

The University Senate of Michigan Technological University

Proposal 30-16 (Voting Units: Academic)

Minor in Rail Transportation

Submitted April 1, 2016 by the
Department of Civil and Environmental Engineering

1. Introduction

This proposal recommends establishing an undergraduate minor titled “*Minor in Rail Transportation*” through the Department of Civil and Environmental Engineering, in collaboration with the Rail Transportation Program (RTP) at the Michigan Tech Transportation Institute (MTTI). Required courses offered as part of this minor are currently offered in the Civil and Environmental Engineering, and Business and Economics programs. Electives are found in the Civil, Mechanical, Electrical, and Business programs. The minor is available to students from any department. The Minor is designed to give students recognition that in addition to their degree, they have completed a set of elective courses oriented toward the needs of the rail industry. Civil, Mechanical, and Electrical Tracks have been created for the minor, and other tracks may be added in the future to support additional disciplines.

2. Rationale

A shift in the U.S. transportation environment has led to a revival in rail transport, especially in freight rail. The desire for reduction of highway and air traffic congestion has also led to growth of urban rail systems and plans for future intercity passenger and high speed rail. This growth requires a corresponding increase in railroad transportation and engineering education. Simultaneously, the U.S. railroad system is nearing capacity as more companies explore rail freight as a supplement or an alternative to truck transportation, thus creating pressure to add more trains to a system with no excess capacity.

The demand for railroad work continues, according to the AAR “America’s freight railroads have reinvested \$575 billion since 1980 — and are planning to spend an estimated \$29 billion in 2015 alone to modernize the rail network and equipment¹. Additionally, passenger rail transportation is receiving unprecedented attention through high speed rail development in California, and a new privately funded system in work for Texas². “Higher Speed Rail” services are being implemented in the Chicago-Detroit, Chicago-St Louis³, and Miami-Orlando⁴ corridors. Many cities and states are making major investments in new commuter rail and light rail transit systems, including the new Detroit M-1 light rail system.

¹ Association of American Railroads web site, <https://www.aar.org/BackgroundPapers/Freight%20Railroad%20Capacity%20and%20Investment.pdf> , Accessed Sept 14, 2015

² The Texas Central Railway, *The Project*, <http://www.texascentral.com/project> accessed Sept 15, 2015

³ The Midwest High Speed Rail Association, *Projects by State/Route*, <http://www.midwesthsr.org/projects-stateroute>, accessed Sep 15, 2015

⁴ Work begins — finally — on Miami-to-Orlando fast train, <http://www.miamiherald.com/news/business/article1981627.html>, Accessed Sept 15, 2015.

In the meantime, an aging rail employee demographic presents a severe threat to sufficient level of individuals equipped to handle the design and operation of both new and existing rail systems⁵. The Association of American Railroads (AAR) estimates that 15,000 new employees will be needed in the industry in 2015⁶. Over the past decade, Michigan Tech has developed a leadership position in railroad transportation/engineering education and has established an international reputation for its innovative Rail Transportation Program (RTP). The number of students participating in coursework and Railroad Engineering and Activities Club (REAC) has increased significantly over the past decade (Figure 1) and major rail companies, engineering consultants, contractors and manufacturers have increased their internship/full time recruiting activities on campus to meet their demands (Figure 2), including their involvement in student/research projects. The Michigan Tech Rail Transportation Program is also a member of a US DOT funded University Transportation Center, called NURail, which includes seven universities, including the Universities of Illinois (Urbana-Champaign and Chicago), Kentucky, Tennessee, MIT, and Rose-Hulman Institute of Technology. The NURail consortium should provide future opportunities for course collaboration and the development of on-line courses.

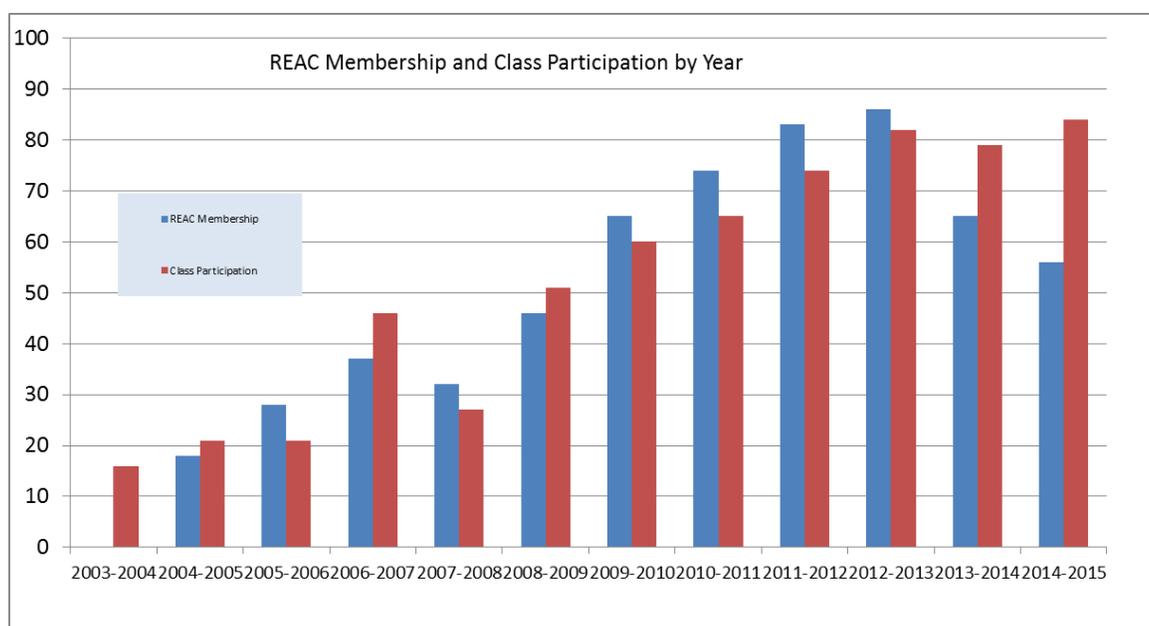


Figure 1 - Course participation and REAC membership over time at Michigan Tech

⁵ Federal Railroad Administration, Railroad Industry Modal Profile, An Outline of the Railroad Industry Workforce Trends, Challenges, and Opportunities, October, 2011, <http://www.fra.dot.gov/Elib/Document/92>, Accessed Sept 15, 2015

⁶ 2015 Outlook, Executive Summary, <https://www.aar.org/policy/2015-outlook>, Accessed Sept 15, 2015

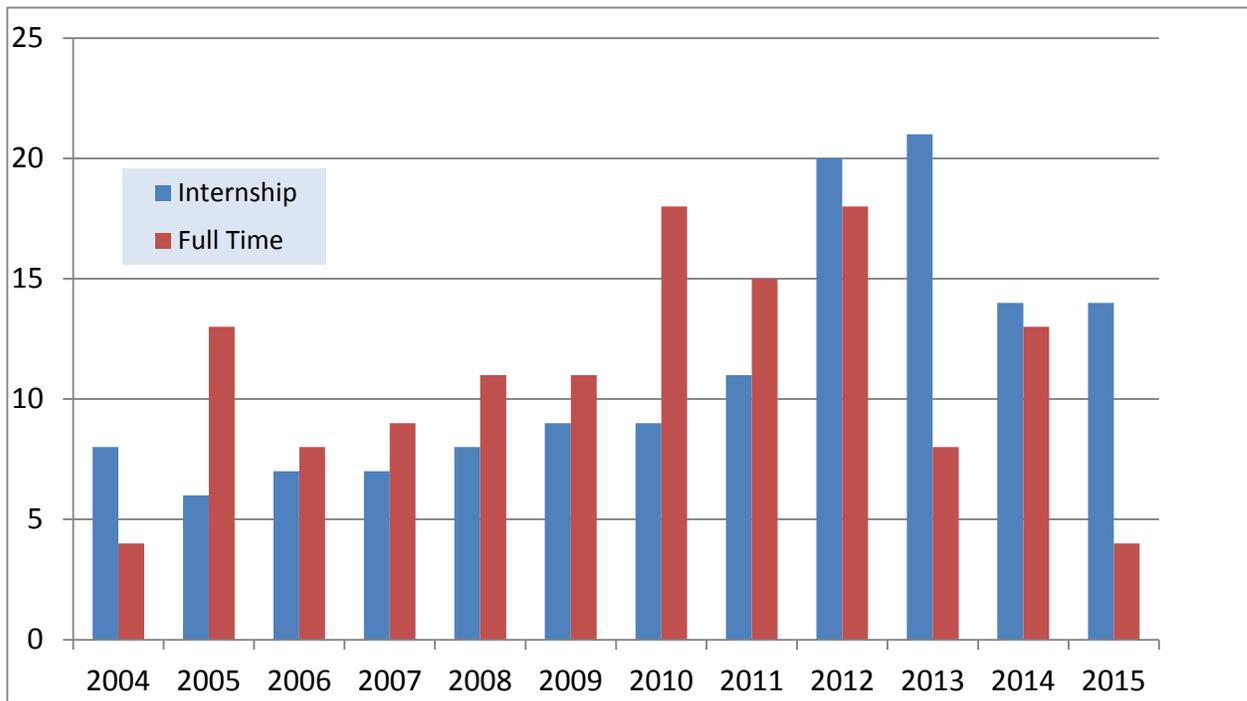


Figure 2 - Industry Recruitment (2015 numbers not complete)

RTP faculty and staff have been active in the education committees for both the American Railway Engineering and Maintenance-of-Way (AREMA) and American Public Transportation Association (APTA), and have used those connections to develop a sound understanding of industry education needs. The industry has identified graduates with a bachelor’s degree as their primary target group and have identified leadership, problem solving and communication skills as the most valuable “non-technical” skills for their graduates. This minor provides students from various disciplines with: 1) a general introduction to rail transportation; 2) an introduction to rail topics within their discipline; and 3) courses that cover the most critical non-technical skills for industry professionals.

3. Details of Catalog Copy

I. Title of Minor:

Minor in Rail Transportation

II. Description:

This minor is targeted to Michigan Tech students with interests in the rail transportation industry. The mix of discipline specific and multi-disciplinary class requirements for this minor provides students with the basic skills and background necessary to rapidly become effective specialists and leaders in the railroad industry. In addition to courses in rail transportation and engineering, students also learn logistics, management, leadership, and/or communications skills to meet the demands of rail industry careers. Railroads, consultants, transit agencies, industry suppliers, construction firms, and government agencies are all looking for graduates with versatile skills, who can become effective engineers, managers and team leaders in various company positions, and understand the requirements placed by the industry on its professional staff. In addition to civil engineering and business needs, the industry is increasingly looking for graduates with the technical expertise needed for their signal and communications systems (including IT systems), and the background to handle the latest developments in mechanical systems. This minor assists students in preparing to meet those needs, the main learning goals are provided below.

Learning Goals

Minor in Rail Transportation

1. Disciplinary Knowledge	Rail Industry Knowledge Base Students will demonstrate familiarity with the major concepts and technologies, system components, industry terminology, and engineering and operational practices of the rail industry and rail transportation as part of overall transportation system.
2. Disciplinary Knowledge	Professional Development Students will be able to apply concepts and technologies toward practical applications, including design and data analysis of various system components
3. Leadership	Leadership Students will demonstrate an understanding of leadership principles, problem solving, management fundamentals, motivation, mentoring, and effective communication.
4. Communication	Communication Students will be able to communicate effectively in a variety of formats.
5. Safety	Industry Safety Culture Students will demonstrate understanding of the importance placed on safety by the rail industry and the fundamental processes to achieve it.

III. List of Courses:

The initial list of courses was developed based on input provided by almost 500 industry professionals (collected via on-line survey) and consultations with faculty from CEE and other departments. Additional courses from various departments with a rail focus or a close alignment with rail industry skill demands could be added to the elective list in the future. Note that civil, mechanical, and electrical tracks have already been created to expand the relevance of the minor.

Table 1 outlines the core and elective requirements. Course selection has been discussed and reviewed with the Rail Transportation Advisory Board (RTAB) that consists of industry leaders at different points of their career. Figure 3 - Program Flow Chart, shows the minor requirements in a graphic format.

Table 1 - Minor Course Requirements

Required Courses All Majors (7 total credits)		
CE 4404	Railroad Engineering	3
CE 4490	Rail Transportation Seminar	1
OSM 4700	Logistics and Transportation Management	3
Plus ONE of the following Leadership/Professional Elective courses (3 total credits)		
AF 3010	Leadership Studies I	3
MGT 3100	Leadership Development	3
AF 3020	Leadership Studies II	3
HU 3120	Technical and Professional Communication	3
MGT 3000	Organizational Behavior	3
OSM 3200	Project Management	3

Civil Track - Plus NINE credits from the following Technical Electives (9 credits)		
CE 3401	Transportation Engineering	3
CE 4333	Estimating and Planning of Construction Projects	3
CE 4407	Transportation Design	3
CE 4905	Senior Design or Enterprise Design Project (Railroad Theme)	3
CE 4990	Independent Study in Rail Topics	3
CE 5408	Public Transit	3
Xx xxxx	A course in rail topics from another university (requires advance written approval by the Director, Rail Transportation Program)	3

Mechanical Track - Plus NINE credits from the following Technical Electives (9 credits)		
MEEM 3911	Mechanical Engineering Practice IV	3
MEEM 4220	Internal Combustion Engines I	3
MEEM 4450	Vehicle Dynamics	3
MEEM 4655	Production Planning	3
MEEM 4901/4911	Senior Design or Enterprise Design Project (Railroad Theme)	4
MEEM 4990	Independent Study in Rail Topics	3
Xx xxxx	A course in rail topics from another university (requires advance written approval by the Director, Rail Transportation Program)	3

Electrical Track - Plus NINE credits from the following Technical Electives (9 credits)		
EE 3120	Electric Energy Systems	3
EE 4219/4220	Introduction to Electric Machinery and Drives with lab	4
EE 4227/4228	Power Electronics with lab	4
EE 3160	Signal Systems	3

EE 3171	Microcontroller Applications	4
EE 3250	Introduction to Communications Theory	3
EE 3261	Control Systems	3
EE 4253	Real Time Signal Processing	3
EE 4805	Electrical Engineering Project	3
EE4901/4910	Senior Design or Enterprise Design Project (Railroad Theme)	4
Xx xxxx	A course in rail topics from another university (requires advance written approval by the Director, Rail Transportation Program)	3

Track alignments shown in Table 1 are intended to demonstrate routes in those disciplines for the Rail Transportation Minor. They are not intended to be restrictive, any of the courses listed may be used by a student in any major to complete the elective requirements.

Total: Minimum 19 credits

IV. Prerequisites:

- AF 3010 – (Sophomore standing or above)
- AF 3020 – (Sophomore standing or above)
- CE 3401 – (Sophomore standing or above)
- CE 4333 – (CE 3332)
- CE 4404 – (Junior standing or above)
- CE 4407 – (CE3401, SU2000, Sophomore standing or above)
- CE 4490 – (Junior standing or above)
- CE 4905 – (Senior standing)
- CE 5408 – (Senior standing with permission of instructor)
- HU 3120 – (UN 1015, Junior standing or above)
- MGT 3000 – (Sophomore standing or above)
- MGT 3100 – (Sophomore standing or above)
- OSM 3200 – (MA 2710 or MA 2720 or MA 3710 or EET 2010 or BUS 2100 or BA 2100)
- OSM 4700 – (MA 2710 or MA 2720 or MA 3710) and (MA 1135 or MA 1160 or MA 1161)
- MEEM 3911 – (MEEM 3901 and EE 3010 and MEEM 3400 and MEEM 3600)
- MEEM 4220 – (MEEM 3210)
- MEEM 4450 – (MEEM 3502 and MEEM 3000) or (EE 3305 and MEEM 2700)
- MEEM 4655 – (MEEM 3501)
- MEEM 4901 – (MEEM 3000(C) and MEEM 3502(C) and MEEM 3900)
- MEEM 4911 – (MEEM 4901 and MEEM 3000(C) and MEEM 3502(C) and MEEM 3900)
- MEEM 4990 – (Permission of department required, Sophomore standing or above)
- EE 3120 – (EE 2110 or EE 3010 or (EE 2111 and EE 2112(C)))
- EE 3160 – ((EE 2110 or EE 2112) and (MA 2320 or MA 2321 or MA 2330) and (MA 3520 or MA 3521 or MA 3530 or MA 3560))
- EE 3171 – ((EE 2241 or CS 1121 or CS 1111) and (EE 2174 or EE 2173))
- EE 3250 – (EE 3160)
- EE 3261 – (EE 3160)
- EE4219 – (EE 2110 or EE 2112 or EE 3010)
- EE4220 – (EE4219(C))
- EE 4227 – (EE 3120 and (EE 3130(C) or EE 3131))
- EE 4228 – (EE 4227(C))
- EE 4253 – (EE 4252)

EE 4805 – (Permission of instructor and department required)

EE 4901 – (EE 3131 or (EE 3130 and EE 3305) and (EE 3901 or EE 4900) and (EE 3170(C) or
EE 3171(C) or EE 3173(C)))

EE 4910 – (EE 4901)

4. New Course Descriptions

The minor requires no new courses.

5. Estimated Costs

No additional costs anticipated as the program uses existing courses.

6. Planned implementation date

The program can be implemented as soon as approved.

Rail Transportation Minor (Min. 19 Credits)

Required Courses (7 Credits)

CE 4404 - Railroad Engineering
CE 4490 - Rail Transportation Seminar
OSM 4700 - Logistics and Transportation Management

Leadership/Professional Electives (3 Credits)

MGT 3100 Leadership Development
AF 3020 - Leadership Studies II
HU 3120 - Technical and Professional Communication
AF 3010 Leadership Studies I
OSM 3200 - Project Management
MGT 3000 - Organizational Behavior

Railroad Focus Technical Electives (9 Credits)

Civil Track

CE 3401 – Transportation Engineering
CE 4333 - Estimating and Planning of Construction Projects
CE 4407 - Transportation Design
CE 4905 - Senior Design (Railroad Theme)*
CE 4990 - Independent Study in Rail Topics*
CE 5408 - Public Transit
XX-XXXX A course in rail topics from another University*

Mechanical Track

MEEM 3911 – Mechanical Engineering Practice IV
MEEM 4220 - Internal Combustion Engines I
MEEM 4450 - Vehicle Dynamics
MEEM 4901/4911 - Senior Capstone Design (Railroad Theme)*
MEEM 4990 - Independent Study in Rail Topics*
XX-XXXX A course in rail topics from another University*

Electrical Track

EE 3120 – Electric Energy Systems
EE 4219/4220- Intro to Electric Machinery and Drives with lab
EE 4227/4228 - Power Electronics with lab
EE 3160 – Signal Systems
EE 3171 – Microcontroller Applications
EE 3250 – Introduction to Communications Theory
EE 3261 – Control Systems
EE4253 – Real Time Signal Processing
EE 4805 – Electrical Engineering Project with Railroad Focus*
EE 4901/4910 – EE Design Project with Railroad Focus*
XX-XXXX A course in rail topics from another University*

Figure 3 - Program Flow Chart

* An independent study, project, or a senior or enterprise design course with a railroad focus in the student’s major discipline, or a course in rail topics from another university may be substituted for one of the Railroad Focus courses with prior written approval by the Director, Rail Transportation Program.

COURSE DESCRIPTIONS

AF 3010 - Leadership Studies I for Non-AFROTC Students

For non-AFROTC students. AFROTC cadets should enroll in AF3001. Study and practice of leadership

in civilian and military organizations. Topics include leadership principles, problem solving, management fundamentals, counseling, motivation, mentoring, and effective communication. Various leadership theories are discussed. The course includes discussion, informal lecture, self-evaluation of leadership traits, and experiential exercises.

Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Fall

Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman

AF 3020 - Leadership Studies II for Non-AFROTC Students

For non-AFROTC students. AFROTC cadets should enroll in AF3002. Study of leadership in civilian and military institutions. Topics include officership, team building, feedback, Air Force evaluation systems, leadership ethics, professional relations, and communication skills. The course includes discussion, informal lecture, case studies, and experiential exercises.

Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Spring

Restrictions: Permission of instructor required; May not be enrolled in one of the following Class(es): Freshman

CE 3401 - Transportation Engineering

Introduction to transportation in the United States, highway types and systems, principles of route location, vehicle characteristics, highway geometrics and design standards, drainage, environmental considerations, pavement design, and economic principles and engineering criteria for highway improvements.

Credits: 3.0 Lec-Rec-Lab: (0-3-0) Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following Class(es): Freshman

CE 4333 - Estimating and Planning of Construction Projects

Examination of the principles and techniques of estimating construction costs leading to the development of an estimate and proposal submission. The relationship between the contract specification, drawings, and the estimate will be illustrated.

Credits: 3.0 | Lec-Rec-Lab: (2-0-2) | Semesters Offered: Fall

Pre-Requisite(s): CE 3332

CE 4404 – Railroad Engineering

Overview of basic elements and roles of rail transportation, history, organizations and economics, safety, intercity and urban passenger rail, freight operations, track-train dynamics, signals and communications, motive power and equipment, track components, construction and maintenance.

Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall

Pre-Requisite(s): Junior standing or above

CE 4407 - Transportation Design

An introduction to the planning-design-construction process for highways, intersections, and railroads. Operations, capacity, safety, and geometric design features. Horizontal and vertical alignment and cross sections. Design criteria, standards, environmental aspects, cost, and construction considerations. Use of CAD systems in preparing contact plans.

Credits: 3.0 | Lec-Rec-Lab: (2-0-2) | Semesters Offered: Spring

Pre-Requisite(s): SU2000, CE 3401

CE 4490 – Rail Transportation Seminar

Presentations and discussion of current literature and research related to rail transportation.

Credits: 1.0 | Lec-Rec-Lab: (0-1-0) | Semesters Offered: Spring

Pre-Requisite(s): Junior standing or above

CE 4905 – Senior Design

An engineering design project related to civil and environmental engineering.
Credits: 3.0 | Lec-Rec-Lab: (0-2-3) | Semesters Offered: Fall, Spring, Summer
Pre-Requisite(s): Senior standing

CE 5408 – Public Transit

An introduction to public transit, user characteristics, management, transit modes, data collection and surveys, planning, operations, scheduling, transit finances, and future trends
Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall
Pre-Requisite(s): Senior standing with permission of instructor

HU 3120 - Technical and Professional Communication

A study of written and oral communication in technical and scientific environments; emphasizes audience, writing processes, genres of scientific and technical discourse, visual communication, collaboration, professional responsibility, clear and correct expression. Students write and revise several documents and give oral report(s). Computer Intensive.
Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Fall, Spring, Summer
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): UN 1015

MGT 3000 – Organizational Behavior

Covers concepts of human behavior and organizational behavior through the study of people's behavior at work. Develop understanding, attitudes, and skills leading to increased personal effectiveness
Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall, Spring, Summer
Pre-Requisite(s): Sophomore standing or above

MGT 3100 – Leadership Development

Assesses students' current knowledge, abilities and values relevant to leadership and guides students in developing and implementing plans for new leadership abilities.
Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Fall, Spring
Pre-Requisite(s): Sophomore standing or above

OSM 4700 - Logistics and Transportation Management

Focuses on the transportation and distribution services that support demand fulfillment from the receipt of customer orders to order fulfillment. Topics include customer service, order fulfillment, inventory, transportation costs and modes, facility design and operation, carrier selection, and negotiation.
Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall
Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore
Pre-Requisite(s): (MA 2710 or MA 2720 or MA 3710) and (MA 1135 or MA 1160 or MA 1161)

MEEM 3911 - Mechanical Engineering Practice IV

Students further develop their skills to identify and solve ill-defined problems. They tackle a complex system problem by gathering evidence, proposing a solution, and iterating to optimize the solution.
Credits: 3.0 | Lec-Rec-Lab: (0-2-3) | Semesters Offered: Fall, Spring, Summer
Restrictions: Must be enrolled in one of the following Major(s): Mechanical Engineering
Pre-Requisite(s): MEEM 3901 and EE 3010 and MEEM 3400 and MEEM 3600

MEEM 4220 - Internal Combustion Engines I

Teaches the operation and design of various types of internal combustion engines through the application of applied thermodynamics, cycle analysis, combustion, mixtures of gases, fluid dynamics, and heat

transfer.

Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Spring

Restrictions: May not be enrolled in one of the following Level(s): Graduate

Pre-Requisite(s): MEEM 3210

MEEM 4450 - Vehicle Dynamics

This course will develop the models and techniques needed to predict the performance of a road vehicle during drive off, braking, ride, and steering maneuvers. Topics to be covered include: acceleration and braking performance, drive train performance including an introduction to hybrid electric power train architecture, vehicle handling, suspension modeling, tire models, and steering control. Matlab will be used as a computational tool for implementation of the models.

Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Spring

Restrictions: Must be enrolled in one of the following College(s): College of Engineering

Pre-Requisite(s): (MEEM 3502 and MEEM 3000) or (EE 3305 and MEEM 2700)

MEEM 4655 - Production Planning

Provides current issues, such as just-in-time production and reengineering, while covering fundamental production planning topics as scheduling, job design, inventory and forecasting. Provides the fundamental essence of the firm--how its services and products are created and how they are delivered to customers.

Credits: 3.0 | Lec-Rec-Lab: (0-3-0) | Semesters Offered: Fall, Spring

Pre-Requisite(s): MEEM 3501(C)

MEEM 4901 - Senior Capstone Design I

Students work in teams on "open-ended" engineering capstone design projects - most with industrial sponsors - developing original and creative solutions to real engineering problems.

Credits: 2.0 | Lec-Rec-Lab: (0-0-6) | Semesters Offered: Fall, Spring

Restrictions: Must be enrolled in one of the following Major(s): Mechanical Engineering

Pre-Requisite(s): MEEM 3000(C) and MEEM 3502(C) and MEEM 3900

MEEM 4911 - Senior Capstone Design II

Design projects started in MEEM4901 are completed and evaluated using computer-aided engineering methods, physical models, and/or prototypes as appropriate.

Credits: 2.0 | Lec-Rec-Lab: (0-0-6) | Semesters Offered: Fall, Spring

Restrictions: Must be enrolled in one of the following Major(s): Mechanical Engineering

Pre-Requisite(s): MEEM 4901 and MEEM 3000(C) and MEEM 3502(C) and MEEM 3900

MEEM 4990 - Special Topics in Mech Engg

Problems in mechanical engineering, engineering mechanics, manufacturing, or industrial engineering that are not covered in regular courses.

Credits: variable to 6.0; Repeatable to a Max of 6 | Semesters Offered: Fall, Spring, Summer

Restrictions: Permission of department required; May not be enrolled in one of the following Class(es): Freshman

EE 3120 - Electric Energy Systems

An overview of the generation and utilization of electrical energy. Covers three-phase circuits, transformers, photovoltaics, batteries, electromechanical energy conversion, and an overview of electric power systems, including economic issues.

Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall, Spring, Summer

Pre-Requisite(s): EE 2110 or EE 3010 or (EE 2111 and EE 2112(C))

EE 3160 - Signals and Systems

Introduces the mathematical analysis of signals, systems, and control. Topics include differential equations, Fourier series, Fourier transforms, LaPlace transforms, frequency response, Bode plots, state models, and an introduction to control systems.

Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall, Spring, Summer

Pre-Requisite(s): (EE 2110 or EE 2112) and (MA 2320 or MA 2321 or MA 2330) and (MA 3520 or MA 3521 or MA 3530 or MA 3560)

EE 3171 - Microcontroller Applications

Introduces the concepts of microcontroller-based systems. Describes basic characteristics of microcontrollers, then goes into significant detail in the applications of a specific microcontroller. Topics include C and assembly language programming, instruction set interface, ASICs, and polled, interrupt, and DMA input/output.

Credits: 4.0 | Lec-Rec-Lab: (3-0-2) | Semesters Offered: Fall, Spring, Summer

Restrictions: May not be enrolled in one of the following Major(s): Computer Engineering

Pre-Requisite(s): (EE 2241 or CS 1121 or CS 1111) and (EE 2174 or EE 2173)

EE 3250 - Introduction to Communications Theory

Introduction to communications systems and theory; fundamentals of point-to-point communication link design and analysis; analog modulation and demodulation techniques; digital signal representation and filtering; binary data transmission.

Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall, Spring, Summer

Pre-Requisite(s): EE 3160

EE 3261 - Control Systems

Mathematical formulation of control problems (both transfer function and state-variable descriptions); analysis of feedback control systems (stability, transient performance, steady-state error, sensitivity, etc.); analog and digital simulation; and experiments with physical systems.

Credits: 3.0 | Lec-Rec-Lab: (2-0-2) | Semesters Offered: Fall, Spring

Pre-Requisite(s): EE 3160 EE 3180(C)

EE 4219 - Introduction to Electric Machinery and Drives

Provides a thorough understanding of how electric machines can be used to drive loads with control of speed, torque and position. Topics include basic electro-mechanics, rotating machinery, dc machines, ac machines, power electronics and load modeling. Applications include industrial systems, hybrid/electric vehicles and electric power systems.

Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Spring

Pre-Requisite(s): EE 2110 or EE 2112 or EE 3010

EE 4220 - Introduction to Electric Machinery and Drives Laboratory

Provides a hands on understanding of how electric machines can be used to drive loads with control of speed, torque, and position. Topics include basic electro-mechanics, rotating machinery, dc machines, ac machines, power electronics, and load modeling.

Credits: 1.0 | Lec-Rec-Lab: (0-0-2) | Semesters Offered: Spring

Pre-Requisite(s): EE 4219(C)

EE 4227 - Power Electronics

Fundamentals of circuits for electrical energy processing. Covers switching converter principles for dc-dc, ac-dc, and dc-ac power conversion. Other topics include harmonics, pulse-width modulation, feedback control, magnetic components and power semiconductors.

Credits: 3.0 | Lec-Rec-Lab: (3-0-0) | Semesters Offered: Fall, Summer

Pre-Requisite(s): EE 3120 and (EE 3130(C) or EE 3131)

EE 4228 - Power Electronics Lab

Fundamentals of design, construction and control of circuits for electrical energy processing. Covers switching converter principles for dc-dc, ac-dc, and dc-ac power conversion. Other topics include harmonics, pulse-width modulation, feedback control, magnetic components and power semiconductors.

Credits: 1.0 | Lec-Rec-Lab: (0-0-3) | Semesters Offered: Fall

Pre-Requisite(s): EE 4227(C)

EE 4253 - Real Time Signal Processing

Practical implementation of digital signal processing concepts as developed in EE4252. Emphasis on applications of DSP to communications, filter design, speech processing, and radar. Laboratory provides practical experience in the design and implementation of DSP solutions.

Credits: 3.0 | Lec-Rec-Lab: (2-0-2) | Semesters Offered: Spring

Pre-Requisite(s): EE 4252

EE 4805 - Electrical Engineering Project

A project in electrical engineering. An individual student or a group of students complete a mutually-agreed-upon project in consultation with a faculty member.

Credits: variable to 3.0; Repeatable to a Max of 6; Graded Pass/Fail Only | Semesters Offered: Fall, Spring, Summer

Restrictions: Permission of instructor and department required

EE 4901 - EE Design Project 1

The first semester of a program of study in which a group of students work on an engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

Credits: 2.0 | Lec-Rec-Lab: (1-0-3) | Semesters Offered: Fall

Restrictions: May not be enrolled in one of the following Class(es): Freshman, Sophomore, Junior

Pre-Requisite(s): EE 3131 or (EE 3130 and EE 3305) and (EE 3901 or EE 4900) and (EE 3170(C) or EE 3171(C) or EE 3173(C))

EE 4910 - EE Design Project 2

The second semester of a program of study in which a group of students work on an engineering design project in consultation with a faculty member. (Senior project ready as defined by major substitutes for prerequisites)

Credits: 2.0 | Lec-Rec-Lab: (0-1-3) | Semesters Offered: Spring

Pre-Requisite(s): EE 4901