified and approve of this change?	Yes
Are departments within the college and/or departments outside the college in agreement?	N/A
Collegial Communication Comments Field	
Does the course revision impact other courses or programs?	No. The course revision is not a prereq nor appears in programs of study.
Copy/paste the impact report results into this field.	
Graduate Level Course Information	
Will this course be stacked with an undergraduate course?	No
If yes, explain the different expectations for graduate students:	
Attached Syllabus	
Syllabus attached?	Not required
Does the attached syllabus include the required class times and frequency of classroom sessions?	Not required

Steps		
Originator		
Nicole Larson		
Department/Program review		
Jeff Newcomer		
Lisa Ochs		
Amy Lazzell		
Derek Yip-Hoi		
Nicole Larson		
Jason Morris		
Eric Leonhardt		
Andy Klein		
Jill Davishahl		
Reid Dorsey-Palmateer		
Jamie Lawson		
Department/Program review		
Jeff Newcomer		
Lisa Ochs		
Amy Lazzell		
Reid Dorsey-Palmateer		
Tim Kowalczyk		
Charles Barnhart		
Imran Sheikh		
Jill Davishahl		
Andy Klein		
Nicole Larson		
Eric Leonhardt		
Jason Morris		
Derek Yip-Hoi		
Jamie Lawson		
Department/Program review		
Jeff Newcomer		
Lisa Ochs		
Amy Lazzell		
Jill Davishahl		
Andy Klein		
Nicole Larson		
Eric Leonhardt		
Jason Morris		
Derek Yip-Hoi		
College Curriculum Committee		
Courianne Willard		
Jackie Caplan-Auerbach		
Academic Coordinating Commission		
Lizzy Ramhorst		

Jamie Lawson		
Brooke Love		
Catalog Integration		
Jamie Lawson		

PCE - 492 - Course Revision

Status	completed
Hierarchy Entities	Engineering and Design
Approval Process Name	z(Archived) 2021-2022 01. Request for Course Revision
Current Step	Catalog Integration
Originator	Nicole Larson
Created	01/13/2021 03:15PM
Launched	01/13/2021 03:18PM
Form	
Submitter	
Type of Proposal	Course Revision
Prefix:	PCE
Course Number:	492
Academic Department:	Engineering and Design
Course Type	Plastics and Composite Engineering
Rationale for Revision:	Remote instruction during the COVID-19 pandemic has resulted in the use of remote instruction technologies such as Microsoft Teams and Zoom to conduct classes. However, it has been discovered in using these platforms that they also offer benefits for improving engagement, instructional efficiencies and communication and teamwork skills development that are difficult to realize in a face-to-face setting. This is particularly true for the engineering capstone senior project sequence (PCE 491, 492 and 493). At the core of these classes is a teamwork-based, open-ended engineering design project. This requires teams of three or four students to collaborate in problem solving and documentation of their progress and results. In addition,

	these teams rely heavily on regular and easy access to their advisor (the instructor of the class) and their project sponsor (typically an engineer from an external company). It has been discovered in using the platform, that Microsoft Teams helps to improve the ability of teams to more efficiently engage themselves, their advisor, and sponsor in the senior capstone project experience. Further, it has become clear in discussions with industry that the pandemic has also shifted much more of their engineering operations on-line using similar platforms. Thus, continued exposure of majors to these tools after a return to face-to-face instruction will enhance their professional skills in teamwork and communications and their employability. Keeping teamwork and communication skills relevant to changes in industry is a requirement for accreditation of engineering programs. Approval of this proposal would allow the instructor during normal times to integrate this new technology into the course by allowing a portion of the class meetings to be conducted remotely using a platform such as Teams. These remote meetings would coincide with teamwork-based activities where the use of the platform enhances engagement efficiency and develops skills using the technology. NOTE: A course revision proposal has already been submitted and approved by ACC for a separate change to this course which has to do with prerequisites.
Please check all that will be changed:	Course Modality/Delivery Mode
Course Details	
Course Title:	Plastics Capstone Project Proposal
New Transcript Title:	
Credits:	3

Grade Mode	Letter
Course Description:	The second course in the capstone project sequence. Takes project specifications defined in the first course and furthers the planning and design work necessary to support project implementation in the final course. Experience culminates in the writing of a formal project proposal that clearly defines expected project results, resource requirements and project milestones.
Prerequisite(s):	PCE 342; PCE 471; PCE 491
Prerequisite(s) with concurrency:	
Corequisite(s):	
For acceptable MATH or other course prereqs (e.g. HNRS) listed above as 'higher' or 'equivalent' please provide a complete list of these courses for prereq checking and Registration purposes:	
Is this proposal a teacher education certification or endorsement course offering?	No
Are prereqs Banner enforced?	Yes
Minimum Grade:	
Collegial Communication/Impact on Resources	
Have faculty in the Department/ Program been notified and approve of this change?	Yes
Are departments within the college and/or departments outside the college in agreement?	N/A
Collegial Communication Comments Field	
Does the course revision impact other courses or programs?	Yes. The course revision is a prereq for other courses and/or appears in programs of study.
Copy/paste the impact report results into this field.	Though 492 is a prereq for 493, the requested modality change does not impact the content or instruction in 493. **Impact Report for PCE 492** Source: 2020-2021 University Catalog Prerequisites & Notes: PCE 493 - Plastics Capstone Project Implementation Programs: Plastics and

	Composites Engineering, BS
	Source: 2021-2022 Working Catalog
	Prerequisites & Notes: PCE 493 - Plastics Capstone Project Implementation
	Programs: Plastics and Composites Engineering, BS
Graduate Level Course Information	
Will this course be stacked with an undergraduate course?	N/A
If yes, explain the different expectations for graduate students:	
Attached Syllabus	
Syllabus attached?	Yes, syllabus is attached
Does the attached syllabus include the required class times and frequency of classroom sessions?	Yes
Steps	
Originator	
Nicole Larson	
Department/Program review	
Jeff Newcomer	
Lisa Ochs	
Amy Lazzell	
Jill Davishahl	
Andy Klein	
Nicole Larson	
Eric Leonhardt	
Jason Morris	
Derek Yip-Hoi	
College Curriculum Committee	
Courianne Willard	
Jackie Caplan-Auerbach	
Academic Coordinating Commission	
Lizzy Ramhorst	
Jamie Lawson	
Brooke Love	
Catalog Integration	
mie Lawson	

PCE Meeting Agenda – 10/2/19

Meeting Norms: Let's revisit via email

- Start and end on time (end at :50 past the hour)
- Prioritize discussion items by importance

Potential New Norms:

- If you're going to eat, do it quietly
- Review the agenda and all attachments before the meeting and come prepared (items will no longer be printed for you)
- Ask for announcements before moving to discussion items
- Explain new topics in agenda

Announcements/Information/Reminders

- Portland Trip 10/10-11
- Western Preview 10/26
- CHEM 251 W20 MTWF 9-9:50 Lab F 12-2:50
- Safran VP Cabins here 10/8 from 3:15-4:45

Discussion/Action Items

- Renaming our Major
  - The Dean has asked us to look into changing our name to remove the word "plastics." This would put us in a category for ABET where we would have program specific criteria. We already do the program specific criteria if we change to "Polymers." What do we want to do?
  - https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3
- Moving one credit from 491 and moving it to 492
  - Moving project management curriculum
- Resource Committee Updates (See John's email)
  - Self-Sustaining Funds
    - Using them for purchases throughout year? Or be conservative with these for important purchases?
    - Use of funds this year – ID Senior Studio, Vehicle lab moves, Makerspace, ET 312 for Lisa C, ET 106
  - Computer Replacement Fee and 3D Printers
    - Should we replace Stratasys printers? Need to do it soon if we want good trade-in value
    - Should we use funds to buy additional printers and filament for students in lounge and other accessible (PCE/MFGE labs)
      - High temp FDM
      - Metal printer
  - Safety Funds Use
    - Should this come out of self-sustaining?

    - Anything we want to put on needs-list this year?
- Expensive printer or compression molder? (See Nikki's email)
- Removing EE 351/CSCI and replacing it with automation course?
    - We discussed this late last year and with our IAC
    - Do this for next year or wait?
- Senior descriptions (see John's email)
- PCE 491 changes – No more O/F/C – see new ppt.
- What's the agenda for the SAMPE /WWU open house?
- Becoming a "job shop" (ie performing non-value-added work as a favor – not through contracts)
    - How should we approach companies that we work closely with?
- Processes in the program that are not value added? (Remember we asked you to brainstorm last year? Come with ideas.)

PCE - 371 - Course Revision

z(Archived) 2021-2022 01. Request for Course Revision

Submitter

Training materials and helpful links

Note: A Curriculog webpage that includes training materials, etc. will be launched fall 2020.

Curriculog Quick-Start Guide downloadable PDF: Click here
Curriculog Crosslisting Guide downloadable PDF: Click here
ACC syllabus requirement policy: Click here
ACC policy on credit hours: Click here (refer to this policy if a modality/delivery mode is included in this proposal)
Curriculog University (link at bottom of website) includes user manual, etc. Must be signed into myWestern to acces site.

Read before you begin: Important update (September 2020)

IMPORT curriculum data from the Catalog by selecting Import at the top left corner.
Important: ORIGINATOR TRACKING is enabled for the 2021-2022 approval processes that require a user to import data from the 2021-2022 Working Catalog. **Originators can now make revisions to proposals after import and all revisions will be tracked prior to launch. The tracking is available after launch in MARKUP MODE.**
FILL IN all fields required marked with an * after importing data. You will not be able to launch the proposal without completing required fields.
LAUNCH proposal by selecting Validate and Launch Proposal at the top of the proposal. Users can view all revisions to proposals only after the proposal is launched. **When users view proposals in MARKUP MODE, tracked changes made prior to launch and after launch will appear in a different color.**
Proposals can be shared after it is launched. To share a proposal email a direct link (URL) of the proposal and establish communication through Outlook email, or select Send Message About Proposal icon that appears next to the proposal name in My Proposals.
After LAUNCH, the ORIGINATOR must go to Decisions in the Proposal Toolbox to approve which will send the proposal to the next step. The ORIGINATOR may still edit the proposal before approval.

Type of Proposal*

Type of Proposal* Course Revision

Prefix:* PCE

Course Number:* 371

Reminder: A course changing numbers requires a cancellation proposal of existing course and a new course proposal for new course.

Academic Department:* Engineering and Design

Course Type* Plastics and Composite Engineering

Rationale for Revision:* Prerequisite change; ENGR 104 is replaced by ENGR 115.

Please check all that will be changed:*

- [ ] Title
- [ ] Grade Mode
- [ ] Repeatability
- [ ] Description
- [ ] Schedule Type
- [ ] Course Modality/Delivery Mode
- [ ] Credits
- [x] Prerequisites

Course modality definition: Propose to offer a permanent on-campus course either online (for example, during summer quarter) or abroad. Click here for an approved modality change proposal from 2018-2019.

Course Details

Course Title:* Introduction to Plastics Materials and Processes

New Transcript Title:

Credits: 5

Grade Mode Letter

Course Description:* Polymer science and analysis of basic plastics materials; experience in product design, tooling, and processing of thermoplastic.

Prerequisite(s): ENGR 115; ENGR 170

Prerequisite(s) with concurrency:

Corequisite(s):

For acceptable MATH or other course prereqs (e.g. HNRS) listed above as 'higher' or 'equivalent' please provide a complete list of these courses for prereq checking and Registration purposes:

Is this proposal a teacher education certification or endorsement course offering?* ○ Yes ◉ No

Are prereqs Banner enforced?* ◉ Yes ○ No

Minimum grade is "C-" by default and "C" for Woodring courses. If minimum grade is not "C-" or "C (Woodring)," enter grade in "Minimum grade" field and explain grade in rationale above.

Minimum Grade:

Collegial Communication/Impact on Resources

Collegial Communication Guidelines

The ACC requires clear evidence of collegial communication in all instances where a new, revised, or cancelled course or program is likely to impact the curriculum or the enrollment of a course or program in another department.

The ACC strongly recommends collegial communication in cases where a proposal is substantially similar to an existing course or program in another department.

Have faculty in the Department/ Program been notified and approve of this change?* ◉ Yes ○ No ○ In progress

Are departments within the college and/or departments outside the college in agreement?* ○ Yes ○ No ◉ N/A ○ In progress

If the communication is made and approved, insert all communication(s) in the comment box, including the from/date/subject/contents if in an email. If the communication is ongoing, mark in progress and insert final approval(s) later.

Collegial Communication Comments Field

For prereqs or requirements or potential impact to programs outside your department, run an Impact Report. Make sure to select 2021-2022 Working Catalog when generate the report. There are two ways to run an Impact Report:

After importing the course, go to the top left of the proposal and select Run Impact Report.
Click on the following link to go to Impact Report: https://wwu.curriculog.com/reports

Does the course revision impact other courses or programs?*

- [ ] Yes. The course revision is a prereq for other courses and/or appears in programs of study.
- [x] No. The course revision is not a prereq nor appears in programs of study.

Based upon the impact report, initiate communication with impacted departments/programs. This can be done by a message or copy/paste URL of proposal in an email or sending the proposal in a message within Curriculog.

Copy/paste the impact report results into this field.

Graduate Level Course Information

Will this course be stacked with an undergraduate course?*

( ) Yes (•) No ( ) N/A

If yes, explain the different expectations for graduate students:

Attached Syllabus

A syllabus is required for course revisions that include a change in credit hours, a significant change in course content, or a change in modality.

To add an attachment click on Files at the top right of the Proposal Toolbox in the right panel.

ACC syllabus requirement policy: Click here

Syllabus attached?* ○ Yes, syllabus is attached ◉ Not required

Does the attached syllabus include the required class times and frequency of classroom sessions?* ○ Yes ◉ Not required

Steps for PCE - 371 - Course Revision

Originator

Status: *Approved*

Participants

Nicole Larson 11/2/2020 7:37 AM

Department/Program review

Status: *Approved*

Participants

▲ **Engineering and Design Department Review**

Jeff Newcomer * 11/2/2020 5:30 PM

Derek Yip-Hoi * 11/2/2020 1:09 PM

College Curriculum Committee

Status: *Approved*

Participants

▲ **College of Science and Engineering Curriculum Committee**

Jackie Caplan-Auerbach * 11/17/2020 10:53 AM

Academic Coordinating Commission

Status: *Approved*

Participants

▲ **Academic Coordinating Commission**

Lizzy Ramhorst * 12/3/2020 12:37 PM

Catalog Integration

Status: *Approved*

Participants

Jamie Lawson 3/31/2021 5:15 PM

Curriculum Committee Meeting
Agenda and Minutes
Monday October 14th, 2019

A. Changes to the Agenda
- New business to be added?

B. Announcements
- Any?

C. STANDING BUSINESS
- Student Exceptions
    - Zena Moran
  - Approved On-line
    - None
  - Others?

- Review and Approval of Curriculum Changes for Catalog
  - ID 240
  - PCE 491, 492
  - MFGE 491, 492

- Update on ENGR Changes

- Review Committee ToDo List for 2019-20

D. TABLED ITEMS
- None

E. NEW BUSINESS
- Any?

Adjourn

Appendix F
Advising Tools

Plastics & Composites Engineering, BS

2021-2022 Academic Year

WESTERN WASHINGTON UNIVERSITY
ENGINEERING AND DESIGN

ABET accredited
Course offerings subject to change
Major Credits: 150 (GURs not included)

Admissions information - https://engineeringdesign.wwu.edu/
Academic advising available - see contact information below
Pre-major coursework in grey areas/Full major courses in white

	Fall	Winter	Spring
First year	**MATH 124 (5) Calculus 1, FWS**	**MATH 125 (5) Calculus II, FWS**	PHYS 162 (5) Physics w/ Calc II, WS
	CHEM 161 (5) Gen Chemistry I, FWS	**PHYS 161 (5) Physics w/ Calc I, FW**	**ENGR 115 (4) Innovation in Design, WS**
	ENGR 101 (2) Eng., Design, & Society, FW	**CHEM 162 (5) Gen Chemistry II, FWS**	

Pre-major courses in BOLD are required for major admissions.

	Fall	Winter	Spring
Second Year	**ENGR 170 (4) Intro Material Science, FW**	**APPLY TO MAJOR**	**MAJOR COURSES BEGIN**
	ENGR 214 (4) Statics, FW	ENGR 225 (4) Mechanics of Materials, FWS	MFGE 261 (4) Intro to CAD, S
	PHYS 163 (5) Physics w/ Calc III, FS	CSCI 140 or 141 (4) Program. Fund, FWS	PCE 371 (5) Intro to Plastics, FS
		MATH 345 (4) Engineering Statistics, FWS	MFGE 250 (4) Into to Manuf. Automation, S
Third Year	CHEM 251 (5) Elem. Orgainic Chemsitry, F	PCE 372 (5) Intro to Composites, W	CHEM 308 (3) Polymer Chemistry, S
	MFGE 341 (4) Quality Assurance, FW	PCE 342 (4) Design of Experiements, WS	PCE 331 (4) Injection Molding, S
	MFGE 231 (4) Intro to Manuf. Processes, FS	EECE 351 (4) Electronics for Engineers, FW	MFGE 462 (4) CAD Using Surfaces, S
Fourth Year	PCE 491 (WP) (3) Project Research, F	PCE 492 (WP) (3) Project Proposal, W	PCE 493 (4) Project Implementation, S
	PCE 471 (4) Adv Materials & Char, F	PCE 431 (4) Adv Materials and Proc, W	PCE 461 (4) Tooling for Plastics, S
	PCE 472 (4) Advanced Composites, F	MFGE 332 (4) Intro To CAM & CNC, FW	Tech Elective
	Tech Elective	Tech Elective	

Engineering & Design
516 High Street, Bellingham, WA 98229
ENGD@wwu.edu | 360.650.3380
http://engineeringdesign.wwu.edu

Pre-major Advisor: Lisa Ochs
360.650.4132 lisa.ochs@wwu.edu

Notes and Exceptions

Math 341 may be substituted for MATH 345, CSCI 141 may be substituted for 140
Students must complete 7 credits of tech. electives - see website for approved courses
Full majors must complete PHYS 163 by the end of spring quarter year 3
Full majors must complete PCE 342 and ENGR 225 by the end of winter quarter year 3
Student must complete General University Requirements in addition to major courses

Plastics & Composites Engineering, BS

Western Washington University
Engineering and Design

Admissions

Students must first be accepted by the university. **The program accepts major applications during winter quarter only.** Accepted students start major coursework spring quarter. Transfer students may apply at the same time if required coursework is complete or in progress.

Required coursework to apply

MATH 124	Calculus I
MATH 125	Calculus II
CHEM 161	General Chemistry I
CHEM 162	General Chemistry II
PHYS 161	Physics w/ Calculus I
ENGR 101*	Engineering, Design, and Society
ENGR 115	Engineering Innovation
ENGR 170	Intro to Materials Science & Engineering
ENGR 214	Statics

*waived for transfer students

Students may be enrolled in no more than 3 required courses at time of application

Recommended, but not required to apply

MATH 345	Engineering Statistics
PHYS 162	Physics w/ Calculus II
PHYS 163	Physics w/ Calculus III
CSCI 140	Programming Fundamentals
CHEM 251	Elementary Organic Chemistry
ENGR 225	Mechanics of Materials

Required essaay

The program requires applicants to submit a one page or 500 words maximum essay explaining why they want to pursure a degree in PCE.

Applications due

Applications due the first Friday in February every year. Accepted students start major coursework spring quarter. Applicants are notified of decisions before spring quarter registration.

Transfer students

Transfer students are encouraged to contact the pre-major advisor to discuss course equivlancies and recommended time to transfer.

Admissions statistics

35-40 applicants

average 3.1 pre-major GPA (not a cut-off)

24 accepted

Technical Electives

Majors are required to complete 9-13 technical electives before graduation (# depends on year declared). See website for approved list of elective courses. Faculty advisors must approve courses not on this list.

Faculty Contact Information

Professor Nicole Larson, larsonn4@wwu.edu
Professor Nicole Hoekstra, hoekstra@wwu.edu
Associate Professor John Misasi, misasij@wwu.edu
Associate Professor Mark Peyron, mpeyron@wwu.edu

udpated: April 2021

Appendix G

Program Specific Criteria

PCE 331 Laboratory 2 Manual

Rules for Preventing Mold Damage

1. ALWAYS use brass tools. NEVER use a non-brass tool in or around any injection mold. Take off rings and watches when working.
2. Take steps to eliminate flash – it damages the parting line
3. Do not over clamp a mold. Over clamping can damage the mold and the machine platens.
4. Never close the mold when any portion of a part is still in the cavity.
5. Ensure that the mold is securely mounted by using 4 clamps on each half and by having a fellow group member check the installation of the mold.
6. Remedy parts sticking in the mold as soon as possible. If it is still sticking after repeated attempts, please inform the instructor. Parts sticking in the mold have high potential for injury or mold damage.
7. Lubricate and clean all mold components (lubricants and cleaners are in the flammable cabinet by the small compression molder) when you are finished with the tooling, especially prior to storage of the tool for the quarter.
8. Do not make any adjustments to the molds or machines that you have not been specifically trained on.

Rules for Preventing Machine Damage

1. Prior to turning the screw for the first time, ensure that all of the barrel heat zones have come up to temperature for at least 10 minutes (for the "previous material" listed on the machine log from the previous user). Failure to do this can cause extreme screw, barrel, and/or motor damage.
2. Ensure the water is turned on even if the mold heater is not being used. Water is also used to cool the feed throat and cool the motor.

Lab #2
Familiarity with the Four Phases of Injection Molding

Objectives

You are going to make parts that utilize four phases of injection: free travel, fill, pack, and hold. Make sure that you follow this procedure and **document the settings at each step** for your lab report. The primary objectives for this lab are:

1. To determine all process parameters for an injection mold.
2. To understand shrinkage in injection molded parts.
3. To achieve a fully automatic production of injection molded parts.
4. To optimize the cycle time of the process.
5. To investigate part costing.
6. Manufacture tensile bars for testing in PCE 371.

Pre-Lab Activities:

1. Recommended processing conditions and typical shrinkage values for your resin (include reference).
2. Read the **Procedure** below and hypothesize what you expect to see/find as you progress through the lab, going from 95% full to packed part. How will shrinkage change as packing continues? How will part anisotropy change as packing continues? How will the process be affected by packing phase? **Submit your answers on Canvas.**

Procedure:

Days 1 and 2

1. Remove B-half of mold from press and measure/calculate your mold's volume including the sprue, runners, and cavity.
    - You will need the actual dimensions of the part cavity including overall length, gage region width, and gauge region thickness for later analysis
2. Using the shot size equation and the screw size, approximate the screw translation required for your 95% full part.
3. Reload tensile bar mold and ensure that the machine is set up at the beginning of a cycle.
4. At the beginning of this lab make sure that the hold time, hold pressure, and hold flow rates are set to zero. Set all other variables to the midpoint of the recommended value for the resin/machine. Set cooling time long (30 seconds for high shrinkage materials, 60 seconds for low shrinkage materials). Make parts and continue to adjust the shot size, barrel temperatures, mold temperature, back pressure, and injection pressure until:
    - parts are 95% full,
    - parts eject properly,
    - screw reaches the switchover
    - cushion is between the min and max value
5. Record process parameters utilized to obtain 95% full part.
    - how did you measure/quantify if the part was 95% full?
6. Make 5 consistent parts at 95% full, label these parts, and set aside for later analysis. Record all set parameters and machine responses/outputs associated with the 5 parts.
    - Machine outputs to record: screw strokes, cushion actual value, actual injection pressure, actual holding pressure, cycle time
    - Measure and record width, thickness, and length of tensile bars
    - Weigh all 5 parts and record mass (**<u>do not degate parts</u>**, weigh with sprue and runner system on analytical balance)
7. Set the hold pressure to 50-75% of the injection pressure (dependent on viscosity), hold time to 10 seconds, if needed, add time (sum of primary and secondary injection) to the injection timer, and add additional cooling time. Holding phase flow rates should be a non-zero value, but low (0.1 in/sec).
8. Increase the total screw travel by 5% (add 5% volume to both cushion and start position). Make parts until cavity is 100% full. Then make 5 consistent parts, label, and set aside for later analysis. Record all parameters and machine responses associated with the 5 parts.
    - Machine outputs to record: screw strokes, cushion actual value, actual injection pressure, actual holding pressure, cycle time
    - Measure and record width, thickness, and length of tensile bars
    - Weigh each part, record (**<u>do not degate parts</u>**, weigh with sprue and runner system on analytical balance)
9. If part is not fully packed, add another 5% to shot volume (105%). Add 10 seconds to hold time (total of 20 seconds). Make parts until consistent, then make 5 more parts.
    - Make sure the cushion tolerance allows for your amount of screw travel
    - Machine outputs to record: screw strokes, cushion actual value, actual injection pressure, actual holding pressure, cycle time

- Measure and record width, thickness, and length of tensile bars
- Weigh of each part, record (**do not degate parts**, weigh with sprue and runner system on analytical balance)

10. If parts still show signs of sink and require more packing, adjust screw stroke to make parts at 110% and add 10 seconds to holding time (30 seconds total). Make parts until no sink is observed, then make 5 consistent parts. Label these parts and set aside for later analysis.
    - You may not get parts to 110% full. Increase from 105% until no observable defects (this includes if 110% isn't enough).
    - Machine outputs to record: screw strokes, cushion actual value, actual injection pressure, actual holding pressure, cycle time
    - Measure and record width, thickness, and length of tensile bars
    - Weigh each part, record (**do not degate parts**, weigh with sprue and runner system on analytical balance)
11. Make 15 good parts on semi-automatic using the best fill/pack settings that were found. Run with no alarms and with parts ejecting properly.
    - Measure and record width, thickness, and length of tensile bars
    - Weigh each part, record (**do not degate parts**, weigh with sprue and runner system on analytical balance)
12. If successful with step 7 and parts are ejecting well, set the machine on fully automatic. **Get Professor Misasi or TA before proceeding with automatic run.**
13. Make 15 parts sequentially without any alarms. If alarms occur, adjust settings to get 15 good parts automatically.
14. Record the following for 15 cycles:
    - Machine outputs to record: screw strokes, cushion actual value, actual injection pressure, actual holding pressure, cycle time
    - Measure and record width, thickness, and length of tensile bars
    - Weigh each part, record (**do not degate parts**, weigh with sprue and runner system on analytical balance)
15. Close hopper feed. Purge your material from barrel (3-5 purge cycles at 90% shot size). Empty and clean hopper, feed throat, and area around injection molding machine.

Don't forget to keep ALL good tensile bars!

Don't forget to purge barrel, clean hopper, clean feed throat, and vacuum area around injection molding machine after every lab session!!

16. After all data for entire lab has been recorded, degate parts, recycle/discard runners, and give bars to John for use in PCE 371

Data Analysis:

1. Packing and Part Dimensions
    - Calculate the average injection volume and respective standard deviation for each part using the actual shot size for each volume created (95%, 100%, 105%, 110ish%)

- Calculate average part thickness, width, and length along with the respective standard deviations
- Use a bar chart to plot and analyze thickness vs. injection volume (95%, 100%, 105%, 110ish%), include standard deviation on chart
- Use a bar chart to plot width vs. injection volume (95%, 100%, 105%, 110ish%), include standard deviation on chart
- Use a bar chart to plot length vs. injection volume (95%, 100%, 105%, 110ish%), include standard deviation on chart
- How did packing impact each part dimension? What dimensions were most impacted by packing? Why?

2. Part Shrinkage
    - Analyze shrinkage between the mold and measured part dimensions by including table with
        - Is this typical of your material (use references)? Why or why not?

3. Semi-Automatic vs Automatic Full Parts
    - Plot part mass vs. part number for both semi-automatic and automatic mode parts on same scatterplot (clearly label/identify the two datasets)
    - Plot cycle time vs. part number for both semi-automatic and automatic mode parts on same scatterplot (clearly label/identify the two datasets)
    - How consistent are the parts? Why or why not?

Content for Lab Report "Results and Discussion" Section:

Remember to describe all of your data and steps to obtain the data. If you don't tell me it happened, I won't know about it!

1. Detail the procedural steps that were taken to reach 95% full parts.
    - How did you determine what 95% full is?
    - What settings were used and why?
2. Compare the part qualities (dimensions, mass) from 95%, 100%, 105 and 110% to the actual cavity.
    - Data and questions from above
    - Explain if your resin exhibited the predicted shrinkage amount for your resin (*be sure to include references for shrinkage values for your resin*).
3. Detail the procedural steps that were taken to reach automatic and summarize the optimal settings.
4. Describe the differences between semi-automatic and fully automatic modes
    - Calculate, graph and then explain the variation in the 15 parts that were made in semi-auto mode and then also automatic mode
        i. One way to show this is through a (pseudo) control chart (think back to quality assurance class)
    - Describe cycle time differences
5. Describe any defects, potential causes of the defects, and any actions taken to reduce/eliminate the defects. (use references)
6. Summarize the successes and challenges with this lab activity. If there were any alarms, describe what they were and how they were remedied. In the appendix, be sure to include the recommended processing recommendations and list the sources in the bibliography.

Post-Lab Individual Assignment (typed):

1) Show the calculation and calculate the actual clamp force necessary for your injection pressure and projected area of parts made in fully automatic mode. State what clamp force was used during the lab.
2) Calculate part cost for 100, 1000, and 10,000 parts made in a single production batch. Use the example from the book chapter on Canvas (page 56 of .pdf) and information below. Make sure to provide references for any researched values (resin price).
   a. Use a setup time of one hour, 5 pounds of setup resin, and 5% scrap/waste rate, $50.00/hr machine rate, $0 tool cost, no secondary operations and no packaging.

Resin Costs	**Resin & Grade**	**Supplier Name**	**Price $/lb**	
Part Cost	**Part Weight lb**	**Waste Factor -**	**Adjusted Weight lb**	**Cost/Part $/part**
Machine Cost	**Cavities #**	**Cycle Time s**	**Production Rate parts/hr**	**Machine Rate ($/hr) $/hr**
				50

   b. ***Remember to record actual cycle times in order to calculate part cost.***

Introduction

The filling phase of the injection molding cycle is one of the most critical stages to ensure the manufacture of high quality parts. Filling imparts significant shear, pressure, and temperature increases on the polymer which can damage part performance. Thus, a deep understanding of the impacts of processing parameters and the ability to predict the approximate conditions observed by the polymer is important for any plastics and composites engineer. In this assignment you will **use Excel to calculate, predict, and describe the impacts of various processing conditions on critical material properties and molding responses** in injection molding processes. You will use assigned materials data, part geometries information, and an Excel template to perform the calculations. Then you'll need to analyze and describe the obtained data/information.

The Excel template has additional instructions regarding each question which are on sheet tabs respective to the question numbers below. In each question, you'll need to **calculate and plot data using Excel**, **copy the plots to this answer sheet**, and **describe the data and questions** below. This assignment has **three parts that must be completed sequentially**, as each subsequent question builds upon the previous. Once completed, please upload both answer sheet (this document **saved as PDF**) and your **completed Excel sheet**. The assignment goals and general tasks are in the table below.

Goals of this Assignment	***Assignment Tasks***
1. Practice calculating useful parameters used in plastics and composites processing	1. Use questions below and Excel template to calculate properties and parameters
2. Understand the impacts of shear rate on thermoplastics' melt viscosities	2. Use Excel template to plot data in an effective, reader-friendly manner
3. Understand the impacts of processing parameters on pressure drop	3. Copy and paste plots into this document and use as answer sheet
	4. Analyze data and describe using the question/prompts below
	5. Save & upload both Excel sheet & answers to Canvas

Part 1 (14 pts)

Using the WLF-Cross viscosity model equations and the Excel sheet provided on Canvas (pages 1a and 1b), calculate and plot ***viscosity (Pa*s) as a function of shear rate (s^{-1})***, ***zero shear viscosity (Pa*s) vs. temperature (°C)***, and the ***shear thinning shear rate (s^{-1}) vs. temperature (°C)*** for the material assigned to you (on first page of Excel book). Answer the following questions:

a. Plot viscosity vs. shear rate for your material at three different temperatures within the molding temperature range. Note the following observations from your plotted data: How does your material behave with shear? Where does shear thinning begin? Is this a rapid/slow rate of viscosity decrease? How does shear thinning change with temperature? Why?

b. How does your material's viscosity behave as function of temperature? What type of relationship is shown by the data (linear or exponential increase or decrease)? Is the zero-shear viscosity difference with temperature large or small?

c. Look up the most common repeat chemical structure, most common molecular architectures (branched, crosslinked, linear, etc.) and most common crystallinity of your material. Describe your polymer's viscosity behavior in terms of these molecular parameters.

Part 2 (10 pts)

Injection velocity is a critical processing parameter in injection molding as it impacts shear rate, flow rate and other processing properties. Create an Excel spreadsheet (use same workbook as viscosity calculations) to calculate the ***apparent shear rates*** observed in the part, *Hinge Demonstrator*, using ***10 different injection velocities*** and ***two different flow paths***. The part can be found on Canvas as both a .stl CAD file and in slides. Since the part has rectangular geometries instead of the circular flow paths as described in lecture, use the following shear rate equations:

$$\dot{\boldsymbol{Q}} = \boldsymbol{A} * \boldsymbol{V}, A \equiv cross\ sectional\ area\ (mm^2, V \equiv injection\ velocity\ (mm/s)$$

$$\dot{\gamma}_{app} = \frac{6 * \dot{Q}}{W * H^2}, \dot{Q} \equiv volumetric\ flow\ rate\ \left(\frac{mm^3}{s}\right), W \equiv flow\ path\ width\ (mm), H \equiv flow\ path\ height\ (mm)$$

a. Explain your results using your calculated values and scatter plots. Describe the differences between the two flow paths, the flow rates, and shear rates. How does injection velocity impact the shear rate? What type of relationship is the data showing?

b. What are some assumptions that were made to perform these calculations? What other factors might be impacting the flow rate and therefore shear rate during injection?

Part 3 (16 pts)

Using all of the information available in this assignment (viscosity, shear rate, flow rate data, CAD file, equations, etc.), ***calculate the pressure drop*** in the two different flow paths as a function of **(1)** ***10 different injection velocities*** (constant temperature) and ***(2) 10 different processing temperatures*** (constant shear rate). Since the part has rectangular geometries instead of the circular flow paths as described in lecture, use the following equation for pressure drop:

$$\dot{Q} = \frac{W * H^3 * \Delta P}{12 * L * \eta}, L \equiv flow\ length, \Delta P \equiv pressure\ drop\ across\ flow\ length$$

a. Describe the relationship between ΔP and injection velocity. What are all the parameters in the ΔP equation that are impacted by changing velocity? How are the two flow paths impacting these relationships?

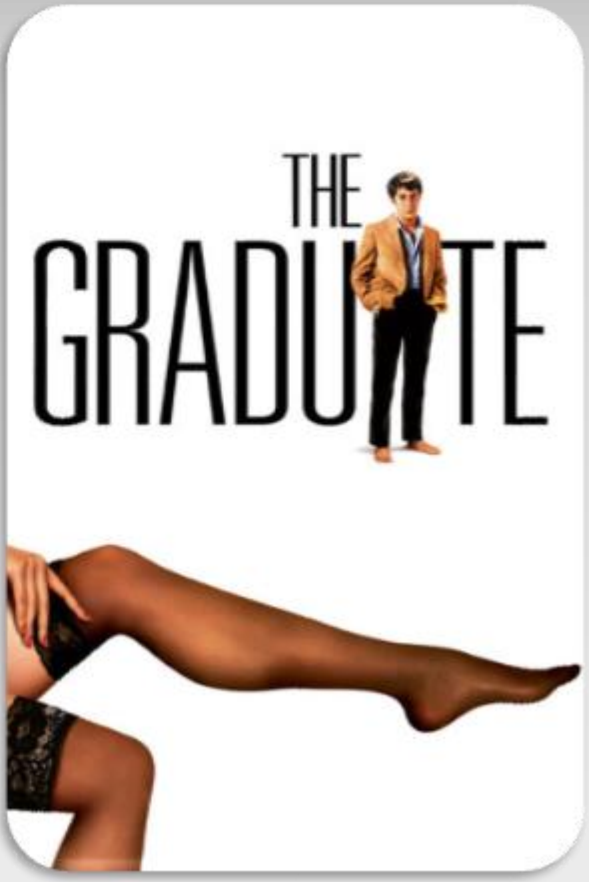
b. Describe the relationship between ΔP and processing temperature. What are the practical implications of this relationship in terms of part geometries, molding cycle time, and eventual part cost?

Introduction to Plastics

http://www.fiberglassguide.com/wp-content/uploads/2015/01/RESIN-PELLETS.jpg

Outline

- What is it?
- Where is it used?
- Why is it useful?
- Who cares?
- Where does it come from?
- What is its future?

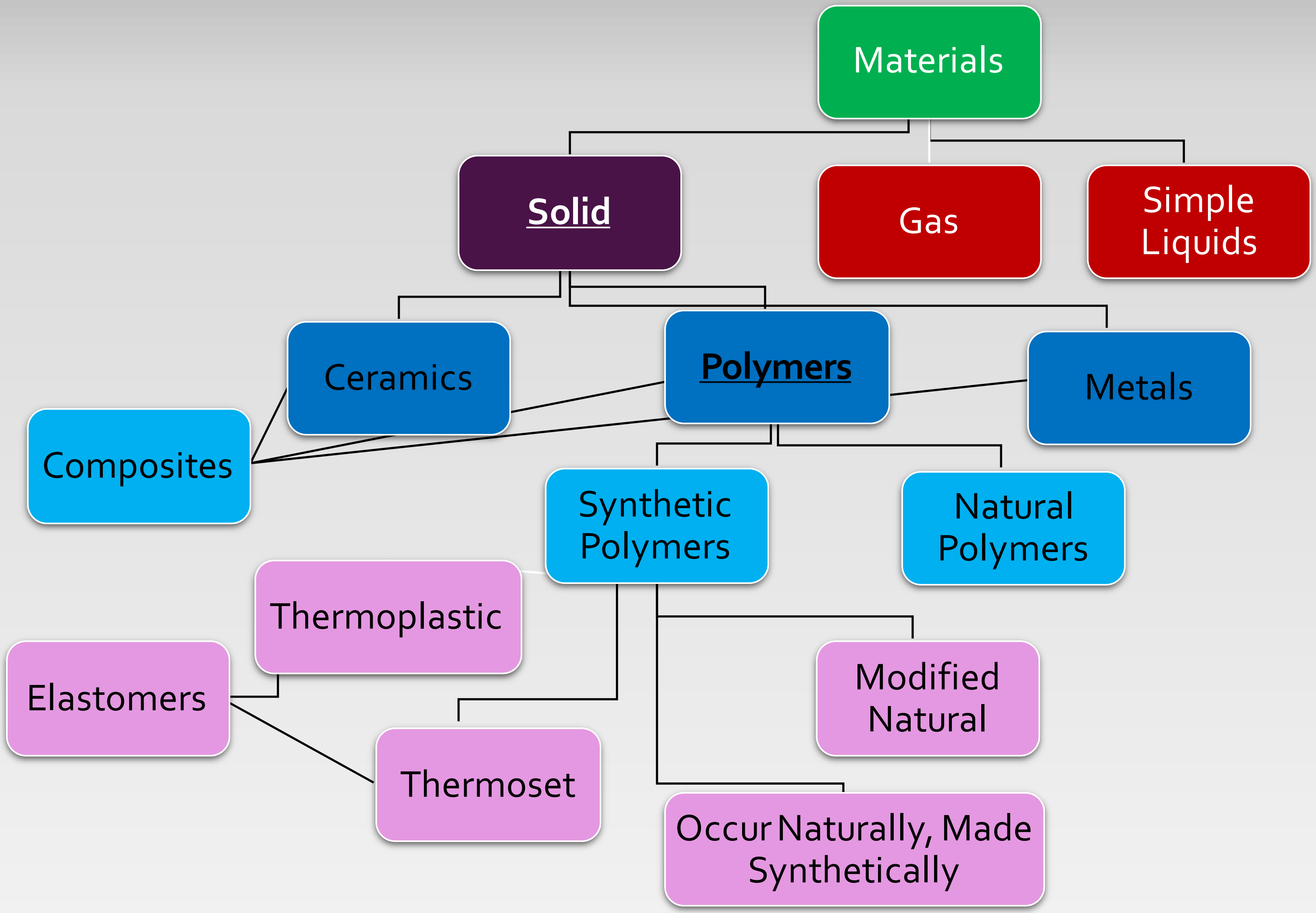


https://www.youtube.com/watch?v=Dug-G9xVdVs

What is a “Polymer”?

What is a “Plastic”?

Classes of Materials



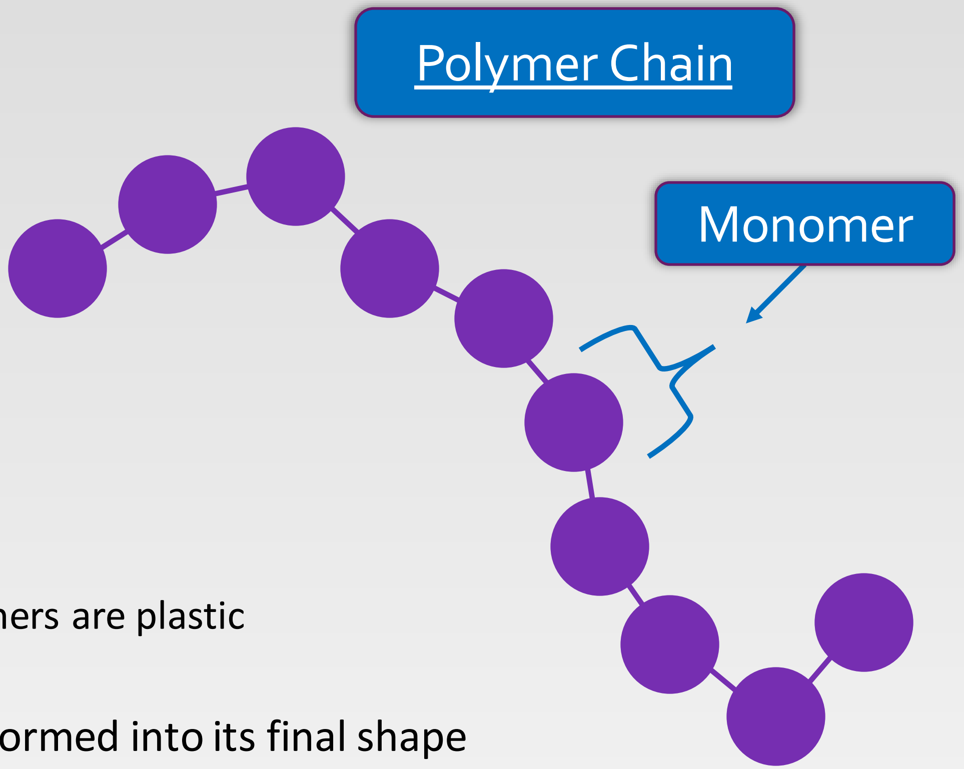
What is Plastic?

Definition

Plastic: a material composed principally of large molecules that are made or modified synthetically

Four Characteristics of "Plastics"

1. Polymers + additives
2. Polymer chain-lengths greater than 2000 g/mole
3. Processed by melt or flow
4. Solid at room temperature



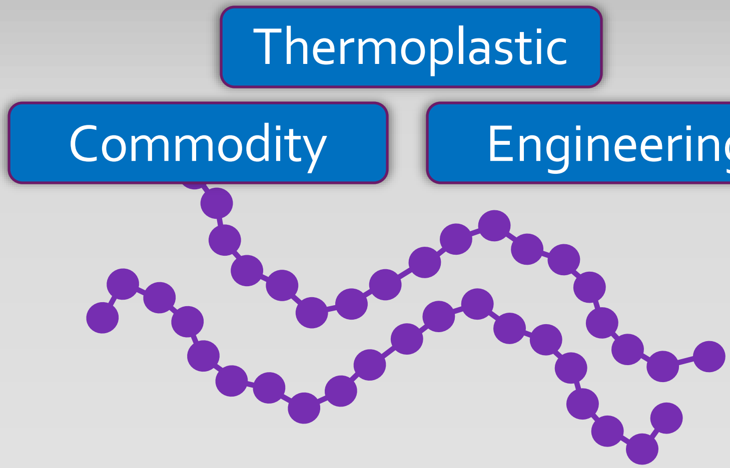
Other Terminology

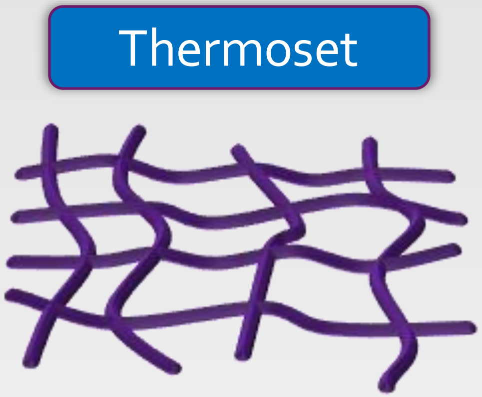
1. Polymer: Greek for "many units"
   - Plastic is polymeric, but not all polymers are plastic
   - Example:
2. Resin: a polymer that has not been formed into its final shape

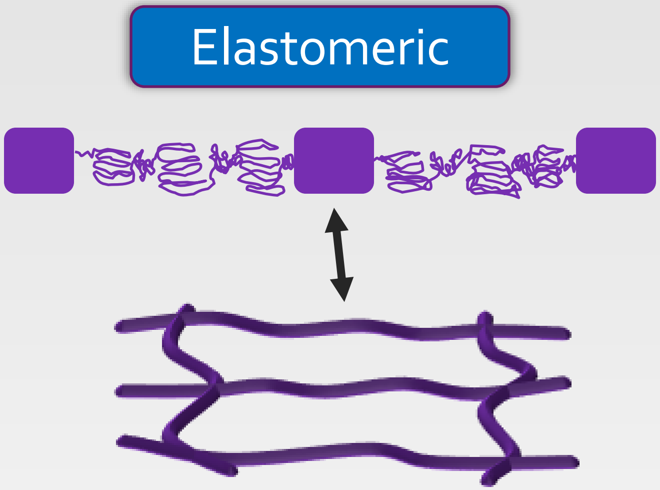
Main Types of Plastic (herein)

Types of Plastic Materials

1. Thermoplastic
   - *Commodity*
   - *Engineering*
2. Thermoset
3. Elastomeric







Why Are Polymeric Materials So Useful?

Advantages

- Inert – corrosion resistant
- Strength to Weight Ratio
- Ease of Processing
- Variety of Manufacturing Processes – Design Flexibility
- Recyclable
- Variety of Transparencies
- Variety of Mechanical Properties – Flexible to Stiff
- Electrical and Thermal Insulator
- Density
- Colors - Aesthetic
- Cost

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- Density
- Colors - Aesthetic
- Cost

Disadvantages

- Non-Degradable
- Mechanical Properties
- Processing Hazards (fumes)
- Low Melt Temperatures
- Non-renewable Resource (petroleum)
- Flammable
- Difficult to Repair
- Chemical Resistance varies
- CTE (Coefficient of Thermal Expansion)

Plastic Properties – IT DEPENDS!

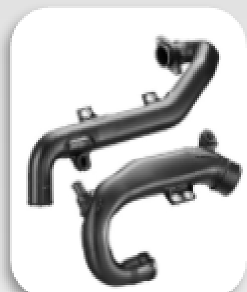
Where is Plastic Used?

Plastic Categories

Plastics

Commodity

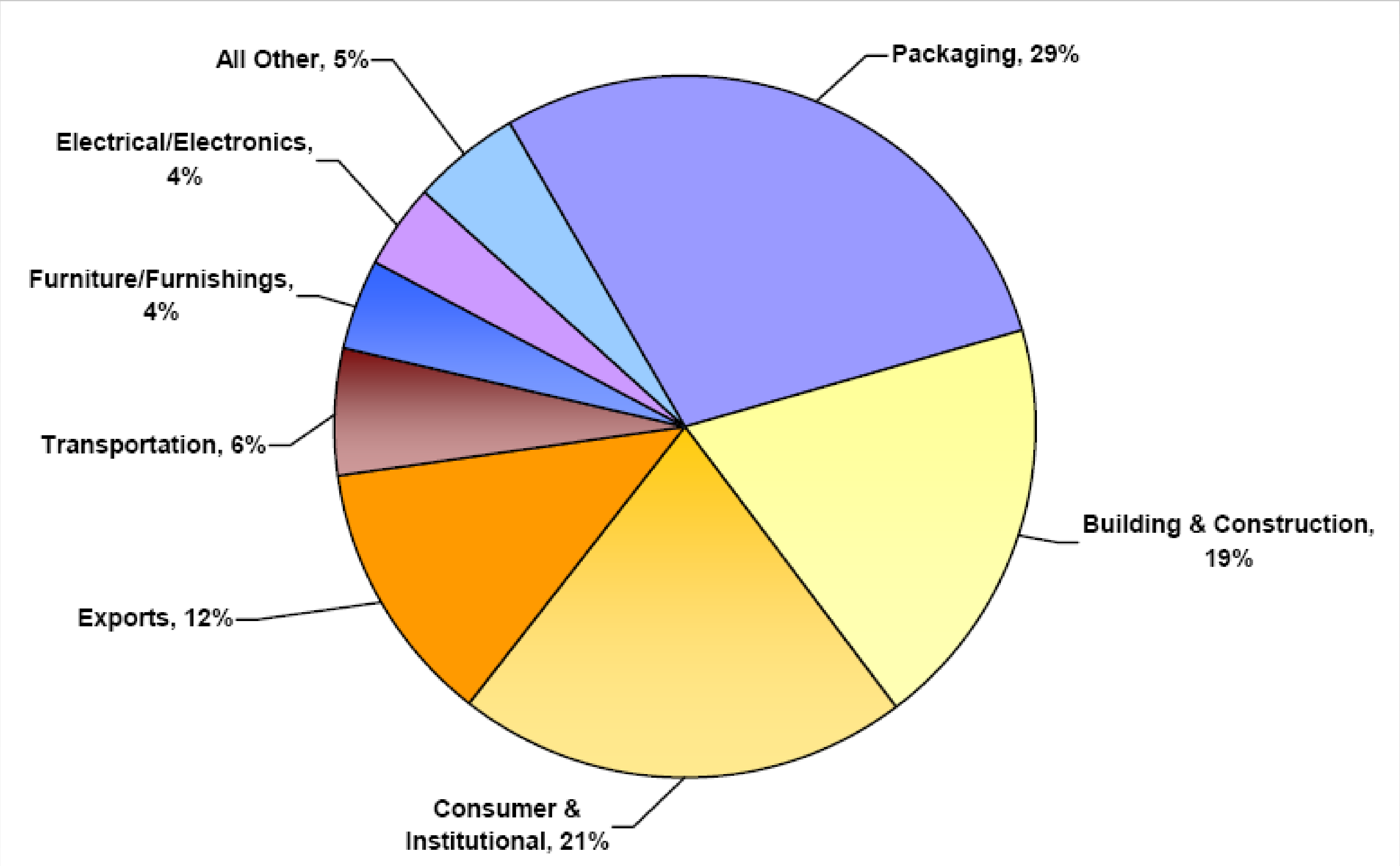
Engineering



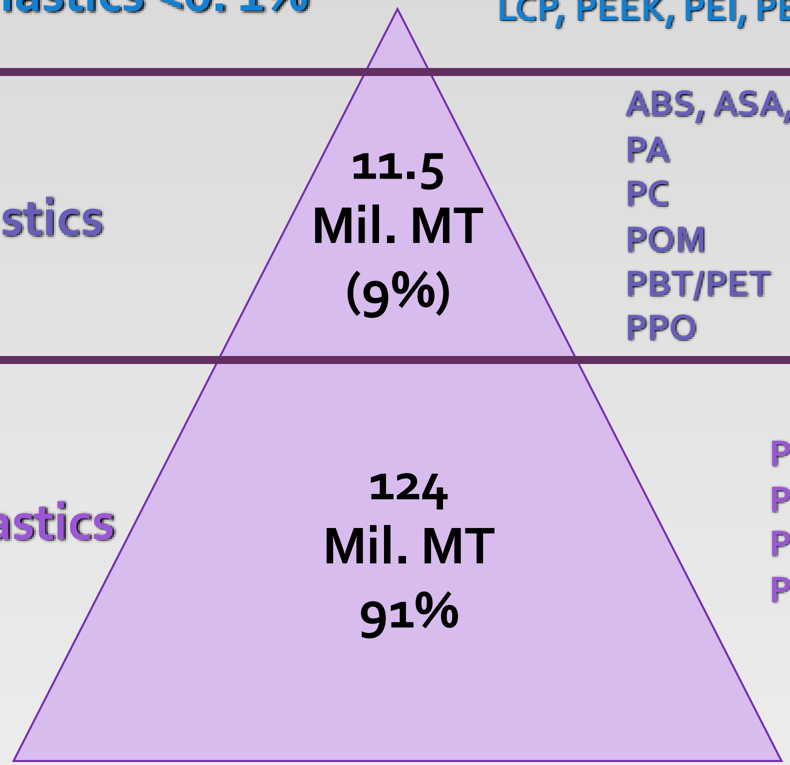
Elastomeric

Thermoset

Major Plastics Markets



The Plastic Demand



	Market	Mil. MT
High Performance Plastics <0. 1%	LCP, PEEK, PEI, PES, PSU	< 0.1
Engineering Plastics	ABS, ASA, SAN	5.8
	PA	2
	PC	2
	POM	0.7
	PBT/PET	0.7
	PPO	0.3
Commodity Plastics	PE	55.5
	PP	30.6
	PVC	27.6
	PS	10.7

www.xmoldpolymers.co.in/Files/Engineering%20Plastics.ppt

Plastics Jobs and Economics

Why Should You Care?

Washington State Jobs

Plastics Industry	
Plastics Materials and Resins	310
Compounding of Resin	40
Plastics Products	9,680
Plastics Machinery	310
Molds for Plastics	240
Plastics Wholesale Trade	440
Captive Plastic Products	2,330
Total Plastics Industry	**13,400**

Washington State Statistics

- Ranked 22nd in industry employment
- Ranked 24th in plastics industry exports
- Plastics industry payroll = $580 million

US Plastic Economics

USA Statistics

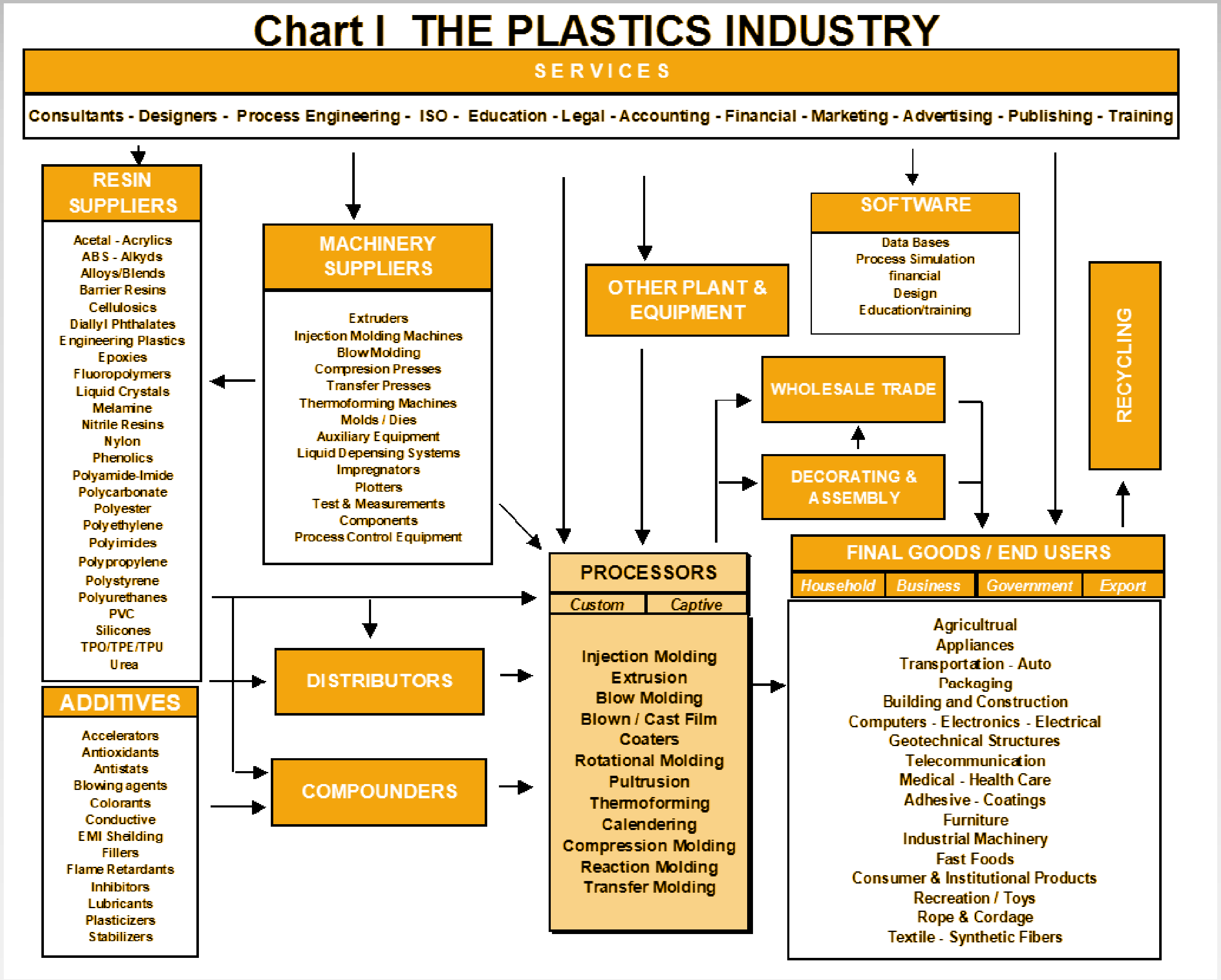
- Directly employs 600,000 people
- $33 billion payroll

Projected Statistics (10 Years)

- 1.1 million people employed
- $47 billion payroll

http://www.plasticsindustry.org/files/PublicPolicy/StateDataSheets/2015/Washington.pdf

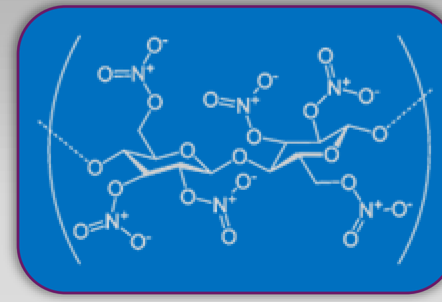
Industries Involved = Jobs



Where Do Plastics Come From?

The Accidental Plastics History

1839: Goodyear and Vulcanization

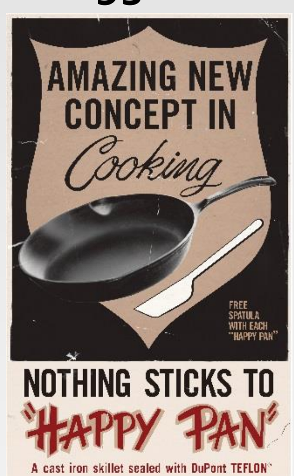


1863: Hyatt and Celluloid

1909: Bakeland and Bakelite

1934: Carothers and Nylon

1938: Plunket and Teflon

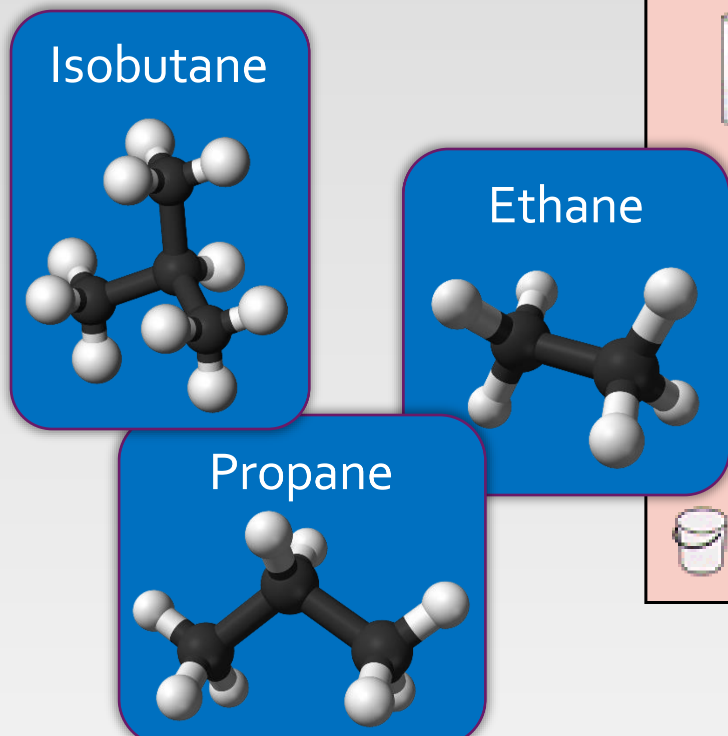


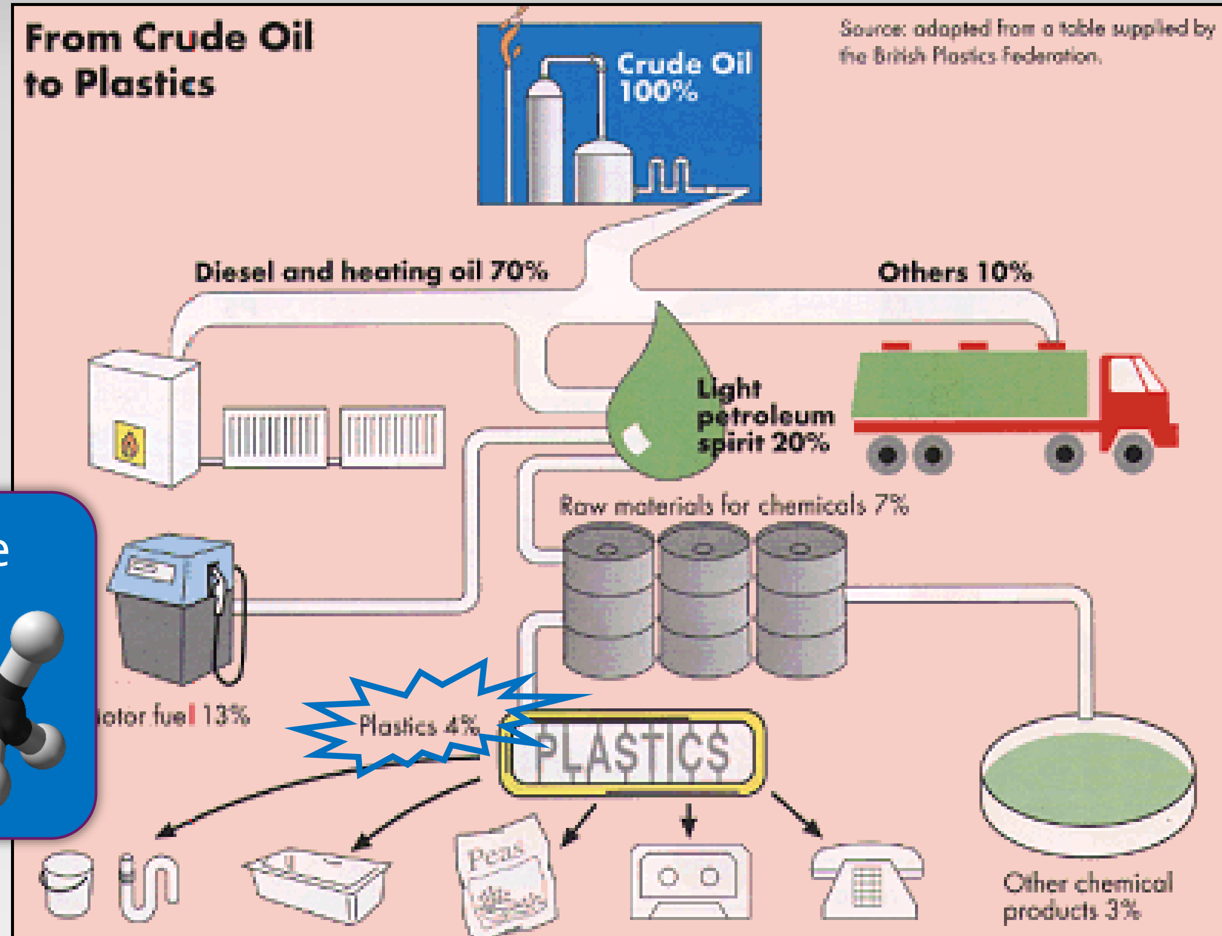
1964: Kwolek and Kevlar

Plastic Origins

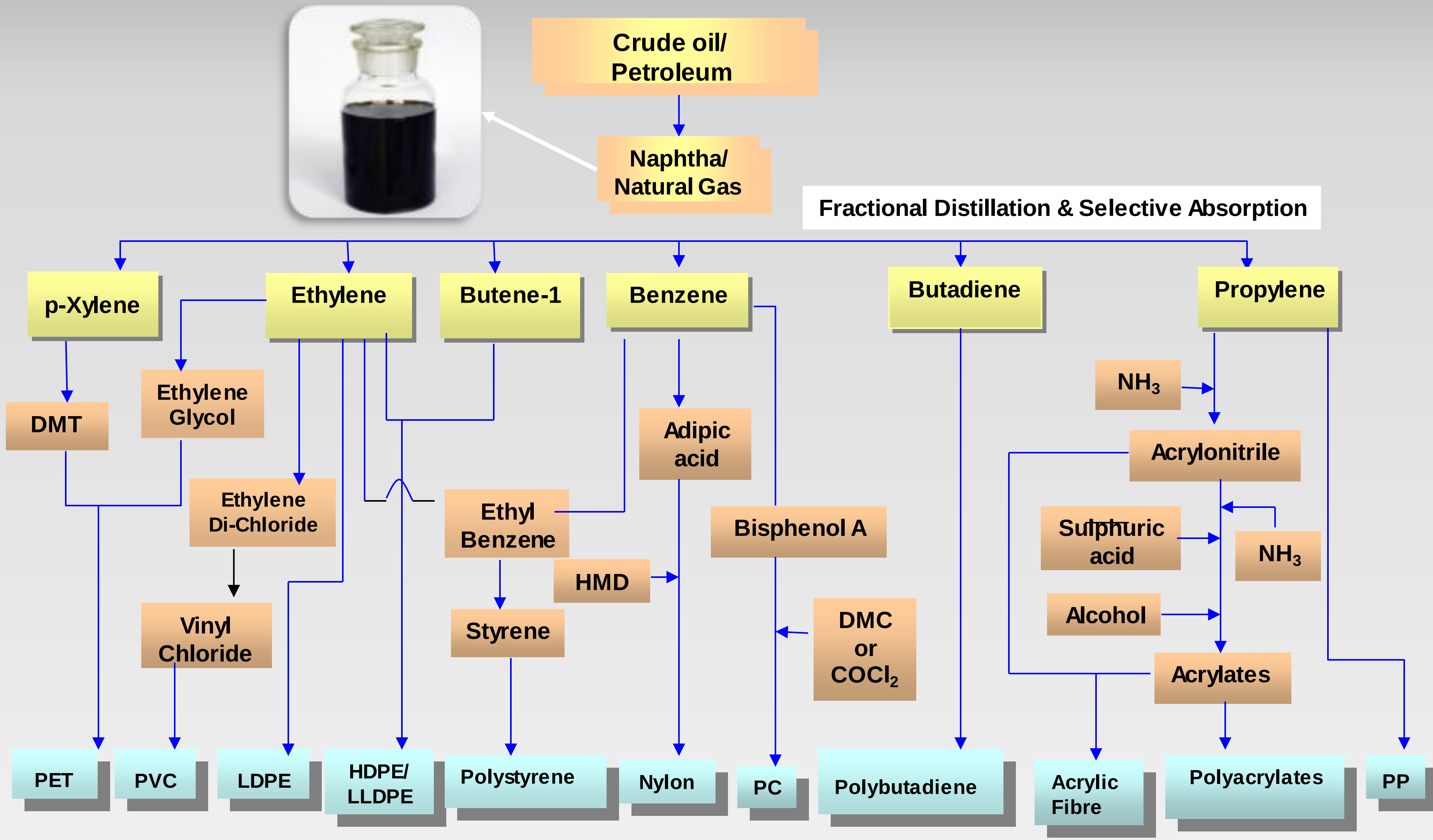
<u>Raw Materials</u>

- Petroleum
  - Propylene (Polypropylene)
  - Isobutylene (Butyl Rubber)
  - Ethylene (PE)





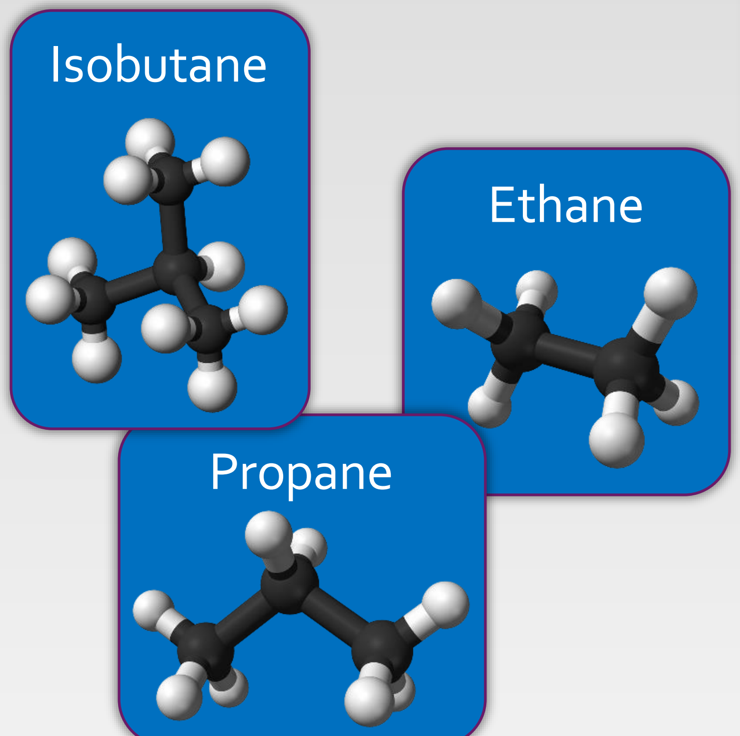
Crude Oil & Hydrocarbons → Plastic

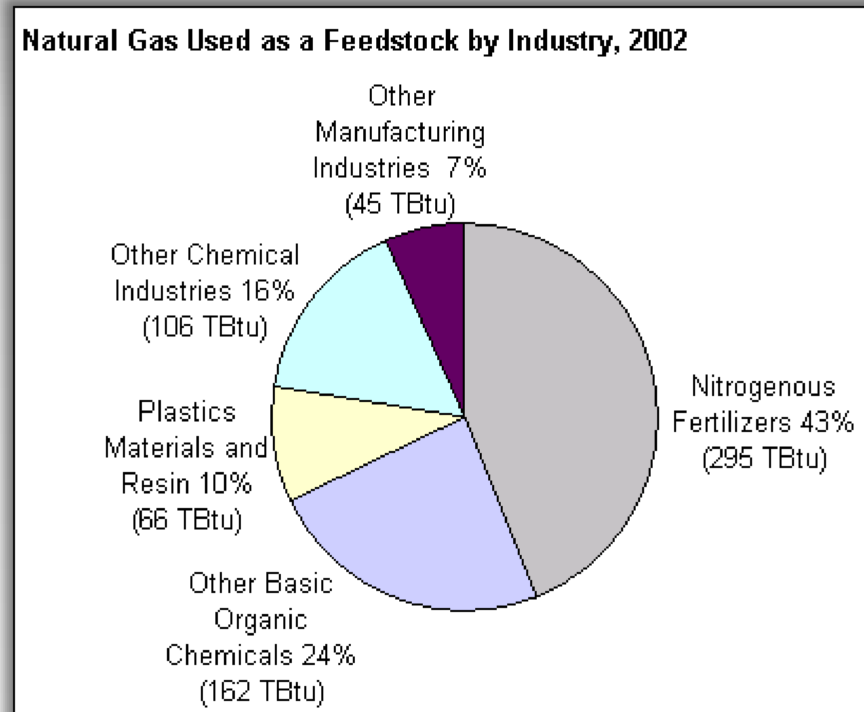


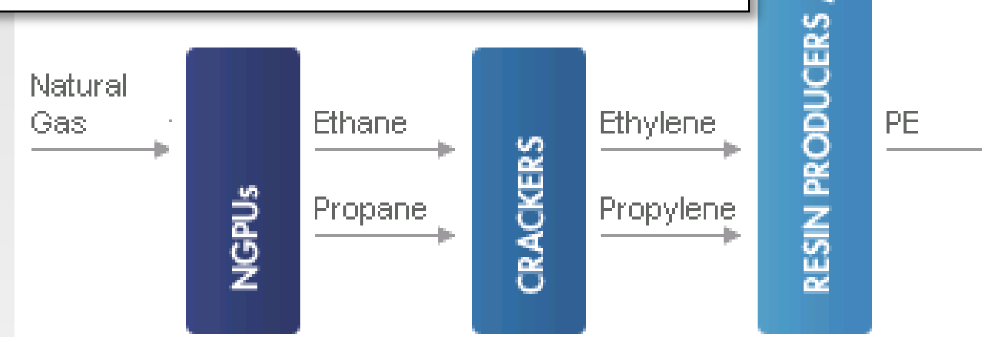
Plastic Origins

Raw Materials

- Natural Gas
  - Ethylene (PE)
  - Propylene (PP)
  - Butylene (Butyl Rubber)



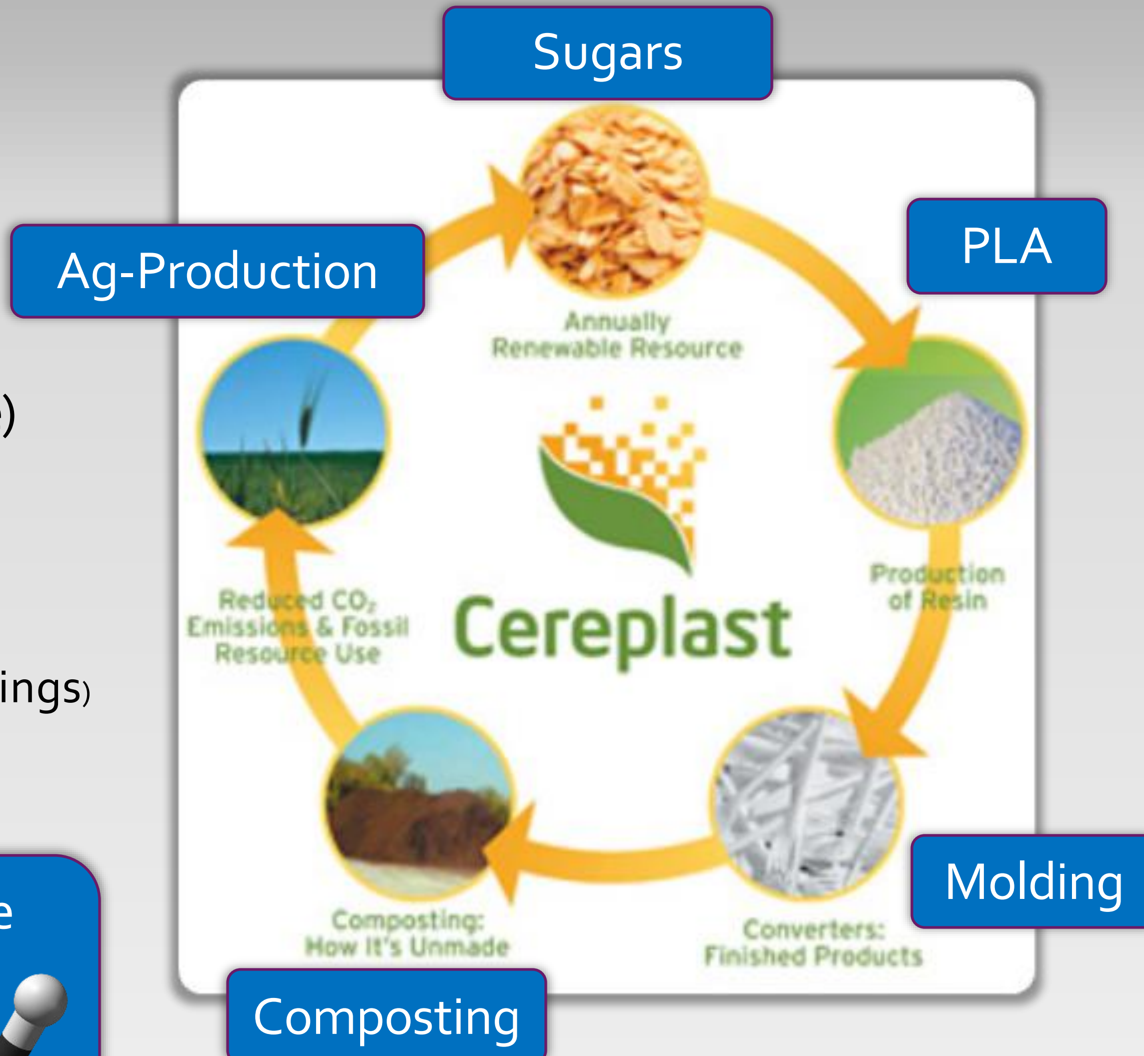


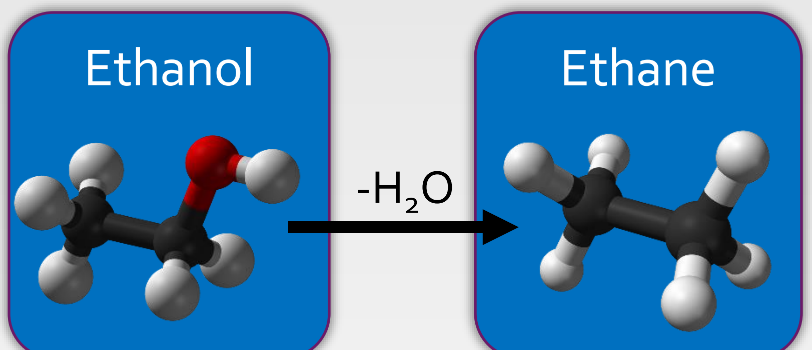


Plastic Origins

Raw Materials

- **"Bioderived"**
  - Ethylene (PE) - *minor*
  - Starch (Packing Peanuts)
  - Cellulose (Cellulose Acetate)
  - Sugars (PLA, PHB, PHA)
  - Natural Oils
    - Castor Oil (PA4,10)
    - Soy Bean Oil (Polyester Coatings)
  - Lignin (Carbon Fiber)





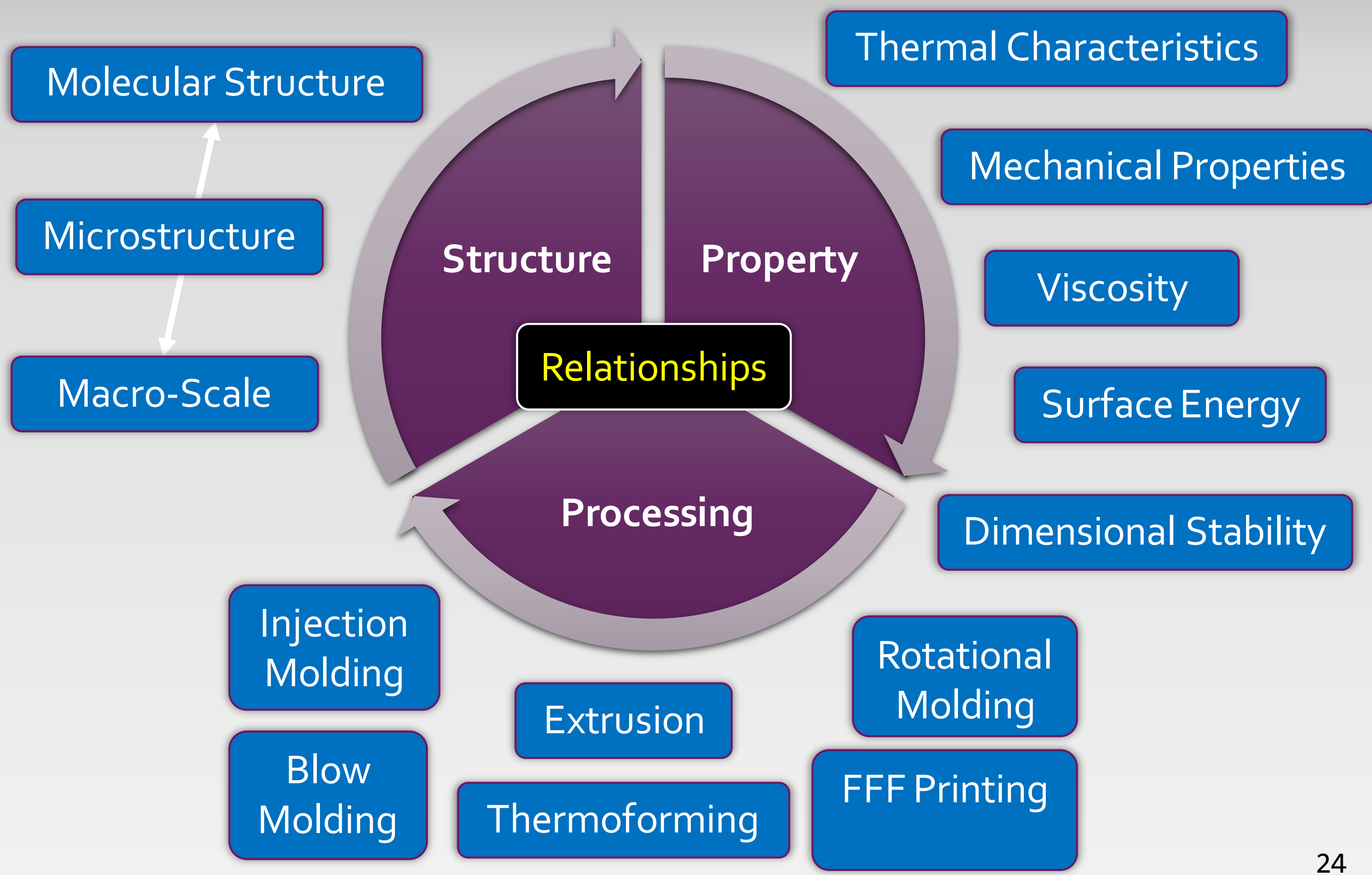
[TetraPak HDPE From Sugar]

The Future of Plastics

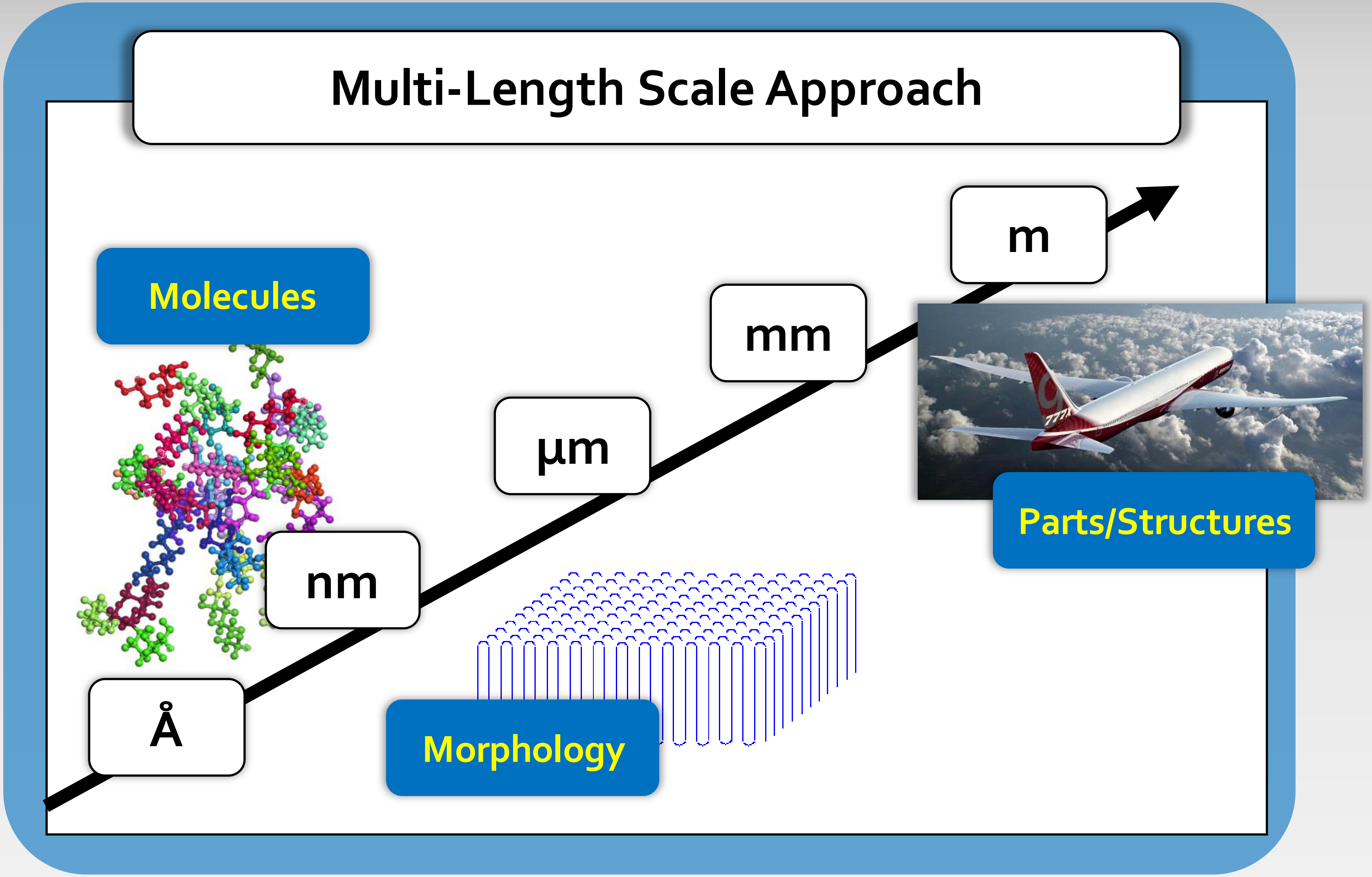
The Future of Plastics…

http://youtu.be/V0jYEbT3Uf8

What's to come in PCE 371



Multiple Length Scales of Properties



Compression Molding

Introduction

In this lab, compression molding of a thermosetting compound (phenolic) will be investigated. Use of thermosets introduces an important consideration into the process: the cure of the thermoset. It is important to examine your parts carefully to determine whether an adequate degree of cure has been obtained.

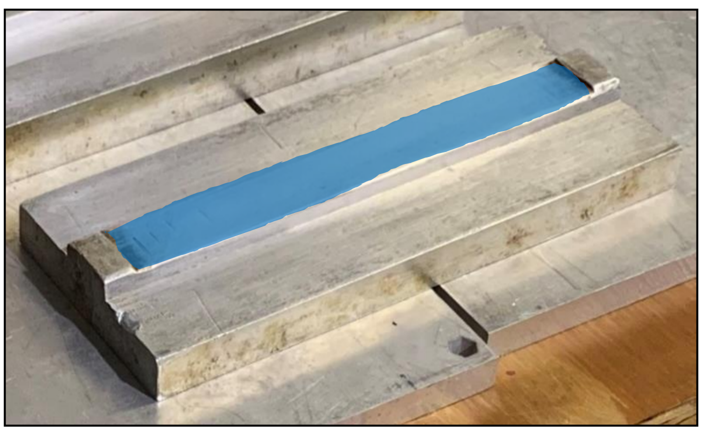
Your primary goals in this lab are to *(1) learn the basics of compression molding, (2) develop an understanding of relationships between process parameters and part quality, and (3) examine the cure process.* To achieve these goals you will perform a series of experiments and test the mechanical properties of your manufactured parts using flexural testing.

Figure 1. Wabash compression molder in PCE labs.

Part 1: Compression Molding

<u>Part 1a: Compression Molder Preparation</u>

1. Turn on the following:
    a. Main power
2. Set platen temperatures to preheat press
    a. Upper and lower = 300 °F
3. Measure mold cavity dimensions, specifically the projected area (seen below in blue)



4. Place mold in press and close to preheat mold
    a. Use as little clamp force as possible (~3 tons)
5. While press is heating, research/obtain a technical datasheet for the phenolic material used in this lab
    a. https://www.plenco.com/technical-data-reports.htm

<u>Part 1b: Compression Force Study</u>

During this study you will vary clamp force applied to the mold and phenolic during compression molding. Parts should be manufactured by changing the force while keeping all other process parameters constant to observe impacts on part weight, quality (consolidation, length of bar, flash, other), and flexural properties.

1. Prepare the mold
    a. Remove from press, place on metal surface, and open

b. Spray mold release on both sides of the mold, making sure to coat the entire mold, not just the cavity

IMPORTANT: Spray mold with silicone release agent! If you do not, mold can be cured shut, damaged, and/or rendered unusable.

c. Don nitrile gloves and weigh **13 grams** of phenolic molding compound
d. Place phenolic in mold, distribute evenly across entire projected area
e. Close mold halves

2. Use the following parameters for the compression force study

Trial Number	Force (tons)	Soak time (min)	Bump time at (min)	Temperature (°F)	Resin mass (g)
1	5	7	3.5	300	13
2	12.5	7	3.5	300	13
3	20	7	3.5	300	13

3. Make 1 part at each setting and make observations about resin distribution, total cycle time, ease of removing from mold, other
4. Take a photo of each bar immediately after molding to report observations visually (**do before trimming!).** Make sure to highlight/discuss the consolidation (degree of cure)
5. Carefully trim each part into a rectangular cuboid (ie. the shape of the mold cavity)
6. Weigh and measure the dimensions of each part after trimming and input the data into the table below:

Trial #	Resin mass (g)	Part mass (g)	Part Volume (cm^3)	Part Density (g/cm^3)	Flex. Modulus (ksi)	Flex. Strength (ksi)	Flex. Strain (%)
1							
2							
3							

7. Test the samples using the 3-point bend fixture and obtain flexural stress, strain, and modulus;
    a. Input the data in the table above
    b. Export the raw data files for plotting in Excel
    c. ***Note: the data from flexural testing may require shifting to obtain proper stress and strain values***

Part 1c: Cure Time Study (CM2, in-person labs only)

During this study you will vary time in which the phenolic cures in the compression molder. Parts should be manufactured by changing the cure time while keeping all other process parameters constant to observe impacts on part weight, quality (consolidation, length of bar, flash, other), and flexural properties.

1. Prepare the mold
    a. Remove from press, place on metal surface, and open
    b. Spray mold release on both sides of the mold, making sure to coat the entire mold, not just the cavity

IMPORTANT: Spray mold with silicone release agent! If you do not, mold can be cured shut, damaged, and/or rendered unusable.

c. Don nitrile gloves and weigh 13 grams of phenolic molding compound
d. Place phenolic in mold, distribute evenly
e. Close mold

2. Use the following parameters for the cure time study.

Trial Number	Force (tons)	Cure time (min)	Bump time at (min)	Temperature (°F)	Resin mass (g)
1	20	5	3.5	300	13
2	20	12.5	3.5	300	13
3	20	20	3.5	300	13

3. Make at 1 part at each setting and make observations about resin distribution, total cycle time, ease of removing from mold, other
4. Take a photo of each bar immediately after molding to report observations visually (**do before trimming!).** Make sure to highlight/discuss the consolidation (degree of cure)
5. Carefully trim each part into a rectangular cuboid (ie. the shape of the mold cavity)
6. Weigh and measure the dimensions of each part after trimming and input the data into the table below:

Trial #	Resin mass (g)	Part mass (g)	Part Volume (cm^3)	Part Density (g/cm^3)	Flex. Modulus (ksi)	Flex. Strength (ksi)	Flex. Strain (%)
1							
2							
3							

7. Test the samples using the 3-point bend fixture and obtain flexural stress, strain, and modulus;
    a. Input the data in the table above
    b. Export the raw data files for plotting in Excel
    c. ***Note: the data from flexural testing may require shifting to obtain proper stress and strain values***

Part 1: Compression Molding Results and Discussion

Tabulate all results and discuss all process variables and data. Identify the important process variables and their effects on product quality, as well as any relationships between variables. Discuss any unusual characteristics of the materials and molds used that you observed. Think about how the curing process impacts the parts in each of the discussion points below.

1. Calculate the pressure on the phenolic compound during molding at each force. Describe why it is important to know the pressure on the material compared to the force.
    a) ***Equation:*** Pressure = Force * Projected Area
    b) ***Table:*** include, trial number, projected area, force, and calculated pressure
2. What were the effects of clamp force on the part quality? What responses (part density, stress, strain, modulus, quality) were most impacted by clamp force and which were least impacted? Why? How does part density compare to the theoretical material density? How do your part properties compare to the properties found on the technical data sheet? Discuss.
    a) ***Figures:*** *Part Density vs. Clamp Force, Stress vs. Clamp Force, Strain vs. Clamp Force, Modulus vs. Clamp Force*
    b) ***Image:*** *all parts, highlight resin distribution and degree of cure/consolidation*
3. What were the effects of cure time on the part quality? What responses (part weight, stress, strain, modulus, quality) were most impacted by clamp force and which were least impacted? Why? How does part density compare to the theoretical material density? How do your part properties compare to the properties found on the technical data sheet? Discuss.
    a) ***Figures:*** *Part Density vs. Cure Time, Stress vs. Cure Time, Strain vs. Cure Time, Modulus vs. Cure Time*
    b) ***Image:*** *all parts, highlight resin distribution and degree of cure/consolidation*

4. Discuss any other important observations you have made regarding the compression molding process.

Part 2: Compression Molding Thermoplastics

Obtain a thermoplastic powder from the lab technician or TAs (acrylic, UHMWPE, recycled HDPE). Using a technical data sheet from an online source and information gained from your Part 1 experiences, mold the thermoplastic into a high quality part. You may use either the flexural specimen mold or any other mold next to the compression molder. Provide a table of your molding parameters. Discuss your molding parameters, part quality, and differences between molding thermosets and thermoplastics (for instance: do you need a bump step?). Use research to support your claims.

Injection Molding: ABS and Recycled ABS

Introduction

Injection molding is one of the most common methods of processing and manufacturing with plastics. Part quality depends on a large number of process variables, many of which interact with one another. In this lab you will gain familiarity with the injection molding process. Pay particular attention to the process variables and how they influence the results. Mechanical recycling is a process of reusing thermoplastic materials by reprocessing them into products without modifying chemically them during recycling. In this lab you'll use equipment that is common to processing and characterization of mechanical recycling.

Your primary goals in this lab are to *(1) learn the basics of injection molding, (2) develop an understanding of relationships between process parameters and part quality, and (3) study the differences between virgin ABS and recycled ABS using MFI and tensile testing.* To achieve these goals you will perform a series of experiments and measure/test manufactured parts from injection molding. You'll then recycle ABS and test its properties.

Figure 1. Newbury injection molding machine in the PCE labs.

Part 1: Injection Molding

<u>Part 1a: Injection Molding Preparation</u>

1. Fill-in the Newbury Injection Molder processing log.
2. Turn on the following:
    a. Main power
    b. Water
    c. Hopper dryer
    d. Hydraulic motor/pump
    e. Snorkel vent

<u>Part 1b: Shot Size Study (IM1)</u>

During this study you will vary the amount of material being injected into the mold, or the shot size. Parts should be manufactured by changing the shot size while keeping all other process parameters constant to observe impacts on part weight and quality (flash, short, surface quality).

1. Set the following injection molding parameters:
    a. Zone 1 – 450 °F

b. Zone 2 – 470 °F
c. Zone 3 – 450 °F
d. Cooling time – 15 seconds
e. Injection Time – 3 seconds
f. Screw Speed – Middle of dial
g. Injection Pressure – Middle of dial (8000 psi)

2. Vary the shot size using the following table. Make at least 3 parts at each setting to ensure consistency:

Sample Number	Shot Size inch	Avg. Part Mass grams	Observations
1	0.75		
2	1.00		
3	1.25		
4	1.50		

3. Weigh part mass before trimming the parts.

4. Discard parts in recycling bin after measurements and observations are taken.

<u>Part 1c: Screw Speed Study (IM2)</u>
During this study you will vary the shear rate the material experiences during refilling the barrel by changing screw speed. Parts should be manufactured by changing the screw speed while keeping all other process parameters constant to observe impacts on part weight and quality (flash, short, surface quality). You will need to test the parts for their tensile properties.

1. Set the following injection molding parameters:
    a. Zone 1 – 450 °F
    b. Zone 2 – 470 °F
    c. Zone 3 – 450 °F
    d. Injection Time – 3 seconds
    e. Cooling time – 15 seconds
    f. Screw Speed – Lowest value on dial
    g. Injection Pressure – Middle of dial (8000 psi)
    h. Shot Size – ***optimal from Study IM1***

2. Vary the screw speed using the following table. Make at least 2 parts at each setting to ensure consistency:

Sample Number	Screw Speed -	Screw Speed rpm	Avg. Part Mass grams	Observations
1	Low			
2	Mid-Low			
3	Mid-High			
4	High			

3. Weigh all parts and record data.

4. Recycle ABS tensile bars in recycling bin in lab.

Part 1d: Injection Pressure Study (IM3)

During this study you will vary the injection pressure the material experiences during the injection phase. Parts should be manufactured by changing only injection pressure while keeping all other process parameters constant to observe impacts on part weight and quality (flash, short, surface quality). You will need to test the parts for their tensile properties.

1. Set the following injection molding parameters:
    a. Zone 1 – 450 °F
    b. Zone 2 – 470 °F
    c. Zone 3 – 450 °F
    d. Injection Time – 3 seconds
    e. Cooling time – 15 seconds
    f. Screw Speed – ***optimal from Study IM2***
    g. Injection Pressure – low end of dial (2000 psi)
    h. Shot Size – ***optimal from Study IM1***
2. Vary the injection pressure using the following table. Make at least 2 parts at each setting to ensure consistency:

Sample Number	Injection Pressure -	Injection Pressure psi	Avg. Part Mass grams	Part Length in	Observations
1	Low				
2	Mid-Low				
3	Mid-High				
4	High				

3. Once parts are fully cooled, weigh and collect data on part length (pick one cavity to measure).
4. Recycle broken ABS tensile bars in recycling bin in lab.

Part 1d: Optimizing Cycle (IM4)

In this study you will manufacture tensile bars using your optimized conditions found from the previous studies. Try and minimize the cycle time by reducing the cooling time. Manufacture 10 tensile bars. Keep all parts made for testing in Part 2.

Part 1: Injection Molding Results and Discussion

Tabulate all results and discuss the optimal values of the process variables. Identify the important process variables and their effects on product quality and cycle time, as well as any relationships between variables. Discuss any unusual characteristics of the materials and molds used that you observed.

1. What were the effects of shot size on the part quality? How did you decide what shot size was appropriate for the remaining molding trials? What was the relationship between shot size and part mass? Where did flash occur? Why?
    a) ***Figures:*** *Part Mass vs. Shot Size*
    b) ***Image:*** *all shots lined up to show difference*
2. What were the effects of screw speed on the part quality? How did screw speed, and therefore shear rate, impact the part mass? Were there any defects observed? Where and why? How were the mechanical properties impacted by screw speed? How did you anticipate screw speed to impact part quality? Why?
    a) ***Figures:*** *Part Mass vs. Screw Speed*

3. What were the effects of injection pressure on the part quality? How did pressure impact the part length? Were there any defects observed? Where and why? How did you anticipate injection pressure to impact part quality? Why?
    a) ***Figures:*** *Part Mass vs. Injection Pressure, Part Length vs. Injection Pressure*

4. What parameters were chosen to manufacture optimized parts? Why? What was the cycle time of your optimized parts? Would there be any way to lower the cycle time further? How? How consistent was the length of the 10 parts made? What led to consistency and what led to variation?
    a) ***Table:*** Manufacturing parameters for optimized parts
    b) ***Figures:*** Part length vs. part number (x-axis should contain 10 parts)
    c) ***Images:*** *Final, optimized part*

Part 2: Mechanical Recycling

<u>Part 2a – Manufacturing 100% Recycled ABS Samples</u>

Obtain regrind ABS and use your parameters from the optimization study to manufacture 100% recycled tensile bars. Make 10 bars. Note any defects or other observations to compare virgin vs. recycled in the Discussion section of your lab report.

<u>Part 2b – Recycled ABS Characterization</u>

Tensile Testing:

1. Use the ASTM tensile bar and the tensile testing procedure described in Lab 1.
2. Collect data from 3 tensile bars per material (virgin and recycled).
3. Export the raw data as a text file for importing into Excel for analysis.

Part 2: Mechanical Recycling Analysis

Analyze the collected recycling data and compare to the virgin material. Discuss how having recycled materials impacts the properties of ABS.

1. What can be said about the "processability" of the recycled ABS? Does it appear to change with recycled content? Why?

2. What are the mechanical properties of each material? How did the mechanical properties change going from virgin to 100 wt% recycled ABS? Why? What information is shown by the error bars? Why is there error and what does that say about the test/materials?
    a) ***Figures:*** *Overlay of each material's stress vs. strain curve (pick one representative curve from each material, plot should have 2 stress v. strain curves properly labeled)*
    b) ***Tables:*** *Average mechanical properties with standard deviations of each material*

Name________________________________ **PCE 431 – Homework 1** **/50**

1. Distributive Mixing
   a. **Calculate the striation thickness (μm)** during the processing of a mixture of organic dye in PMMA in four different zones (below) of a single screw extruder equipped with a distributive mixing head. The process's mass flow rate and residence time in each screw section is constant at 100 grams/min and 30 seconds, respectively. **Show your work as an Excel table**. (6 pts)
   Hint: use the simplified version of the shear rate equation provided

Screw Section	**Flow Path Radius mm**
Compression	3
Metering	1.5
Metering	0.5
Metering	0.1

   b. An average flow path radius of 0.5 mm in the mixing section of a single screw extruder is common, but this does not lead to a high shear rate and requires long residence times to ensure good mixing. Using the given information, **calculate what the minimum residence time (s) is to ensure a striation thickness that will provide a glossy material**. Show your work as an **Excel table**, a **plot of *striation thickness vs. residence time*** and include the **equation used to calculate minimum residence time.** (6 pts)

   Mass Flow Rate = 100 grams/min
   Flow Path Radius = 0.5 mm

2. Dispersive Mixing
   a. Carbon black is one of the most common additives used in industrial polymer compounds and it comes in many varieties. **Calculate the critical separation distance** for carbon blacks with the following properties (4 pts):

Radius (nm)	**Bulk Density (kg/m^3)**
14	50
1000	1000

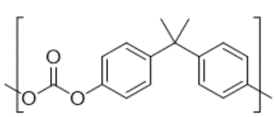
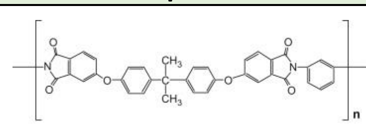
   b. Describe your results for both varieties of carbon black. Think in terms of the properties governing dispersive mixing and the parameters of critical separation distance (4 pts).

3. Thermodynamics of Polymer Solubility
   a. **Predict the solubility of poly(carbonate) and poly(ether imide) at two different temperatures (RT and melt)** from volume fractions of 0-1 using the Flory-Huggins equation and the following parameters. **Submit a neatly formatted Excel spreadsheet** that calculates the **solubility parameters, χ, and ΔG_{mix}**. Plot (on neatly formatted graphs), **ΔG_{mix} vs. PC volume fraction for both temperatures.** (10 pts)

   b. Describe your results using the following questions (8 pts):
      i. Are the solubility parameters close in value? Is this enough to understand how soluble the blends are? Why or why not?
      ii. Do you think χ, the interaction parameter, is a better predictor of solubility compared to the solubility parameter? Why or why not?
      iii. The plot created (ΔG_{mix} vs. ϕ_1) is a version of a phase diagram. What can we glean from the curve shapes and relative magnitudes? Why are they different? If the polymers were to phase separate, what part of each plot would show 2-phase systems versus 1-phase?
      iv. Across all volume fractions, is the magnitude ΔG_{mix} at 303 K large? Describe the impacts of this on the polymer blend and the types of morphologies that might form.

   Hint: *Molar volume of PC (V_1) should be used*.
   Hint: Use the Hoy group attraction constants from the in-class practice problem.
   Hint: Plot the graphs separately as lines not data points so you can make better qualitative observations.

PC			**PEI**			**Constants**		
ϕ_1 vol/vol%	**M_{w1} g/mol**	**ρ_1 g/cm^3**	**ϕ_2 vol/vol%**	**M_{w2} g/mol**	**ρ_2 g/cm^3**	**T K**	**k kcal/K*mol**	**R cal/K*mol**
0 - 1	58500	1.2	0 - 1	62700	1.28	303	1.987*10^{-3}	1.987
Repeat Unit			**Repeat Unit**			616		

4. Thermodynamics of Solids Dispersion
   a. Using the KRUSS Application Report on Canvas, **calculate the free energy of dispersion**, ΔG_d, for the following material formulations:
      i. Melamine-Formaldehyde and Untreated Carbon Black
      ii. Melamine-Formaldehyde and Highly Treated Carbon Black

      Include an Excel table here showing your work and results. (6 pts)

   b. Describe your calculation results in terms of thermodynamic quantities. Think in terms of the additive and polymer's chemical structures and the differences between treated and untreated. *Hint: look up melamine-formaldehyde and carbon black chemical structures.* (6 pts)

Name: **PCE 431 – HW 3** **/60**

1. What factors impact the migration of plasticizers during a polymer's application? How could this driving force be reduced to minimize migration using the thermodynamics of mixing? (6 pts)

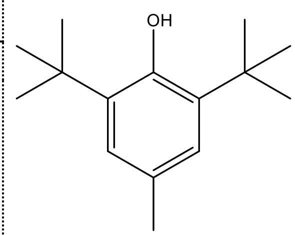
2. Using a silane coupling agent, how would each solid additive be compatibilized with the given polymer? Provide the reactive organic group (Y) and the silicone groups (X). (8 pts)

Polymer Matrix	***Additive/Filler/Reinforcement***	***Silane Functional Groups Y & X***
Poly(propylene)	TiO_2	
Nylon 6, 6	Mica	
Epoxy-Amine Network	$Al(OH)_3$	
Polyester Network	Glass Fiber	

3. Describe/show how the following flame retardants work to disrupt the fire triangle and prevent flame spread. (6 pts):
   - Phosphates
   - Heat Sinks
   - Intumescents

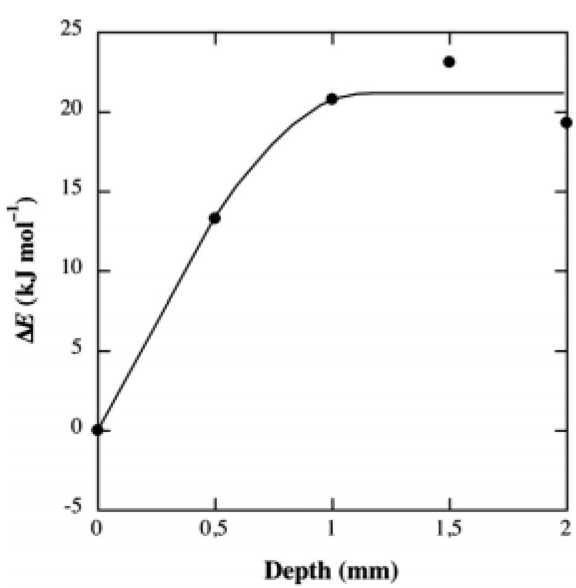
4. BHT was compounded into PC to improve its oxidative stability while in-use as a windshield on an ATV.

   a. Using the data provided below, predict the oxidative induction time in days for the PC compound while being used at 20 °C. Show your work as Excel data/tables/graphs. (8 pts)

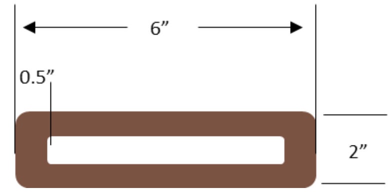
Temperature °C	Time min	BHT
200	34.58	
215	29.88	
230	15.41	
245	12.69	
260	8.23	

   b. How can the efficiency of BHT be increased to increase the OIT to higher values? Show in terms of antioxidant chemical structure and describe. You can draw by hand or use chemical structure drawing software (https://www.acdlabs.com/resources/freeware/chemsketch/). (6 pts)

   c. The figure to the right shows ***activation energy*** for oxidative induction time as a function of the windshield's thickness (x-axis: 0 mm refers to surface of windshield, 2 mm refers to center of windshield cross section). The data shows that the antioxidant's efficiency decreases as a function of wall thickness (part surface has lowest activation energy, part mid-plane has highest activation energy). Describe this obseravtion. (6 pts)



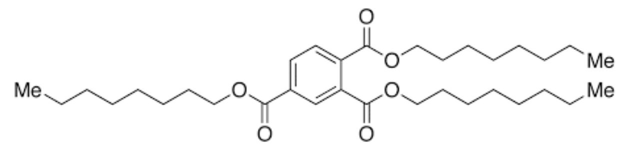
5. Cat's Lumber Empire is in the beginning stages of launching a composite lumber division that compounds and manufactures 2"x6" construction planks from recycled HDPE, PET, and wood flour. The composite lumber is planned to be used for replacement of virgin wood lumber and therefore needs to have high mechanical properties and low density. An image of the lumber cross-section is to the right. You've been brought on as the materials and process engineer to set-up and optimize the compounding and manufacturing processes.



After setting up your TSE line and running the first few trials, you find that the wood flour is distributed and dispersed in the blend, but HDPE and PET are not mixing well and the lumber does not have the high mechanical properties that are desired. You find that the blend morphology is highly lamellar and to achieve better mechanical properties you predict you need a gyroid or island-sea morphology. Describe and show how you would compatibilize the HDPE and PET. Provide the following:

- Fundamentally, why are the two materials not solubilizing and forming lamellar morphology? Quantify/justify your answer.
- Materials needed for compatibilization and why
- Chemically, why will your material(s) lead to compatibilization? Show chemical structures before and after compatibilization
- how they will be synthesized/compatibilized, and why this is the best choice. (12 pts)

6. Show/describe the following about plasticizers (8 pts):
   a. How do plasticizers work? Describe.
   b. What drives plasticizer migration below a polymer's glass transition temperature?
   c. <u>Anti-Fogging Agents</u>: How does an anti-fogging agent work? What chemical properties are required, such as those of trimellitate esters or other plasticizers, to reduce fogging?



Material & Process Design Project Handbook

PCE 431, Winter 2022

Each team of 3-4 students will be designing a material formulation that has specialized properties for a specific application. Each team will also complete a series of processes/experiments to better understand the effects of formulation changes and/or processing on the properties of the formulated material. To meet these two goals, each team will complete a literature review, create specifications, develop a designed experiment, process the material, characterize the material, and then report on the results. The formulation must include at least one polymer and at least one additive. You must use at least one process to mix the formulation and create; many groups will need secondary processes to prepare materials and/or manufacture specimens.

1. **Project Statement** (10 pts) - **group**
   a. Sponsor information
   b. Problem statement – "30,000 ft" view of project, overall goals, and why it is important in your own words
   c. What is currently known about the project/problem
   d. What is currently known about the ingredients, factors, and responses

2. **Literature Review** (50 pts) – **individual/group** – At least five summaries of scholarly works (journal articles, books, professional magazines, conference proceedings) and no more than three of these can be unreviewed sources (white papers, technical bulletins, supplier information). Group **members may not use the same sources**. However, you may submit this as a single document, but please be sure to identify who's sources are who's. Note: these citations should provide adequate background about your problem, ingredients, processing, and/or characterization techniques for your responses. You will be graded on how well the literature reflects your project. The literature review and summary should include:
   a. At least five summaries comprising:
      i. At least one book citation (ebook or print)
      ii. No more than three unreviewed sources (websites, technical/white papers, etc.)
      iii. At least one review of mfg. process(es) related to your project
      iv. At least one review of material(s) related to your project
   b. Citation (properly formatted, use ACS Style Guide, http://www.jlakes.org/ch/web/ACS-StyleGuide.pdf)
   c. Paragraph summarizing what the paper was about, how the paper is helpful/related to your project, and all processing/characterization techniques that were utilized
   d. Key figure(s) from the citation along with an explanation of how data was acquired and useful to your project
   e. Other required information in literature review not included in eight summaries
      i. Material data sheets, both technical (TDS) and safety (SDS)
         1. Discuss any safety hazards that need to be addressed
      ii. Common chemical structures of materials being proposed/utilized
      iii. Reaction pathways (**if reaction is occurring**)

3. **Benchmark** (25 pts) – **group** – Identify **all properties** that are important for the project along with **all possible** characterization techniques. Down select properties and characterization techniques and justify why each were selected. Quantify benchmark value/range for each property/condition that will be included in the investigation along with a justification (**include references**). These benchmark values are your material/process specifications.

   Each student in group must characterize a different property and analyze it using statistical analysis techniques. Identify who is responsible for each specific property/technique.

4. **Equipment Plan** (50 pts) – **group** – Describe what equipment will be used to ensure appropriate mixing and to create the appropriate specimen shape for characterization (likely 2 different processes). Justify this decision (use references and/or remind me of your constraints). Ensure to include the following:
    a. Mixing equipment and machine parameters (barrel ID, screw OD, types of screw elements, temperature capability, max torque, max pressure, feeder rate ranges, etc.)
    b. Equipment used to dry materials (if needed)
    c. Auxiliary equipment such as feeders, pullers, winders, quality control (describe machine parameters and ranges)
    d. Dies, molds, tooling required for compounding and specimen fabrication
    e. Secondary processing equipment for material preparation and specimen fabrication

5. **Experimental Design & Characterization Plan** (25 pts) – **group** – Design an experiment that uses DOE principles and/or statistical analysis to evaluate your formulations/processes. Provide, describe, and justify the following:
    a. Type of experimental design and statistical analysis to be performed after data collection (with justification)
    b. Discussion of the factors chosen (with justification)
    c. Factor levels chosen (with justification, quantified, references)
    d. Number of repeats and/or repetitions (with justification)
    e. Describe properties/responses chosen and how you will characterize each
        i. Include the volume/mass for the specimen for that technique (used to calculate the quantity needed for ingredients).
    f. Tables with factors, levels, and responses (and coded and uncoded if DOE used)

Table 1. Common analysis and characterization techniques (not an exhaustive list).

Category	**Examples**			
Thermal Analysis	DSC	TGA	DMA	
Microscopy	SEM	Image J	UV Vis	Optical Comparator
Viscosity	Rheometer	Melt Index	Brookfield Viscometer	
Surface	AFM	Goniometer	Profilometer	
Composition	NMR	EDX	GPC	FTIR
Mechanical	Strength	Modulus	Hardness	HDT
Other	Conductivity	Solubility	Dimensional	Spectrophotometer

6. **Formulation & Processing Plan** (25 pts) – **group** – Provide a description of your planned formulation. Include the following:
    a. Table which includes: ingredients list, quantity needed for experiment, quantity in-house, approx. cost
    b. Chemical structures (generic if exact not known) of ingredients
    c. Calculations/measurements to show predicted solubility/compatibility of ingredients for **<u>all</u>** experimental runs
    d. Create a compounding run list (table form) relevant to your project. It may include some or all of the following:
        i. Run identification number
        ii. Material concentrations
        iii. Processing parameters
        iv. Process control responses (like pressure, torque, die temperature, avg. residence time)
        v. Other important data to collect during processing (qualitative observations, feeder rates, etc.)

Table 2. Example of ingredients list table.

Ingredient	**Quantity**	**Supplier with contact info**	**~Cost**	**Have or Need?**
Extrusion grade PP	35 lbs	Filtrona Scott.Luedke@filtrona.com	$0.70/lb	Have
Antioxidant	1 lb	Cargill John Harris (800) 566-0145	$13.00/lb	Need – 2 week lead time
¼" long fiberglass	15 lbs	PPE (888) 787-1200	$2.20/lb	Have

7. **Compounding Report** (100 pts) – **group** – Submit a memo that includes descriptions and analysis of the following:
   a. Brief introduction of project
   b. Summary table(s) of the experiment with all runs, materials, and parameters
   c. Description of all process equipment and set-up used versus what was planned
      i. Diagram(s) of process(es) (See Fig. X below)
   d. Describe and include data of feeder calibrations
   e. Processing conditions from TDS and what you used (use a table)
   f. Any process changes to be made for DOE runs
   g. Include information about the cycle/residence time for the control processing
   h. Calculate the lab time needed to complete the proposed DOE. Comment if the proposed DOE needs to be modified.

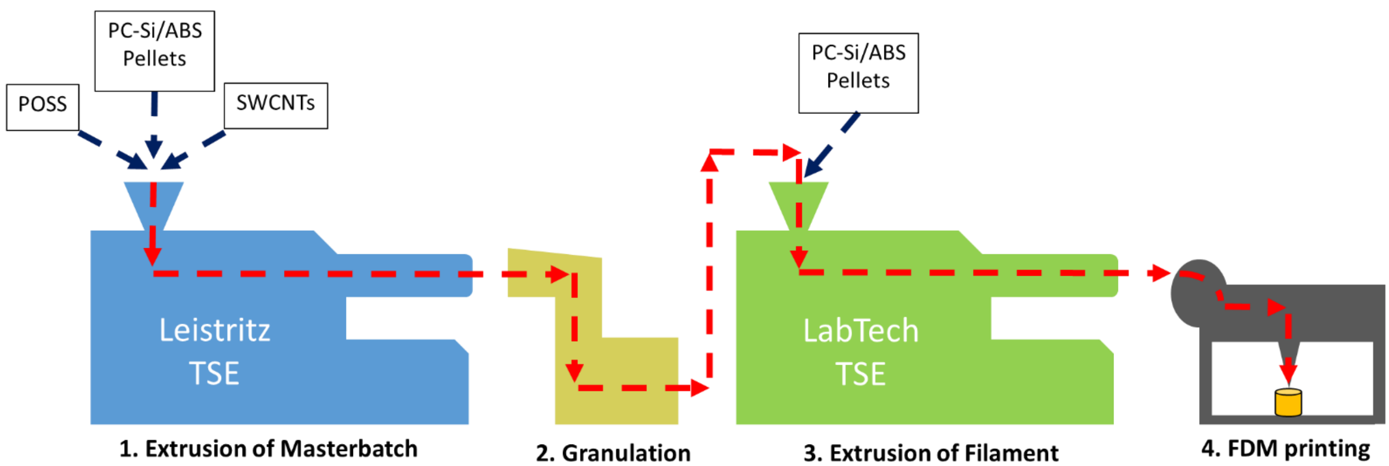


Figure 1. Example of a diagram of process and flow of experimentation.

~~8. **SAMPE Poster Abstract** (10 pts) – group – Submit an abstract that will be used in your final paper for review.~~
   ~~a. Describe the basic project background ("30,000 foot view"), goal of project, materials used, experiments/processes used, and high level overview of results.~~
      ~~i. If no results yet, make sure to provide note in assignment~~
      ~~ii. Must update abstract for final paper submission~~
   ~~b. This abstract can be used to submit for submission the SAMPE 2020 Student Poster Competition (if interested). **Must let Professor Misasi know ahead of deadline** if you want to use your poster and abstract for SAMPE.~~

9. **DOE Data** (50 pts)_– **group** – Submit memo describing your data collection processing trials. The memo should contain:
   a. DOE processing data such as:
      i. Set vs actual process parameters

    ii. Torque and specific energy calculations
    iii. Material throughput/residence time distributions
    iv. Temperatures and Pressures
    v. Screw/mixing speed
  b. Any adjustments to the DOE you made and why
  c. Any adjustments to process and why
  d. Any characterization data (responses)
  e. Description of data
  f. Plan for remainder of quarter

10. **Oral Presentation** (50 pts) – **group** – Formal poster presentation about the project. An electronic submission of the poster must be submitted on Canvas. Hard copy of poster must be printed for presentation.

11. **Technical Paper** (100 pts) – **group** – Submit an electronic copy of a final report that compiles all the information studied throughout the project. Use the other assignments to help write this document! The final report MUST be in the form of a technical paper as described by the formatting guide and example on Canvas. The following information should be included:
    a. Abstract (updated from previous assignment)
    b. Introduction
        i. Rewrite **Project Statement** & **Literature Review** into a condensed 3-4 paragraph introduction
        ii. No need to include figures or data
        iii. Ensure to describe project goals
    c. Methods
        i. Data/information on materials used (ex: name, purity, solubility parameter, supplier, etc.)
        ii. Description of processes from **Processing Plan** document and any updates made during quarter
        iii. Process diagrams
        iv. Characterization techniques and protocols for each (see technical paper example)
        v. DOE information from **DOE Plan** document and any updates made during quarter
        vi. Equations used to obtain data
    d. Results and Analysis
        i. Figures/tables/graphs/images showing data obtained
        ii. Analysis and discussion of mixing method(s)
        iii. Analysis and discussion of control/baseline data
        iv. Analysis of DOE data (statistical analysis such as regression or other)
    e. Conclusion
        i. Reiterate goals of project
        ii. Summarize formulation, processing, and characterization
        iii. Summarize DOE analysis
        iv. Summarize qualitative findings
        v. Suggest what future work is needed to complete research project
    f. Appendices
        i. Include **ALL** raw data here (processing, characterization, DOE analysis)
        ii. Add as tables and text (not jpegs or other image file)

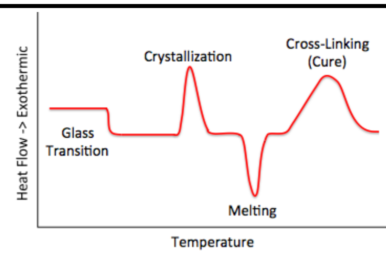
12. **Teamwork Evaluation** (50 pts) – **individual** - Members of each team will evaluate the contributions of each person of their team (25 pts). The instructor will evaluate the contributions of each person of the team (25 pts). Submit evaluation electronically for confidentiality.

Lab 3 – Differential Scanning Calorimetry

PCE 471: Advanced Materials & Characterization

Western Washington University

Mark Peyron & David Rider *Modified: 6/16/2022 (M. Peyron)*



Lab Goals

- Understand concepts of differential scanning calorimetry (DSC) and the energetics of thermal transitions in a semi-crystalline thermoplastic.
- Gain experience with setting up and using a DSC instrument.
- Quantify and properly interpret and present DSC data for both a commodity thermoplastic and your unknown material.
- Learn the advantages and disadvantages of modulated DSC.

1. Purpose

Examine thermal transitions in an unknown polymer sample using DSC. Data work up will permit a quantified interpretation of the data.

2. Theory

Differential scanning calorimetry (DSC) is a technique in which the temperatures and the net heat transfer between a sample and a reference cell are measured. The thermal transitions of a wide range of materials such as chemicals, thermoplastics, thermosets, food additives, and pharmaceuticals are measured using DSC.

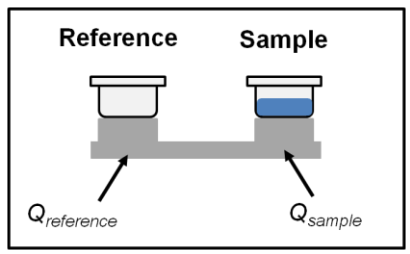


Fig. 1: Schematic representation of DSC sample cell.

Typically, the sample is sealed in an airtight (hermetic) aluminum pan and studied alongside an empty hermetic aluminum pan that acts as a reference. The sample and the reference pan are heated by two different heating elements in the furnace. The heaters work to keep the sample pan and reference pan at the same temperature during the temperature program. Thermal transitions such as melting or crystallization involve release ("exothermic") or absorption ("endothermic") of heat which leads to a differential heat transfer required to maintain the sample and the reference at the same temperature. A purge gas such as nitrogen is usually used to ensure thermal efficiency and establish an inert atmosphere.

DSC is the most commonly used instrument for characterization of thermal transitions in thermoplastics, thermosets and their composites. Completely amorphous polymers such as atactic polystyrene can be characterized using their glass transition temperature (T_g) which represents a transition from a rigid glassy state to a rubbery liquid like state. In DSC, the T_g is captured by an appreciable change in the heat transfer rate vs. temperature plot; this is really representing a change in polymer morphology and microstructure that manifests itself as a change in specific heat capacity (c_p). Since amorphous polymers soften considerably beyond their T_g (modulus decrease by a factor of 10^3 or more), the T_g often specifies the ultimate in-service temperature of the material. Semi-crystalline polymers such as Nylon consist of amorphous ***and*** crystalline domains, and they exhibit a glass transition and a melting transition.

Furthermore, depending on processing conditions and chemical structure, semi-crystalline materials may also exhibit a crystallization peak on heating (see Figure 2a).

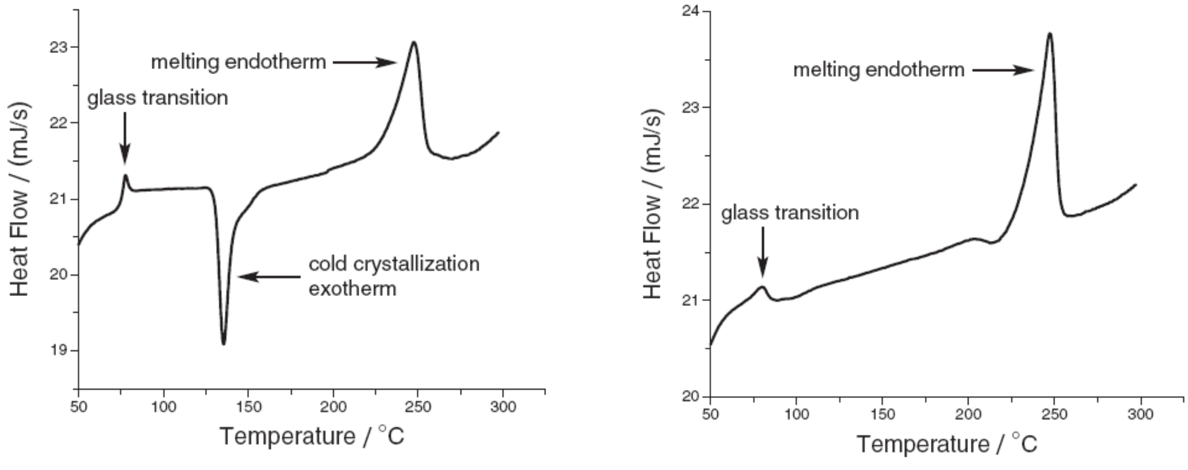


Fig. 2: Thermal transitions in a semi crystalline polymer: **a)** crystallization on heating; **b)** no crystallization on heating (T. D'Amico, C.J. Donahue, E.A. Rais, J. Chem. Ed. (2008) 85, 404). Note: endothermic direction is up.

The degree of crystallinity is an important parameter for semi crystalline polymers. The degree of crystallinity can be determined from the crystallization exotherm when crystallization occurs on heating (see Fig 2a) using the Equation 1 below:

$$\text{Percent Crystallinity} = \frac{\Delta h_f - \Delta h_c + \Delta h_{er}}{\Delta h_{f\,100\%}} \times 100 \quad [1]$$

Here Δh_f is the specific enthalpy of melting, Δh_c is the specific enthalpy of crystallization, Δh_{er} is the specific enthalpic relaxation (usually endothermic) and $\Delta h_{f100\%}$ is the specific enthalpy of melting for a fully crystalline polymer. Literature values of $\Delta h_{f100\%}$ can often be found, especially for common polymers.

When no crystallization is observed on heating (see Fig 2b), the degree of crystallinity may be estimated from the melting peak alone, as shown in Equation 2:

$$\text{Percent Crystallinity} = \frac{\Delta h_f}{\Delta h_{f\,100\%}} \times 100 \quad [2]$$

The degree of crystallinity is influenced by processing conditions and thermal history of the polymer. For example, when a semi-crystalline polymer is cooled from the melt, the degree of crystallinity increases with decreasing cooling rates. In this lab, the impact of two different cooling procedures on the thermal properties of a semi crystalline polymer is examined.

It is common usage in DSC experiments to plot "heat flow" versus temperature. The term "heat flow" is a misnomer, as heat is not a substance. A better term is _specific heat transfer rate_ (SHTR units are usually mW/g) and this is determined from the net power required to maintain the sample and reference pans at the same temperature divided by the sample mass.

3. Procedure

These instructions are written assuming that initially you measure only your assigned polymer. Later you can complete the DSC analysis of your unknown engineering material. Or you may only be running experiments on your unknown material. Adapt the procedure to your circumstances.

3.1 Pre-Lab Preparation

Your team has been assigned a polymer and/or unknown material for analysis. You may have to flatten a pellet of piece of filament with the available DSC smasher demonstrated in class and available in the analysis lab. Before you start your experiment, you must also look up the glass transition (T_g) and melting (T_m) temperatures of your assigned semi-crystalline polymer or base this on a screening DSC run. Write the information below; this will be used to set your experimental conditions.

Assigned polymer or material	**T_g (°C)**	**T_m (°C)**

3.1 Specimen Preparation and Thermal Treatments

a) Use <u>standard pans</u> and lids for this experiment (Fig. 3). The total mass of pans + lids should be within about ± 0.5 mg of each other. Be sure to use one of these mass-matched pans/lids for the reference cell.

standard pan (left) **& lid** (right)

hermetic pan (left) **& lid** (right)

Fig. 3: Common DSC pans

b) Measure ~ 6 – 10 mg samples of your powdered or flattened (you can cut or break off an appropriately-sized specimen to fit inside the DSC pan) polymer. Use an analytical balance with a precision of ± 0.01 mg to measure the mass of the pan and then pan + sample. You will need three samples of your polymer:

- **Sample 0 uncapped, for visual inspection only, not DSC**
- **Sample 1 will be capped and quench cooled**
- **Sample 2 will be capped and slow cooled.**

c) Place a lid on your sample (it nests inside the larger diameter pan). Be sure the press sealer has the appropriate bottom die. Fig. 4 shows the bottom die for the crimper. This bottom di e can be installed or removed without removing the upper die; use the set screw and screw the based down to remover and up to position the clamp. Set the proper gap spacing (when closed the top and bottom dies should be separated about the thickness of a paper clip). Test the gap position with your reference pan/lid. Position the capped pan on the bottom die; gently pull the handle forward to close the pan. Repeat this sample preparation procedure for samples 1 and 2. Place the remaining polymer in an uncovered pan (this sample will be used to observe the extent of melting during thermal treatments). **NOTE: Remember to keep track of sample identity and sample mass!**

standard **hermetic**

Fig. 4: Bottom dies

c) Place the uncovered sample pan (#0) and the two covered sample pans (#1 and #2) on the top of a hot plate. Set the hot plate temperature to a temperature ~20-30 °C above the upper melting temperature determined in your screening DSC run. Observe the extent of melting of the polymer sample in the uncovered pan. This can be used as a reference to track the extent of melting in the two covered pans.

d) The thermal treatment step above may be used to create different thermal histories for samples 1 and 2. Samples are melted and then undergo different cooling processes to alter the amorphous and crystalline structures. Either of the following quench methods may be used.

   1) You will find a labeled aluminum block or cold pack in the AMSEC freezer in the small room behind the XRD instrument. Use this as a "quench block" for sample 1, as described below, but the cooling block must be used immediately when removed from the freezer. When sample 0 is completely melted, use forceps to place sample 1 on the quench block; this will rapidly cool the specimen. Allow sample 1 to remain on the block for several minutes, then remove it to the benchtop. Return the quench block to the freezer. If the sample is to be analyzed later, place the sample in a small, folded piece of foil, label it with your team's name and "Q" for quenched. Place this in a labeled glass scintillation vial and store in the bin in the AMSEC refrigerator.

   2) Next, turn off the hot plate, and allow the sample 2 to cool slowly on top of the hot plate. While sample 2 cools, you can proceed to program the DSC instrument with sample 1. When cool, place in the DSC or in foil and in the refrigerator (see above).

e) Set up a modulated heat-only DSC experiment for each sample. Base the MDSC experimental parameters based on your screening DSC experiments.

3.2 Modulated DSC measurements

Sample Preparation

Place a reference pan/lid in one of the reference positions. Place samples 1 and 2 into the loading tray, noting the numbered position. In this case, you will have weighed, thermally-treated samples already in standard pans.

Pre-test System Checks

1) Log into FOM, then open **TA Instrument Explorer** and double-click **Q100** icon. Check purge gas flow rate (50 mL/min). Be sure the Event ON is selected.

Software Inputs

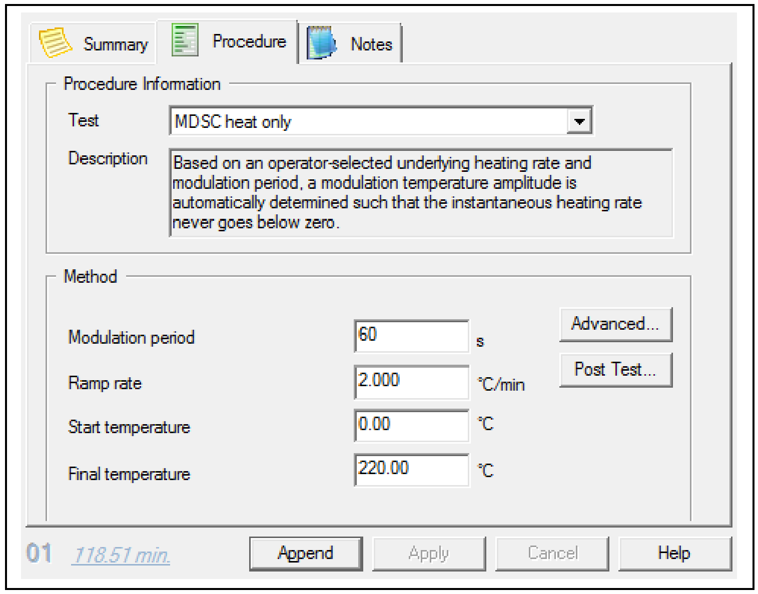
1) **Summary** tab
   - Mode: *Modulated*
   - Test: *MDSC Heat Only*
   - Sample Name: *<give descriptive sample name>*
   - Pan Type: *Aluminum*
   - Sample Size: *<sample mass>* *Note: Use the highest precision analytical balance (± 0.01 mg)*
   - Comments: *<give additional sample information> i.e. slow cooled, quenched etc.*
   - Data File Name: Store in the DSC data location, under the PCE 471 folder
   - NOTE: file name should first include team name, then descriptive information.

2) **Procedure** tab

Test: *MDSC Heat Only*. See the example and information below.

You need >5 modulation cycles in a given transition to obtain good data, and TA Instruments has developed guidance for users. See Appendix A to select your recommended modulated conditions (*i.e.*, ramp rate & period). The *MDSC heat only* experiment sets the modulation amplitude (based on other settings) to prevent the system from cooling during a modulated heating cycle.

For the known semi-crystalline polymer, set the start T at ~ 50 °C below T_g and the final T at 50 °C above the melting temperature.



3) You can change from a MDSC heat-only experiment to a "Custom" one at this point, and enter additional steps, end-of cycle notes, etc.

4) **Notes** tab
   - Operator: *<your team and/or individual names>*
   - Extended Text: *<any additional information you would like to record>*
   - Sample: *#1 Nitrogen*
   - Flow Rate: *50 mL/min*

5) Click **Apply** to save changes to save changes.

6) When the sample(s) is/are loaded, turn on refrigerated cooling by: ***Control > Event > On*** then click **Play** (green arrow). It is good practice to also reset the auto-sampler before beginning your run.

3.3 Scoping Run - Simple DSC measurements – Unknown Material Only

This was already done in Fall 2021. You may be able to observe melting endotherm and thus estimate the melting temperature by performing a "scoping" DSC run. This will help you optimize the subsequent modulated DSC experiment. You will perform a scoping run using a simple DSC ramp scan at a relatively high ramp rate. Set the upper temperature at least 50 °C below the degradation onset temperature. Try 0 °C as the initial temperature; this may be too high or too low, but makes an okay initial try.

When the thermogram is analyzed you have a good chance of estimating the melt temperature and possibly T_g. If only one transition is observed, use the rule-of-thumb that, for temperature in K, T_g/T_m ~ ½ – ⅔. This will help you identify the lower temperature; remember to go about 50°C below T_g, if possible, to avoid interference from the unreliable start-up hook region and to allow you to draw a viable baseline.

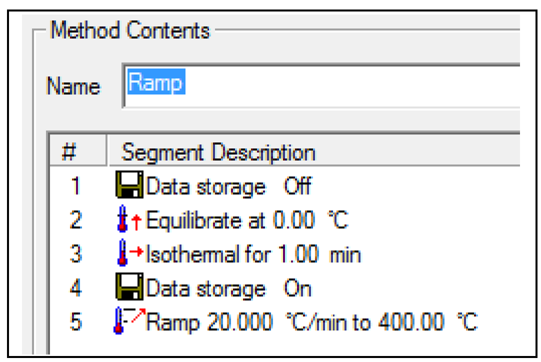
<u>**Software Inputs**</u>

1) **Summary** tab
   - Mode: *Standard*
   - Test: *Ramp*
   - Sample Name: *<give descriptive sample name>*
   - Pan Type: *Aluminum*
   - Sample Size: *<sample mass>* *<u>Note</u>: Use the highest precision analytical balance (± 0.01 mg)*
   - Comments: *<give additional sample information> i.e. scoping run etc.*
   - Data File Name: Store in the DSC data location, under the PCE 471 folder
   - NOTE: file name should first include team name, then descriptive information.

2) **Procedure** tab

   In the example shown, the temperature goes from 0 to 400 °C (based on a TGA degradation onset of 450 °C) and the ramp rate is high: 20 °C/min. Data are only recorded during the ramp cycle.

   If your scoping run temperature ranges are wrong, run a second one with more appropriate ranges selected. For example, you may need to start at a higher or lower temperature.



3) **Notes** tab
   - Operator: *<your team and/or individual names>*
   - Extended Text: *<any additional information you would like to record>*
   - Sample: *#1 Nitrogen*
   - Flow Rate: *50 mL/min*
4) Click **Apply** to save changes to save changes.
5) When the sample(s) is/are loaded, turn on refrigerated cooling by: ***Control > Event > On*** then click **Play** (green arrow). It is good practice to also reset the autosampler before beginning your run.

4. Analysis of DSC Data for the Polymer Samples – *these are examples practiced in class*

You will carefully examine thermal transitions in a semi-crystalline polymer using both standard DSC and modulated DSC signals. If you wish to use the TA software on your personal computer, go to: https://s3.amazonaws.com/Advantage/Advantage_v5.5.22.exe .

4.1 In-class example analyses

These activities are listed at your CANVAS course page (DSC Analysis #2: File = DSC-PET.001).

a) Open the file using the TA Universal Analysis software. Make a professional plot of specific heat rate versus temperature.

b) Create an inset plot for the glass-transition region. Under the "Graph" heading, click "Inset View". Adjust the parameters to create a professional-quality inset graph showing about 20-30°C on either side of the T_g.

c) Use the "Annotate Plot" button (looks like the Letter A and a pencil) to correctly label main features in the plot. The red cross-hairs that appears after you populate the text field with content will specify where your label will be fixed. You can move this by left clicking and dragging. Annotate the following regions on the graph: 1) start-up hook, 2) glass transition, 3), cold crystallization, 4) broad melting transition, 5) enthalpic relaxation (as an inset plot).

d) Export this plot to be 6 inches wide for the report template; export the plot without header information. The final font size should be close to 10 point when reduced.

4.2 Evaluate and annotate your DSC data

a) Start with the file for the slow-cooled polymer sample. Open your data file from TA Universal Analysis. In the pop-up window, note the size of the sample analyzed and the exothermic direction. Also inspect the content in the *Signals …* domain by clicking the button "***Heat Flow (W/g)***" as the Y1 content. The type is normal. The *x* content should be *temperature*. Inspect the content in the *Units* domain by clicking the button. If you did more than one cycle, click "Data Limits…" and bullet the "cycle limits" option to restrict the view to a single heat cycle. Click OK. If only a single cycle was measured, this will not be necessary. Omit the data for the start-up hook.

b) Under the view menu, select "*Method Log*" to make note of the details of the thermal analysis experiment. Note the number of heating and cooling steps, if appropriate.

c) Use the "Annotate Plot" button to correctly label the main features in the plot. The red cross-hairs that appears after you populate the text field with content will specify where your label will be fixed. You can move this by left clicking and dragging. Hit enter to locate the text.

d) In order to qualify the effectiveness of your modulation, produce a second plot, with Y1 = "***Heat Flow (W/g)*** *" and* Y2 = *"**Modulated Heat Flow (W/g)**"*. Zoom in on the melt region. In your report caption cite the number of modulation cycles at full width at half-height for the melt region. **Include this graph in your report and also export it to a PowerPoint presentation (this will be included in your report submission). Save your analysis with a unique name.**

4.3 Quantifying degree of crystallinity

Note: this is for your assigned data set; it may or may not be applicable for your unknown material.

a) Examine the baselines before and after the crystallization and melting transitions. Start by using the "Integrate Peak linear" button (looks like a red line overtop a well with a white shaded region) to determine the enthalpy of melting and enthalpy of crystallization. You can adjust the integration limits by left click/dragging the red crosshair and line. Make sure to include the full area of the peak (*i.e.*, included any weak but noticeable onset area in the integration). Hit enter to execute the calculation. Drag the resulting textbox near the area of each peak. Fill values into the table below.

You will also examine the effect of type of baseline on the uncertainty in the melting and crystallization regions. To do this, switch the baseline type to a cubic spline (this is often the best choice when the baselines have different slopes or show a step change). Repeat the crystallization and melting area calculations as above using spline baselines, and then fill in the table below. If a baseline is not applicable, then use "N/A".

<table>
<tr><th rowspan="4">Total Heat Signal</th><th>Transition</th><th>T range (°C)</th><th>T at peak (°C)</th><th>Linear Baseline Δh (J/g)</th><th>Spline Baseline Δh (J/g)</th><th>Ave. Δh ± ½ range (J/g)</th></tr>
<tr><td>enthalpic relaxation</td><td>-</td><td></td><td></td><td></td><td>±</td></tr>
<tr><td>crystallization</td><td>-</td><td></td><td></td><td></td><td>±</td></tr>
<tr><td>melting</td><td>-</td><td></td><td></td><td></td><td>±</td></tr>
</table>

b) Your instructor will provide references from which you may find published values for enthalpy c change associated with 100% crystalline material, $\Delta h_{f100\%}$. Using the data above, calculate the degree of crystallinity of the sample prior to the heating step. Propagate the uncertainty in Eq. 1 or 2, as appropriate. For $\Delta h_{f100\%}$, assume an uncertainty of ±1.5 J/g. Estimate the uncertainty in Δh_c and Δh_f from the table above.

4.4 Exporting your data plot

Use the "Annotate Plot" button to correctly label the main features in the DSC thermogram. *Your final annotated plot should show only your choice of the* *<u>most appropriate baseline</u>*.

- For the purposes of the data interpretation exercise, you will export the plot that you have created with the TA software and use it in your report. IMPORTANT: For final project reports (written and presentation files), you could also re-plot the graph using Excel or Origin in order to present a professional graph where you can set fonts and scales of axes, axes labels, etc. *If you do use the Universal Analysis output, then you must make the re-sized graphs appear according to high-quality, professional standards, including matching fonts.*
- In Universal Analysis, under *File → Options*, set the default Export Plot option to "no header". Click "*Export Plot…*" option. Bullet the file option and browse to the appropriate destination for your to save and recover your plot. Bullet the bitmap or enhanced metafile option for the highest resolution figure option (leave the pixel count as default) and select the "all colors" option from the pull down

menu. Click Export. Include this graph in your report and also export it to a PowerPoint presentation. Save your analysis with a unique name.

4.5 Quantifying degree of crystallinity – Reversible and Nonreversible Signals

a) Repeat steps 4.2 and 4.3 using separate graphs of the "***Reversible Heat Flow (W/g)***" and "***Nonreversible Heat Flow (W/g)***". Make separate graphs of each signal as Y1.

b) Annotate the transitions as with total heat signal. Define baselines and tabulate your results below (as in Section 4.3). You will use the both plots to complete the table below; see class examples from lecture and from TA Instruments guides posted on Canvas.

c) Calculate initial crystallinity and its uncertainty as you did in Section 4.3.

Modulated Heat Signals	Transition	*T* range (°C)	*T* at peak (°C)	Linear Baseline Δ*h* (J/g)	Spline Baseline Δ*h* (J/g)	Ave. Δ*h* ± ½ range (J/g)
	enthalpic relaxation	-				±
	crystallization	-				±
	melting	-				±

d) Export plots to PowerPoint and to your report template, and save your analysis as you did earlier.

4.6 Repeat the data analysis for your quench-cooled sample

Repeat steps 4.2 – 4.5 for your quench-cooled sample data.

a) Annotate separate graphs of total heat flow, reversible heat flow and nonreversible heat flow. Determine enthalpy changes and define baselines.

b) Calculate % crystallinity, appropriate for your materials.

c) Save your plots to your report and to your PowerPoint documents. Save you analysis file with a unique name.

Total Heat Signal	Transition	*T* range (°C)	*T* at peak (°C)	Linear Baseline Δ*h* (J/g)	Spline Baseline Δ*h* (J/g)	Ave. Δ*h* ± ½ range (J/g)
	enthalpic relaxation	-				±
	crystallization	-				±
	melting	-				±

	Transition	T range (°C)	T at peak (°C)	Linear Baseline Δh (J/g)	Spline Baseline Δh (J/g)	Ave. Δh ± ½ range (J/g)
Modulated Heat Signals	***enthalpic relaxation***	-				±
	crystallization	-				±
	melting	-				±

4.7 Determining change in specific heat capacity and glass-transition temperature from your data plots

As part of the modulated experiment, you obtain specific heat capacity data. In this analysis, you will compare the results from a standard DSC run and modulated one. Since the glass transition is a thermodynamically-reversible process, it shows up in the reversible MDSC signal.

a) **Start with the slow-cooled data set**.

b) Create a temperature-based plot with **Y1 = Heat Capacity (J/(g·°C))** and **Y2 = Rev Cp (J/(g·°C))**. Adjust the temperature range to focus in on the glass transition region (about ± 20°C around the T_g). Change the *y*-axes to be identical ranges.

c) Use the "*T_g tool*" to determine the glass transition temperatures based on each of the two signals. Delete all labels except for the T_g value on each curve. *Be sure to use the ½ height method*.

d) Select Y1, and use the "*Curve value at x*" tool to find the value of specific heat capacity at the chosen baseline points before and after T_g. Leave this value label on the graph temporarily until you complete the table below. Report c_p to three significant figures.

e) Clean up and annotate your graph, and export it to your report and to your PowerPoint document.

f) **Repeat this analysis with the quench-cooled data set**.

thermal treatment	signal analyzed	T_g (°C)	Δc_p due to glass transition (J/g·K)
slow-cooled	**Total c_p**		
	Rev c_p		
quench-cooled	**Total c_p**		
	Rev c_p		

Before quitting TA Universal Analysis, save each graphical analysis plot with a unique filename. This will save you lots of time if you should need to do slight modifications later.

Appendix A: Recommended Modulated DSC Experimental Parameters

Modulated DSC allows thermal data to be separated into "kinetic" and "thermodynamically reversible" terms. This has multiple advantages. However, the ramp rates are lower than in standard DSC because, in order to sample the transitions (T_g, crystallization, melting, etc.), at least 4-5 modulation cycles must occur over the temperature range of the transitions. For example, in you are ramping at 2C/min, and a transition occurs over a temperature range of 20 °C, then the transition is measured over a period of (20 °C)/(2 °C/min) = 10 min. The modulation period must be, at most, 2 minutes in order for 4-5 cycles to occur during the transition. Fig. A-1 shows a data for a sample of PET with the modulation parameters shown in the caption. Table A-1 shows parameters suggested by TA Instruments. ***For most polymers, a 2-4 °C/min ramp and 40-60 s period should work, but other conditions may be used too.*** Exceptions include ones with large enthalpic relaxation. Also, **5-10 mg is a reasonable mass for most samples**.

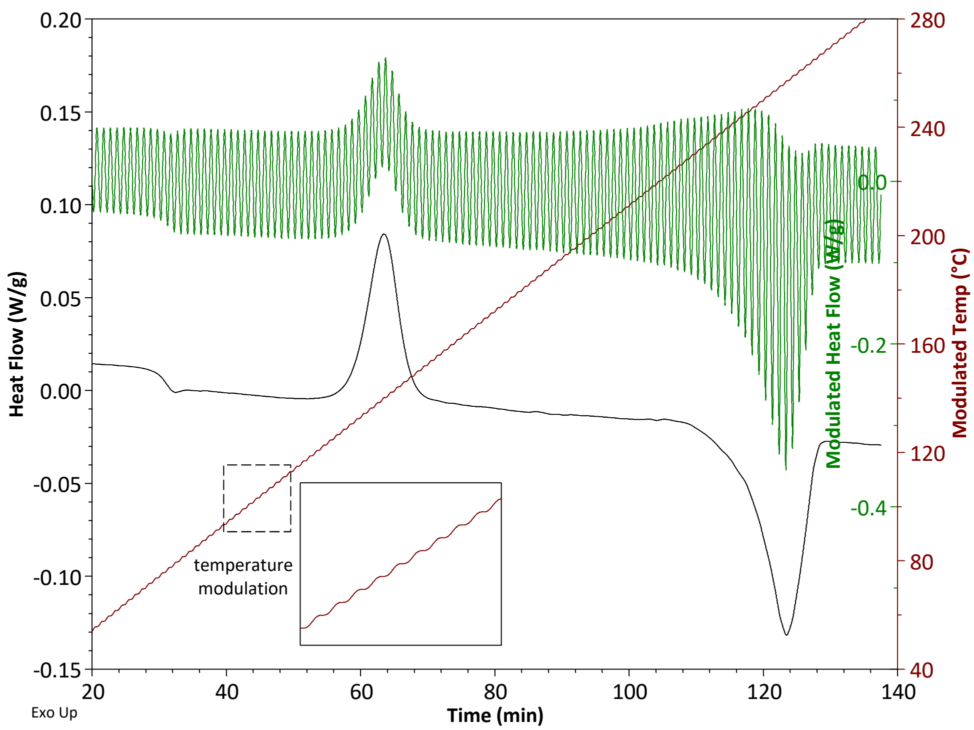


Fig. A-1: Modulated DSC data for a sample of PET (5.7 mg). 60 s period, 2 °C/min ramp, 0.32 °C amplitude.

Table A-1. Modulation amplitude for selected values of ramp rate and modulation period.

TA instruments		Modulation Period (s)						
		40	50	60	70	80	90	100
Ramp Rate (K/min)	0.1	0.011	0.013	0.016	0.019	0.021	0.024	0.027
	0.2	0.021	0.027	0.032	0.037	0.042	0.048	0.053
	0.5	0.053	0.066	0.080	0.093	0.106	0.119	0.133
	1.0	0.106	0.133	0.159	0.186	0.212	0.239	0.265
	2.0	0.212	0.265	0.318	0.371	0.424	0.477	0.531
	5.0	0.531	0.663	0.796	0.928	1.061	1.194	1.326

L. C. Thomas, "Modulated DSC® Paper# 3 Modulated DSC® Basics; Optimization of MDSC® Experimental Conditions," Technical report, TA Instruments, 2005.

Appendix B: Enthalpies of Fusion for Selected Polymers

Enthalpies of fusion for 100% crystalline polymers are listed in the table below. Data are given as specific enthalpy of fusion (J/g) and molar enthalpy of fusion (kJ/mol of repeat units).

Table B-1. Enthalpies of fusion for 100 % crystalline polymers

Polymer	$\Delta h_{f,100\%}$ (J/g)	$\Delta h_{f,100\%}$ (kJ/mol)*	Reference
PVOH [polyvinyl alcohol]	161	7.11	1
POM [polymethylene oxide]	326	9.79	1, 5
PVDF [polyvinylidene fluoride]	105	6.70	1
PBS [poly(butylene succinate)]	110.3	18.99	2
PLA [polylactide]	93.1	6.71	3
Syn-PS [syndiotactic polystyrene]	53.2	8.79	4
PBT [poly(butylene terephthalate)]	142-145	22.2-22.7	5
PA66 [polyamide 6,6]	200-226	44.9-50.7	1, 5
UHMWPE	291	8.16	6
PHB [polyhydroxy butyrate]	146	7.90	7
PBAT [poly(butylene adipate-co-terephthalate)]	114	*composition dependent*	8
LM PAEK [low melting poly aryl ether ketone]	130	*composition dependent*	9

* *Per mole of repeat unit*

References

[1] R.L. Blaine, "*Polymer Heats of Fusion*", *TA Instruments Applications Note TN048*, www.tainstruments.com/pdf/literature/TN048.pdf. Summarized from B. Wunderlich, *Thermal Analysis*, Academic Press, pp. 417-431, 1990.

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[3] E.W. Fischer, H.J. Sterzel, and G. Wegner, "Investigation of the structure of solution grown crystals of lactide copolymers by means of chemicals reactions," *Kolloid Ze. Ze. fuer Polym.*, vol. 251, p. 980, 1973.

[4] A.J. PasztorJr, B.G. Landes, P.J. Karjala, "Thermal properties of syndiotactic polystyrene", *Thermochimica Acta*, vol. 177, pp. 187-195, 1991.

[6] S. Kurtz, "*The UHMWPE Handbook. Ultra-High Molecular Weight Polyethylene in Total Joint Replacement.*" Elsevier. 2004.

[7] P.J. Barham, A. Keller, E.L. Otun and P.A.Holmes, "Crystallization and morphology of a bacterial thermoplastic: poly-3-hydroxybutyrate". *Journal of Materials Science*, 19(9), 2781-2794, 1984.

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[9] J. Audoit, L. Rivière, J. Dandurand, A. Lonjon, E. Dantras and C. Lacabanne, "Thermal, mechanical and dielectric behaviour of poly(aryl ether ketone) with low melting temperature". *Journal of Thermal Analysis and Calorimetry*, 135 (4). 2147-2157. ISSN 1388-6150, 2019.

PCE 471: Notes for Unknown Materials Report

(M. Peyron Dec. 2020)

Graphics and formatting.

- Spelling and grammar errors will be graded harshly.
- Only correct formatting will be permitted.
  - Use proper subscripting and superscripting (e.g. T_g not Tg, and 10^3 not 10^3).
  - Temperatures in Celsius must be cited with a degree symbol (30 °C, not 30 C or 30 deg C).
  - All axes in graphs must have labels.
  - Table have captions above the table; figures have captions below the figures.
- For every four, total formatting, spelling, or grammar errors, you will lose a letter grade.
- Define acronyms the first time used.
- Refer to the instruments as instruments, not as "machines".
- If you are pasting graphs from Excel, be sure these are in Office format and not as low-resolution pictures (pngs or jpgs).

Proposed matrix material(s)

- Include photo(s) of your neat sample.
- Cite appropriate references for properties, spectra, etc.
- Create ChemDraw-editable graphic(s) of proposed matrix material(s).
- Resolve or address any conflicts between your data and your proposed material(s).
- Provide a logical and concise narrative of how you identified your material(s).
- If more experimental data or runs would have been beneficial, specify the experiment(s) that should be done next. This probably belongs in the conclusions section, but that is up to you.

IR Spectroscopy

- Properly formatted Excel plot (see example) with appropriate annotations.

TGA

- N_2 and N_2-then-air plots of wt % remaining vs temperature and/or time, depending on your run.
- Show onset degradation temperature and meaningful mass loss plateaus, especially char and/or reinforcements.
- Be sure descriptive captions show sample mass, ramp rate, and gas environment.

SEM

- Show SE and/or BSE image of neat sample.
- As appropriate, show SE and/or BSE image of degraded samples.
- EDS analysis of above. These compositions must show the locations on companion images.

DSC

- You are expected to do a complete, yet concise interpretation of DSC data. Expect this to be the most complex analysis as you have quenched vs slow-cooled data and modulated data.
    - Use both heating and cooling steps, as apt.
    - Is your material amorphous or semi-crystalline? Cite experimental evidence.
    - Is/are melt peak(s) observed?
    - Is cold-crystallization observed?
    - How many T_g's vs melt peaks? What does this mean?
- Be sure all captions immediately allow readers to know the type of experiment, ramp rate, and sample mass.
- Annotate T_g values, as appropriate. How many? Comment on enthalpic relaxation, if evident.
- Draw appropriate crystallization and melting baselines. Interpret magnitude of the enthalpy changes.
- You may have several graphs for this section. Universal Analysis graphics are fine, but there should be no headers on these graphs.

DMA

- Plot of storage modulus, loss modulus, tan delta vs temperature. Annotate T_g values, as appropriate. Comment on how reinforcements could shift T_g, if appropriate.
- Identify relaxation events.
- Be sure descriptive caption shows ramp rate, fixture type, and specimen geometry.
- Be sure to cite storage modulus at ~30 °C and to provide a "does this make sense" check with reference values. If you have reinforcements, then how should your data compare with un-reinforced matrix? Don't use average values from Matweb as they are too broad. Look for specific grades of materials to narrow the range of values.

PCE 472 - ADVANCED COMPOSITES

LAMINATE PROPERTIES

Objectives: To gain experience with handling and working with advanced composite materials, to understand the influence of fiber orientation on the properties of a composite laminate, and to gain experience with elevated temperature processing.

Procedure:

1. You can choose a group of 3 students (one group will have 4). Each group will be provided with a different geometry and type of fiber sufficient to make a laminate.

2. Prepare an aluminum sheet to serve as a base for the panel. Be sure to take the cure cycle into consideration when choosing materials. Panels should have at least 10" of usable length in the 0 and 90 directions.

3. Using specified materials and manufacturing techniques, make the panel.

4. Cut tensile bars on the composites band saw at 0° to the long axis of the laminate. Specimen should conform to ASTM D3039 which can be found in the reference section of the library or on Canvas.

5. Test samples for tensile strength and modulus.

6. Using the rule of mixtures, laminate analysis, and Altair FEA determine the theoretical values for the strength, modulus, load to failure, and elongation.

7. Prepare a group write-up of your findings. Explain your observations and any sources of error that you can identify. Include your calculations, and comparisons to your results. Explain any differences you find.

The total value of this lab is 200 points.

Project for PCE 472 – Advanced Composites

Objective	Create a SAMPE Bridge (see Canvas for rules) using an elevated temperature process. You are required to make 2 bridges and the second must build off what you learned from the first. If you choose to use materials that we do not possess, you will be required to source them yourself. Categories for bridges are: I-Beam, Square, or Open. You can choose your specific material category but you are limited to the materials we have on-hand.
Available Processes	Your team can choose any elevated temperature processes to manufacture your product. Potential equipment options are: autoclave, compression molder, ovens, etc.
Tooling	Due to restrictions last year because of COVID you will not be required to create your own tooling. Instead you are able to choose existing tooling either from the lab or that you have sourced for this project.
Teams	You will be required to create the project as a team effort. You will need to divide into teams of 3 (and one of 4) at the beginning of the quarter.
Beam Design Review	Your team needs to complete a consultation with both David and myself to go over the step by step design and build of your bridge. You will need to include a timeline and all necessary materials (BOM), equipment, and personnel needed to make the bridge. Your timeline must take into consideration that you are not the only group using a particular pieces of equipment in the lab. You are also not allowed to chose a project that requires skills that you do not possess (ie, machining, use of the shop bot, etc) and, if you need special help from faculty or staff, it is their prerogative to say yes or no. At the meeting you will need to justify your design, the materials you are proposing to use for the part and the tool, and the manufacturing method. Theoretical calculations and/or FEA are also expected as part of the justification.
Testing	Your team will test your beam during class time twice. The expectation is for you to improve on your design/fabrication from the testing of Beam 1 to Beam 2.
Paper, Poster, & Presentation	Each team will be required to turn in a paper, virtual poster, and deliver a presentation of that poster. The paper should include explanations the following items: concept (bridge type and category), material choice, design, manufacturing, properties, reasons for doing what you did, how physical testing compared to theoretical testing, and lessons learned. You may add additional sections if you choose. The poster and presentation should follow the SAMPE guidelines and will be graded according to their rubric.

Team Evaluations: Each team member will evaluate the others. The way you work in your team will have a direct impact on your grade. Evaluation forms are located on Canvas under the grading scheme for this project.

Grading: Since this is a team effort, each member of the team will receive the same grade for the paper, but your grades may differ based on which members present the results and the feedback received from your group members. This grade is worth 440 points, so keep that in mind. The grade will take into account completeness of the project, the paper, the poster, the presentation, points for making project gates, and how your teammates viewed your contributions.

ALL DELIVERABLES ARE DUE AT THE BEGINNING OF THE CLASS TIME ON THE SPECIFIED DATE

Deliverables:

Project Given:	9/22
Project Plan & Timeline:	10/27
Bridge Testing 1:	11/8
Bridge Testing 2:	11/17
Virtual Poster:	11/30
Presentations	11/30 & 12/2
Paper:	12/6 @ noon
Teammate Evaluation	12/6 @ noon

Points:

Plan & Timeline	30
Bridge 1	50
Bridge 2	50
Poster	60
Presentation	50
Paper	100
Completeness of project	50
Teammate Evaluation	50