Institutional Effectiveness Report
2020-2021

Program: Mechanical Engineering BS

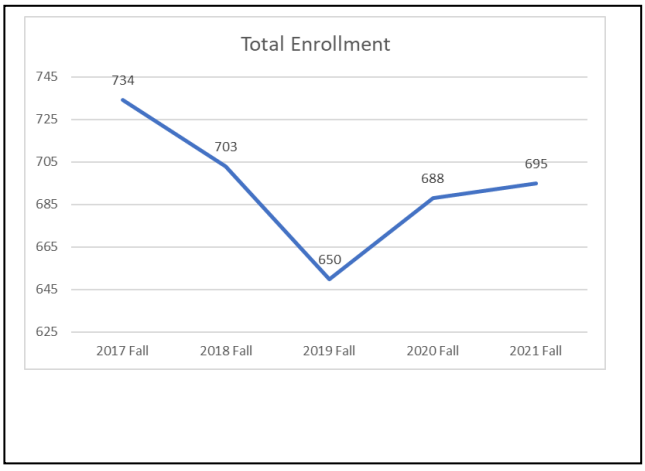
College and Department: College of Engineering – Mechanical Engineering

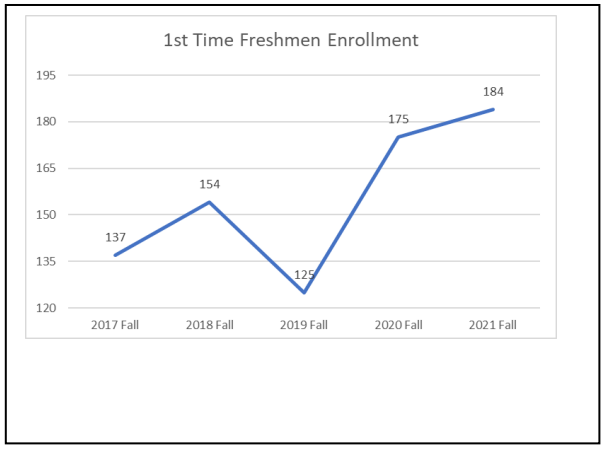
Contact: Mohan Rao

Mission: The Mechanical Engineering (ME) Department, within a regional and global context, will prepare its students for productive career in a competitive, dynamic, technologically-based society; will advance the knowledge of mechanical engineering principles and applications; and will serve the public.

VISION: The Mechanical Engineering Department at Tennessee Tech aspires to be recognized globally for outstanding education and research, leading to well-qualified engineers who are adaptive professionals, inquisitive, entrepreneurial and successful in engineering practice, research, and public service.

The B.S. in Mechanical Engineering (BSME) at Tennessee Tech is a traditional, on-campus lecture/laboratory program with on-ground course delivery offered almost exclusively during the day. There currently are no distance learning courses offered by the Mechanical Engineering Department. A co-op program is available through the Tennessee Tech Center for Career Development as an optional (but very popular) choice. The student enrollment trend in the ME department over past five years is shown in the plot below along with first time Freshman enrollment.





The complete curriculum including flow charts and elective courses for the three ME degree options can be found on the TTU-ME Department website at

https://www.tntech.edu/engineering/programs/me/me-degree.php

The web site also lists all the courses, their syllabi, faculty and staff and other program highlights. The Bachelor of Science in Mechanical Engineering (BSME) degree offered by the Department of Mechanical Engineering is accredited by the Engineering Accreditation Commission of ABET, http://abet.org.

Program Goals:

PG 1: Our graduates excel in diverse career paths using their engineering knowledge and professional skills to address complex problems and make positive impacts on society.

PG 2: Our graduates serve their profession and the public as ethical team members and leaders with awareness of modern issues, commitment to inclusive collaboration, and effective communication.

PG 3: Our graduates practice adaptive learning, expanding and enhancing their knowledge, creativity, and skills through professional development, continuing education, and/or earning advanced degrees.

Student Learning Outcomes:

It is expected that by the time of graduation, the Tech's ME students will have….

SLO 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

SLO 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.

SLO 3: an ability to communicate effectively with a range of audiences.

SLO 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.

SLO 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.

SLO 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

SLO 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

A departmentally developed curriculum map can be found in Appendix 1 that shows the connections between courses and student learning outcomes.

Student Outcomes mapped to Program Goals

ME Department Program Goals	Student Outcomes
Our graduates excel in diverse career paths using their engineering knowledge and professional skills to address complex problems and make positive impacts on society.	1, 2, 4, 6, 7
Our graduates serve their profession and the public as ethical team members and leaders with awareness of modern issues, commitment to inclusive collaboration, and effective communication.	3, 4, 5
Our graduates practice adaptive learning, expanding and enhancing their knowledge, creativity, and skills through professional development, continuing education, and/or earning advanced degrees.	1, 5, 6, 7

Assessment Methods:

1. *Alumni Survey (AS):* Alumni surveys are sent to graduates of the BSME program at one year and five years post- graduation. The fifteen questions on this survey occur in three sections. Section 1 (four questions) gathers data related to the Program Goals; Section 2 (seven questions) is used to assess alumni perception of ability with respect to ABET Student Outcomes; and Section 3 (four questions) requests text feedback on program strengths, weaknesses, suggested improvements, and open comments. The electronic Alumni Survey is issued annually in late fall via Machform and employs a 0-4 point scale in Sections 1 and 2, so there is no adjustment of scale prior to combining with other measures. Data from the Alumni Survey informs the evaluation of each Student Outcome (1-7).

2. *Co-Op Employer Survey (CES):* Approximately one-half of ME students participate in cooperative education agreements (co-ops) and/or internships during their program of study at Tech. For students who participate in co-op appointments sponsored through Tennessee Tech University's Center for Career Development, the co-op employers are required to complete a formal evaluation of the performance of each student at the end of each term in the co-op program. For College of Engineering students, the Tech Co-op Employer Survey (CES) also includes program- and Student Outcome-related assessment questions. These co-op surveys are considered a valuable source of direct feedback from employers, providing insight into student performance in-process, i.e., before they graduate. The Co-Op Employer Survey employs a 5-point scale (1 to 5), which is then converted to the 0-4 point scale by subtracting 1 point. Data from the Co-op Employer Survey informs the evaluation of five of the Student Outcomes (1, 3, 4, 5, 7).

3. *External Evaluation of Senior Design Projects (EESDP):* The External Evaluation of Senior Design Projects (EESDP) is conducted by evaluators invited from the ME External Advisory Board and from industry partners. These assess the Senior Design Projects and Project Presentations. The EESDP instrument uses the 0-4 pt. level-of-attainment scale. This instrument form has undergone three significant revisions, described in a later section, as part of the program's continuous improvement process. Data from the External Evaluation of Senior Design Projects informs the evaluation of five of the Student Outcomes (2, 3, 4, 5, 7). This assessment method is currently under discussion by the ME department Goals and Assessment Committee for possible revision.

4. *Instructional Outcomes Faculty Assessment (IOFA):* The Instructional Outcomes Faculty Assessment (IOFA) instrument provides a direct assessment of the level-of attainment of the students in a class

with regards to the Course Instructional Outcomes. The Instructional Outcomes Faculty Assessment is surveyed for eight selected courses in the BSME curriculum (ME3001 Mechanical Engineering Analysis, ME3023 Measurements in Mechanical Systems, ME4910/2910 Professionalism and Ethics, ME 4020 Applied Machine Design, ME 4410 and ME 4420 Senior Capstone, ME 4720 Thermal Design, and ME4751 Energy Systems Lab). The assessment, completed by the course instructor at the end of each semester, consists of a detailed analysis of the extent to which the Course Instructional Outcomes are achieved, as evidenced by student performance on specific test and homework problems, and other course assignments. The IOFA tool uses the 0-4 pt. level-of-attainment scale. Data from the Instructional Outcomes Faculty Assessment informs the evaluation of each of the Student Outcomes (1-7).

5. *Instructional Outcomes Student Survey (IOSS):* The Instructional Outcomes Student Survey (IOSS) is administered to students in eight selected courses in the BSME curriculum, same as for the IOFA above. The IOSS tool provides a pre/post self-assessment of student progress in achieving the Instructional Outcomes of the course. This is based on the difference between a student's perception of their level of knowledge for each Course Instructional Outcome upon entering a course and upon leaving the course. The IOSS survey is considered an indirect data source for assessment of Student Outcomes, as it requires a conversion through detailed mapping of a Course Instructional Outcomes to the Student Outcomes. The Instructional Outcomes Student Survey tool uses the 0-4 pt. level-of-attainment scale. Data from the IOSS informs the evaluation of each of the Student Outcomes (1-7).

6. *Senior Exit Interview Written Survey (SEIWS):* The Senior Exit Interview Written Survey (SEIWS) is one part of the Senior Exit Interview process. Students graduating from the BSME program provide self-assessment of their level of attainment of the ABET Student Outcomes, self-reporting of their engineering club and pre-professional activities while at Tennessee Tech, and text feedback regarding the BSME program and the ME Department. The Senior Exit Written Survey uses a quantitative 1-5 pt. “satisfaction” scale which is then converted to a 0-4 pt. scale for later combination with other assessment instruments results. The quantitative data is reviewed in conjunction with the Senior Exit Interview Oral Focus Groups, and the Goals and Assessment Committee summarize the qualitative comments. The data from the Senior Exit Interview Written Survey informs the evaluation of each of the Student Outcomes (1-7).

7. *Senior Exit Interview Oral Focus Groups (supporting source of evidence):* The Senior Exit Interview Oral Focus Groups (SEIOFG) process consists of an open discussion forum of graduating seniors with the ME chair and associate chair. The interview serves as a valuable source of suggestions for program improvement, as well as a source of supporting feedback on student performance. After receiving the feedback from the students, continuing concerns are compiled by the Goals and Assessment Committee and brought to the ME faculty for further discussion and possible action. Full records of student commentary are stored with all other assessment records.

8. *ME External Advisory Board Feedback (supporting source of evidence):* Feedback from the ME External Advisory Board is an important source of evidence for program improvement, guidance, and provides supporting evidence regarding the performance of students who are graduates of the BSME program. The External Advisory Board is composed of member representatives of several key constituency groups of the program, i.e., employers, alumni, and the professional community at large. Meeting minutes are kept with the other assessment data.

Expected Level of Attainment of the Student Outcomes

The expected level of attainment of Student Outcomes is scored with a 0-4 point level-of- attainment scale where each level is defined as 4 = Excellent, 3 = Good, 2 = Satisfactory, 1 = Low, and 0 = Negligible. Data from the assessment instruments are combined according to the evaluation plan to determine the final scored value each year for each Student Outcome.

A score of 3-to-4 is the desired level-of-attainment for each Student Outcome. A score between 2-to-3 is cause for review by the ME Goals and Assessments Committee, with possible actions and/or continued monitoring recommended to the ME faculty. A score lower than 2 requires corrective action to be taken by the ME faculty after review and recommendations for change by the ME Goals and Assessments Committee.

Results:

SLO 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	2.9	2.9	3.0	2.9	2.4	3
Co-op Employer Survey	3.0	3.1	3.2	3.2	3.2	3.2
Grades in STEM Courses (Math, Chemistry, Physics, Engineering).	3.1	3.1	3.1	3.1		3.2
Instructional Outcome – Faculty Assessment			3.4	3.1	2.8	2.8
Instructional Outcome – Student Survey	2.6	2.7	2.8	2.8	2.9	2.8
Senior Exit Interview Written Survey	3.6	3.7	3.8	3.4	3.5	3.5
Overall Level of Attainment	3.0	3.1	3.2	3.0	3.0	3.1

SLO 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

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	2.7	2.7	3.0	2.8	2.3	2.9
External Evaluation of Senior Design Projects			3.3	2.8	3.0	3.2
Instructional Outcome – Faculty Assessment			3.5	3.1	2.7	2.8
Instructional Outcome – Student Survey	2.6	2.8	2.9	2.7	3.0	2.9
Senior Exit Interview Written Survey	3.5	3.5	3.7	2.9	3.4	3.3
Overall Level of Attainment	2.9	3.0	3.3	2.9	2.9	3.1

SLO 3: an ability to communicate effectively with a range of audiences

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	2.8	3.1	2.9	3.1	2.3	3
Co-op Employer Survey	2.4	2.9	3.0	3.0	3.2	3.0
External Evaluation of Senior Design Projects			3.3	2.6	3.0	3.2
Instructional Outcome – Faculty Assessment			3.4	3.1	3.1	3.4
Instructional Outcome – Student Survey	3.0	2.9	3.0	2.9	3.0	2.8
Senior Exit Interview Written Survey	3.5	3.4	3.6	2.9	3.3	3.4
Overall Level of Attainment	3.1	3.2	3.3	2.9	3.0	3.1

SLO 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

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	2.8	3.1	2.7	3.3	2.6	3.3
Co-op Employer Survey	2.5	2.9	3.0	3.1	3.3	3.2
External Evaluation of Senior Design Projects			3.3	2.7	2.9	3.0
Instructional Outcome – Faculty Assessment			3.3	2.8	2.4	2.7
Instructional Outcome – Student Survey	2.2	2.9	2.8	2.7	2.8	2.8
Senior Exit Interview Written Survey	3.9	3.6	2.9	3.0	3.4	3.5
Overall Level of Attainment	2.9	3.1	3.0	2.9	2.9	3.1

SLO 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.

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	3.0	3.3	2.9	3.4	3.0	3.3
Co-op Employer Survey	3.5	3.5	3.5	3.5	3.6	3.4
External Evaluation of Senior Design Projects			3.3	2.5	3.0	3.1
Instructional Outcome – Faculty Assessment			3.6	3.3	2.9	2.9
Instructional Outcome – Student Survey	2.9	3.0	3.0	2.9	3.1	2.8
Senior Exit Interview Written Survey	4.0	4.0	4.0	3.4	3.5	3.4
Overall Level of Attainment	3.3	3.4	3.4	3.2	3.2	3.2

SLO 6: an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	2.8	3.0	2.9	3.1	2.9	3.2
Co-op Employer Survey					3.2	3.3
Instructional Outcome – Faculty Assessment			3.6	3.1	2.8	2.7
Instructional Outcome – Student Survey	2.6	2.7	2.9	2.9	2.9	2.8
Senior Exit Interview Written Survey	3.4	3.5	3.6	3.2	3.4	3.5
Overall Level of Attainment	2.9	3.1	3.2	3.1	3.0	3.1

SLO 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Assessment Instrument	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Alumni Survey	3.0	3.4	3.1	3.4	3.3	3
Co-op Employer Survey	3.0	3.1	3.2	3.2	3.4	3.5
External Evaluation of Senior Design Projects			3.4	2.7	3.3	3.2
Instructional Outcome – Faculty Assessment			3.3	2.7	2.7	2.8
Instructional Outcome – Student Survey	2.4	2.6	2.7	2.9	2.9	2.9
Senior Exit Interview Written Survey	3.8	3.3	2.3	3.3	3.6	3.5
Overall Level of Attainment	3.1	3.1	3.0	3.0	3.2	3.1

Modifications for Improvement:

Continuous Improvement Plan for 2021-2022

The ME department goals and assessment committee in consultation and input from the entire faculty have decided to adopt a new paradigm for assessment and continuous improvement as described below.

Change 1: Adopt a Cycle of Assessment, Evaluation, and Change for the seven student outcomes on a two -year cycle schedule, see Figure 1. This new plan will replace the current process of obtaining data every semester in seven courses using the Instructional Outcomes Student Survey and the Instructional Outcomes Faculty Assessment

Student Outcome	20-21	21-22	22-23	23-24	24-25	25-26
SO 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.		A	E C	A	E C	A
SO 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.			A	E C	A	E C
SO 3. An ability to communicate effectively with a range of audiences.		C A	E C	A	E C	A
SO4. 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.		A	E C	A	E C	A
SO5. 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.		A	E C	A	E C	A
SO 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.			A	E C	A	E C
SO 7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.			A	E C	A	E C

Figure 1. New two-year cycle for ME Program **Assessment (A), Evaluation (E), and Change (C).**

Change 2: During 2021-2022, implement a process to collect direct measures of student performance on four of the seven student outcomes, SO1, SO3, SO4, and SO5

- Identify four performance indicators (PI) for each of these four student outcomes, this was accomplished by full faculty participation in the Fall 2021 retreat. The performance indicators are written with use of Bloom's Taxonomy and contain distinct verb and subject content aligned to each student outcome, see Figure 2
- During Fall 2021, teams of faculty for each SO, with each team facilitated by a member of the Goals and Assessment Committee, will determine the necessary artifacts from student work in selected courses that will be used to assess performance on that outcome by student cohorts. Each SO team will be involved in assessing the student artifacts using rubrics to assess each of the performance indicators for that particular student outcome.
- The SO Teams will also develop rubrics for assessing the student artifacts.

- The cohort of students assessed will be determined from the Spring 2022 courses as decided by the full faculty in December 2021.

Learning Outcome	Performance Indicators
ME-SO1 The ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	ME-SO1-PI1 Restate complex problems into subparts with proper assumptions.
	ME-SO1-PI2 Identify and apply appropriate methods.
	ME-SO1-PI3 Analyze data resulting from the methods.
	ME-SO1-PI4 Produce a viable approach/deliverable.
ME-SO2 The ability to apply the engineering design process to produce solutions that meet specified needs with consideration for public health and safety, and global, cultural, social, environmental, economic, and other factors as appropriate to the discipline.	TBD in 2022-2023
ME-SO3 The ability to communicate effectively with a range of audiences.	ME-SO3-PI1 Identify target audience and adapt communication.
	ME-SO3-PI2 Deliver effective oral presentations that convey subject matter.
	ME-SO3-PI3 Generate appropriate solid models and technical drawings for analysis and construction.
	ME-SO3-PI4 Create organized documentation that supports reproducible processes and results .
ME-SO4 The 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.	ME-SO4-PI1 Describe ethical responsibilities in codes for the engineering profession
	ME-SO4-PI2 Apply ethical resaoning in engineering scenarios
	ME-SO4-PI3 Judge the impact of engineering decisions and solutions in global, economic, environmental and societal contexts
	ME-SO4-PI4 Demonstrate professional responsibilities as an engineer
ME-SO5 The 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.	ME-SO5-PI1 Identify roles and responsibilities of each member.
	ME-SO5-PI2 Manage team communication to achieve objectives.
	ME-SO5-PI3 Create a project task and timeline.
	ME-SO5-PI4 Demonstrate individual accountability for the team's success.
ME-SO6 The ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	TBD in 2022-2023
ME-SO7 The ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	TBD in 2022-2023

Figure 2. Performance Indicators for SO1, SO3, SO4, and SO5

Change 3: Three ME department faculty will be participating in a pilot program with the CITL and iLearn support staff to use the Learning Outcomes tool in their iLearn courses.

- The learning materials, assignments, and rubrics in an iLearn course can be tied directly to the Student Outcomes and Performance Indicators.
- The pilot use of this tool will generate data that shows how students are performing and the data can be aggregated across the courses taught by these faculty in Fall 2021 and Spring 2022.
- Additional faculty may join the pilot program in Spring 2021 to test drive the use of this approach to generate program level data for assessing the four student outcomes.

Change 4: Actions to improve the SO3 communication with solid modeling and technical drawings

- Beginning in Fall 2021, the ME3001 course which is required by all ME majors in the program of study, will adopt use of SolidProfessor as a required text for the course.
- SolidProfessor is a four-year license to a web-based set of resources (videos, reading materials, and certifications) that ME student can purchase from the bookstore.
- SolidProfessor has learning modules to develop skill with solid modeling, technical drawings, design for manufacturing, etc
- Additional ME courses will leverage the student access to this learning resource by modifying existing and/or developing new assignments to require use of solid modeling and technical drawing
- This change is informed by prior years assessment, both in course and at the program level, that indicates students are not proficient with solid modeling and technical drawing as graduating seniors

Change 5: Examine the potential improvements possible by requiring ME courses in the freshman year

- Our departmental data, and review of engineering education literature, informs our commitment to programmatic changes starting in the freshman year.
- While addressing Change 4, efforts were made to work with the freshmen course ENGR1110 Engineering Graphics, taught in Basic and General Engineering, to adopt new approaches to instruction and to use learning resources such as SolidProfessor.
- Those efforts were unsuccessful, hence our adoption of change in a junior level course, ME3001.
- The ME Curriculum Committee and the Goals and Assessment Committee will explore options and develop plans that would allow the department to offer ME courses beginning in the freshman year.

Appendices

1. Curriculum Map

Appendix 1: Curriculum Map

Course	Student Outcomes I = Introduce, R = Reinforce, D = Demonstrate						
Number and Title	**1**	**2**	**3**	**4**	**5**	**6**	**7**
ME 2330 Dynamics	I						I
ME 2910 Professionalism and Ethics			R	D	R		I
ME 3001 Mechanical Engineering Analysis	I				I	I	I
ME 3010 Materials & Processes in Manufacturing	I	I		I			
ME 3023 Measurements in Mechanical Systems	R			I	I	R	I
ME 3050 Dynamic Modeling & Controls	I	I					
ME 3060 Dynamic Modeling & Controls Lab			I		I	R	I
ME 3210 Thermodynamics I	I						
ME 3220 Thermodynamics II	R	I		I			
ME 3610 Dynamics of Machinery	R	I		I	I		
ME 3710 Fluid Dynamics	R						
ME 3720 Heat Transfer	R						
ME 4010 Machine Design	R	R		I		I	
ME 4020 Applied Machine Design	D	D	R	I	I	R	R
ME 4410 Senior Design Project I	D	R	R	R	R		D
ME 4420 Senior Design Project II		D	D	D	D	D	D
ME 4720 Thermal Design	D	D	R	I	I	R	R
ME 4751 Energy Systems Lab	R					D	