

Bachelor of Science in Mechanical Engineering

Program Description

The Mechanical Engineering Department offers a design-oriented, project-based undergraduate program emphasizing fundamental engineering principles, with many courses providing hands-on and active learning experiences.

The Bachelor of Science in Mechanical Engineering program intentionally embeds professional and technical skills, e.g., working on teams, engineering design, technical communication, and programming throughout the Mechanical Engineering curriculum. Our project-based design spine is bookended by the first-year experience in Introduction to Design (EDNS 151) and our multidisciplinary capstone experience (EDNS 491 & 492) in the senior year. Following their first year at Mines, our students enter our project-based design spine in the middle years (sophomore and junior).

This project-based experience teaches design methodology and stresses the creative aspects of the mechanical engineering profession. The courses help prepare students for open-ended, industry-based projects in the senior design experience.

Students receive a strong foundation in mechanical engineering disciplines and a working knowledge of modern engineering tools, e.g., design and manufacturing techniques.

If students want to gain depth in a particular area of mechanical engineering, they can align their four ME electives in one of our eight tracks: Aerospace, Automotive, Automation and Controls, Biomechanics, Energy, Manufacturing, Materials, and Nuclear Energy. With over 80% of our students participating in industry-sponsored internships or research with our faculty, our graduates are well prepared for a mechanical engineering career in a world of rapid technological change. Students may continue to graduate school or pursue careers in automation and robotics, automotive, aerospace, defense, manufacturing, patent law, power generation, sustainable energy, and more.

Program Educational Objectives

The Mechanical Engineering program contributes to the educational objectives described in the Mines' Graduate Profile and the ABET accreditation criteria. Accordingly, the Mechanical Engineering program at Mines has established the following program educational objectives for the BS in Mechanical Engineering degree:

The Mechanical Engineering program prepares graduates within three to five years of completing their degree to:

- Apply their Mechanical Engineering education as active contributors to their professional community and society more broadly;
- Effectively communicate information and its practical and societal impact to a diverse and globally integrated society;
- Demonstrate their commitment to professional development and life-long learning through workforce readiness training, professional community involvement, and community outreach;
- Embody ethical, environmental and societal responsibility encompassing diversity, equity and inclusion in their professional activities.

Student Learning Objectives

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.

ABET Accreditation Status

The Bachelor of Science in Mechanical Engineering is accredited by the Engineering Accreditation Commission of ABET, <https://www.abet.org>, under the commission's General Criteria and Program Criteria for Mechanical and Similarly Named Engineering Programs.

Primary Contact

mechanical@mines.edu

Bachelor of Science in Mechanical Engineering Degree Requirements:

First Year

		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			1.0
EDNS151	CORNERSTONE - DESIGN I			3.0
HASS100	NATURE AND HUMAN VALUES			3.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
HASS215	FUTURES			3.0
CSCI128	COMPUTER SCIENCE FOR STEM			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.0
CSM202	INTRODUCTION TO STUDENT WELL-BEING AT MINES			1.0
				30.0

Sophomore

		lec	lab	sem.hrs
CEEN241	STATICS			3.0

MTGN202	ENGINEERED MATERIALS			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
MEGN200	INTRODUCTION TO MECHANICAL ENGINEERING: PROGRAMMING AND HARDWARE INTERFACE			3.0
OR				
MEGN201	INTRODUCTION TO MECHANICAL ENGINEERING: DESIGN & FABRICATION			4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.0
S&W	SUCCESS AND WELLNESS			1.0
				18.0
Spring		lec	lab	sem.hrs
EENG281	ELECTRICAL CIRCUITS			3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
MEGN212	INTRODUCTION TO SOLID MECHANICS			3.0
MEGN261	THERMODYNAMICS I			3.0
MEGN201	INTRODUCTION TO MECHANICAL ENGINEERING: DESIGN & FABRICATION			3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective			3.0
				18.0

Junior				
Fall		lec	lab	sem.hrs
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING			3.0
MEGN300	INSTRUMENTATION & AUTOMATION			3.0
MEGN315	DYNAMICS			3.0
MEGN324	INTRODUCTION TO FINITE ELEMENT ANALYSIS			3.0
EBGN321	ENGINEERING ECONOMICS (EBGN321 has a prerequisite of 60 credit hours.)			3.0
				15.0

Spring		lec	lab	sem.hrs
MEGN301	MECHANICAL INTEGRATION & DESIGN			3.0
MEGN351	FLUID MECHANICS			3.0
MEGN381	MANUFACTURING PROCESSES			3.0
MEGN481	MACHINE DESIGN			3.0
MECH	Mechanical Engineering			3.0
ELECT	Elective*			
				15.0

Senior				
Fall		lec	lab	sem.hrs
EDNS491	CAPSTONE DESIGN I			3.0
MEGN471	HEAT TRANSFER			3.0

MECH	Mechanical Engineering	3.0
ELECT	Elective*	
FREE	Free Elective	3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) 400-Level Restricted Elective	3.0

Spring			lec	lab	sem.hrs
EDNS492	CAPSTONE DESIGN II				3.0
MECH	Advanced Engineering Sciences				3.0
ELECT	Elective				
MECH	Mechanical Engineering				3.0
ELECT	Elective*				
FREE	Free Elective				3.0
ELECTIVE	CULTURE AND SOCIETY (CAS) Mid-Level Restricted Elective				3.0
					15.0

Total Semester Hrs: 126.0

* Mechanical Engineering students are required to take four Mechanical Engineering elective courses. At least one of these courses must be from the Advanced Engineering Sciences list. The remaining must be from either the Advanced Engineering Sciences list or the Mechanical Engineering Electives list.

Advanced Engineering Sciences:

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
MEGN416	ENGINEERING VIBRATION	3.0
MEGN451	AERODYNAMICS	3.0
MEGN461	THERMODYNAMICS II	3.0

Mechanical Engineering Electives:

AMFG5XX	Non-seminar and research credit	
AMFG501	ADDITIVE MANUFACTURING PROCESSES	3.0
AMFG511	DATA DRIVEN ADVANCED MANUFACTURING	3.0
AMFG521	DESIGN FOR ADDITIVE MANUFACTURING	3.0
AMFG522	LEAN MANUFACTURING	3.0
AMFG523	DESIGN AND ANALYSIS OF EXPERIMENTS	3.0
AMFG531	MATERIALS FOR ADDITIVE MANUFACTURING	3.0
AMFG581	OPTIMIZATION MODELS IN MANUFACTURING	3.0
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
CEEN320	INTRODUCTION TO CONSTRUCTION ENGINEERING	3.0
CEEN401	LIFE CYCLE ASSESSMENT	3.0
CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
CEEN406	FINITE ELEMENT METHODS FOR ENGINEERS	3.0
CEEN433	MATRIX STRUCTURAL ANALYSIS	3.0
CEEN493	SUSTAINABLE ENGINEERING DESIGN	3.0
CEEN570	WATER AND WASTEWATER TREATMENT	3.0
CSCI200	FOUNDATIONAL PROGRAMMING CONCEPTS & DESIGN (AMFG5XX::Non-seminar and research credit)	3.0
CSCI303	INTRODUCTION TO DATA SCIENCE	3.0

CSCI306	SOFTWARE ENGINEERING	3.0	HNRS355	VERTICALLY INTEGRATED PROJECTS FOR EXPERIENTIAL RESEARCH (Student can earn up to 3 credit hours of ME elective credit through the VIPER program. Students must complete 3 consecutive semesters of the VIPER program to earn ME elective credit.)	
CSCI341	COMPUTER ORGANIZATION	3.0			
CSCI404	ARTIFICIAL INTELLIGENCE	3.0			
CSCI437	INTRODUCTION TO COMPUTER VISION	3.0			
CSCI442	OPERATING SYSTEMS	3.0			
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0			
CSCI473	ROBOT PROGRAMMING AND PERCEPTION	3.0	HNRS455	VERTICALLY INTEGRATED PROJECTS FOR EXPERIENTIAL RESEARCH (Student can earn up to 3 credit hours of ME elective credit through the VIPER program. Students must complete 3 consecutive semesters of the VIPER program to earn ME elective credit.)	
CSCI5XX	Non-project and research credit				
EBGN453	PROJECT MANAGEMENT	3.0			
EBGN525	BUSINESS ANALYTICS	3.0			
EBGN553	PROJECT MANAGEMENT	3.0			
EBGN563	MANAGEMENT OF TECHNOLOGY AND INNOVATION	3.0	MATH324	STATISTICAL MODELING	3.0
EDNS401	PROJECTS FOR PEOPLE	3.0	MATH332	LINEAR ALGEBRA	3.0
EDNS444	INNOV8X	3.0	MATH334	INTRODUCTION TO PROBABILITY	3.0
EDNS450	DESIGN FOR THE BUILT ENVIRONMENT	3.0	MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
EDNS544	INNOV8X	3.0	MATH432	SPATIAL STATISTICS	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0	MATH436	ADVANCED STATISTICAL MODELING	3.0
EENG310	INFORMATION SYSTEMS SCIENCE I	3.0	MATH454	COMPLEX ANALYSIS	3.0
EENG383	EMBEDDED SYSTEMS	4.0	MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0	MATH5XX	Non-project and research credit	
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0	MEGN4XX	Mechanical Tech Elective (not including 499 & required 400-level courses)	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0	MEGN414	MECHANICS OF COMPOSITE MATERIALS	3.0
EENG411	DIGITAL SIGNAL PROCESSING	3.0	MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
EENG417	MODERN CONTROL DESIGN	3.0	MEGN391	INTRODUCTION TO AUTOMOTIVE DESIGN ((Automotive track students only))	3.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0	MEGN417	VEHICLE DYNAMICS	3.0
EENG5XX	Non-seminar and research credit		MEGN423	APPLIED COMPUTATIONAL FLUID DYNAMICS	3.0
ENGY340	NUCLEAR ENERGY	3.0	MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
ENGY419	THE PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0	MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
ENGY475	INTRODUCTION TO NUCLEAR ENGINEERING	3.0	MEGN441	INTRODUCTION TO ROBOTICS	3.0
ENGY5XX	Non-seminar and research credit		MEGN452	INTRO TO SPACE EXPLORATION AND RESOURCES	3.0
FEGN5XX	Non-project and research credit		MEGN453	AEROSPACE STRUCTURES	3.0
FEGN525	ADVANCED FEA THEORY & PRACTICE	3.0	MEGN454	ORBITAL MECHANICS	3.0
FEGN527	NONLINEAR APPLICATIONS IN FEA	3.0	MEGN455	AEROSPACE SYSTEMS ENGINEERING	3.0
FEGN526	STATIC AND DYNAMIC APPLICATIONS IN FEA	3.0	MEGN456	SPACE OPERATIONS AND MISSION DESIGN	3.0
FEGN528	FEA FOR ADVANCED DESIGN APPLICATIONS	3.0	MEGN465	ELECTRIC VEHICLE POWERTRAIN SYSTEMS	3.0
HNRS155	VERTICALLY INTEGRATED PROJECTS FOR EXPERIENTIAL RESEARCH (Student can earn up to 3 credit hours of ME elective credit through the VIPER program. Students must complete 3 consecutive semesters of the VIPER program to earn ME elective credit.)		MEGN466	INTRODUCTION TO INTERNAL COMBUSTION ENGINES	3.0
HNRS255	VERTICALLY INTEGRATED PROJECTS FOR EXPERIENTIAL RESEARCH (Student can earn up to 3 credit hours of ME elective credit through the VIPER program. Students must complete 3 consecutive semesters of the VIPER program to earn ME elective credit.)		MEGN467	PRINCIPLES OF BUILDING SCIENCE	3.0
			MEGN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
			MEGN475	INTRODUCTION TO NUCLEAR ENGINEERING	3.0
			MEGN479	OPTIMIZATION MODELS IN MANUFACTURING	3.0
			MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	3.0
			MEGN486	LINEAR OPTIMIZATION	3.0
			MEGN487	NONLINEAR OPTIMIZATION	3.0
			MEGN488	INTEGER OPTIMIZATION	3.0
			MEGN498	SPECIAL TOPICS IN MECHANICAL ENGINEERING (SPECIAL TOPICS)	1-6

MEGN5XX	ANY 500-LEVEL MEGN COURSE	3.0	MTGN475	METALLURGY OF WELDING	2.0
MEGN500	INTRODUCTION TO ENGINEERING RESEARCH		MTGN593	NUCLEAR MATERIALS SCIENCE AND ENGINEERING	3.0
MEGN501	ADVANCED ENGINEERING MEASUREMENTS	3.0	NUGN506	NUCLEAR FUEL CYCLE	3.0
MEGN502	ADVANCED ENGINEERING ANALYSIS	3.0	NUGN510	INTRODUCTION TO NUCLEAR REACTOR PHYSICS	3.0
MEGN505	ADVANCED DYNAMICS	3.0	NUGN520	INTRODUCTION TO NUCLEAR REACTOR THERMAL-HYDRAULICS	3.0
MEGN510	THEORY OF ELASTICITY	3.0	PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
MEGN511	FATIGUE AND FRACTURE	3.0	PHGN310	HONORS PHYSICS III-MODERN PHYSICS	3.0
MEGN514	CONTINUUM MECHANICS	3.0	PHGN350	INTERMEDIATE MECHANICS	4.0
MEGN515	COMPUTATIONAL MECHANICS	3.0	PHGN466	MODERN OPTICAL ENGINEERING	3.0
MEGN517	NONLINEAR MATERIAL BEHAVIOR	3.0			
MEGN523	APPLIED COMPUTATIONAL FLUID DYNAMICS	3.0			
MEGN527	VEHICLE DYNAMICS AND POWERTRAIN SYSTEMS	3.0			
MEGN532	EXPERIMENTAL METHODS IN BIOMECHANICS	3.0			
MEGN533	MUSCULOSKELETAL BIOMECHANICS	3.0			
MEGN535	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0			
MEGN536	COMPUTATIONAL BIOMECHANICS	3.0			
MEGN540	MECHATRONICS	3.0			
MEGN544	ROBOT MECHANICS: KINEMATICS, DYNAMICS, AND CONTROL	3.0			
MEGN545	ADVANCED ROBOT CONTROL	3.0			
MEGN551	ADVANCED FLUID MECHANICS	3.0			
MEGN552	FLUID, THERMAL, AND MASS TRANSPORT	3.0			
MEGN553	COMPUTATIONAL FLUID DYNAMICS	3.0			
MEGN554	ORBITAL MECHANICS	3.0			
MEGN561	ADVANCED ENGINEERING THERMODYNAMICS	3.0			
MEGN565	ELECTRIC VEHICLE POWERTRAIN SYSTEMS	3.0			
MEGN566	COMBUSTION	3.0			
MEGN567	PRINCIPLES OF BUILDING SCIENCE	3.0			
MEGN569	FUEL CELL SCIENCE AND TECHNOLOGY	3.0			
MEGN570	ELECTROCHEMICAL SYSTEMS ENGINEERING	3.0			
MEGN571	ADVANCED HEAT TRANSFER	3.0			
MEGN572	MECHANISTIC UNDERSTANDING ACROSS SCALES TO BUILD BETTER BATTERIES	3.0			
MEGN579	OPTIMIZATION MODELS IN MANUFACTURING	3.0			
MEGN585	NETWORK MODELS	3.0			
MEGN586	LINEAR OPTIMIZATION	3.0			
MEGN587	NONLINEAR OPTIMIZATION	3.0			
MEGN588	INTEGER OPTIMIZATION	3.0			
MEGN592	RISK AND RELIABILITY ENGINEERING ANALYSIS AND DESIGN	3.0			
MNGN333	EXPLOSIVES ENGINEERING I	3.0			
MNGN444	EXPLOSIVES ENGINEERING II	3.0			
MTGN211	STRUCTURE OF MATERIALS	3.0			
MTGN333	INTRODUCTION TO BLADESMITHING	3.0			
MTGN350	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0			
MTGN442	ENGINEERING ALLOYS	3.0			
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0			
MTGN464	FORGING AND FORMING	2.0			
MTGN472	BIOMATERIALS I	3.0			

Major GPA

During the 2016-2017 Academic Year, the Undergraduate Council considered the policy concerning required major GPAs and which courses are included in each degree's GPA. While the GPA policy has not been officially updated, in order to provide transparency, council members agreed that publishing the courses included in each degree's GPA is beneficial to students.

The following list details the courses that are included in the GPA for this degree:

- CEEN241
- EDNS491
- EDNS492
- MEGN100 through MEGN699 inclusive

Tracks for me undergraduate program

Tracks in Mechanical Engineering offer an opportunity for ME undergrads to explore various topics in mechanical engineering in more depth. Students gain depth in the areas by focusing their ME Electives on four courses prescribed in each track. Each proposed track is defined below with one course required in the Advanced Engineering Science Elective and three courses required from the ME Elective courses. Note that undergraduate students are not required to align with a track. Tracks are suggestions for students to gain advanced knowledge in a subdiscipline area and are "transcriptable."

Aerospace

A total of 4 courses is required from the two groups below.

Choose at least 1 of the following four Advanced Engineering Science Elective courses:

MEGN451	AERODYNAMICS	3.0
or MEGN461	THERMODYNAMICS II	
or MEGN412	ADVANCED MECHANICS OF MATERIALS	
or MEGN416	ENGINEERING VIBRATION	

Choose at least 2 of the following ME Elective courses:

MEGN414	MECHANICS OF COMPOSITE MATERIALS	3.0
MEGN423	APPLIED COMPUTATIONAL FLUID DYNAMICS	3.0
or MEGN523	APPLIED COMPUTATIONAL FLUID DYNAMICS	
MEGN452	INTRO TO SPACE EXPLORATION AND RESOURCES	3.0
MEGN453	AEROSPACE STRUCTURES	3.0
MEGN454	ORBITAL MECHANICS	3.0

MEGN554	ORBITAL MECHANICS	3.0
MEGN455	AEROSPACE SYSTEMS ENGINEERING	3.0
MEGN456	SPACE OPERATIONS AND MISSION DESIGN	3.0
MEGN553	COMPUTATIONAL FLUID DYNAMICS (BSME + MSNT program students only)	3.0
FEGN525	ADVANCED FEA THEORY & PRACTICE (BSME + MSNT program students only)	3.0

Automation & Controls

Must take both:

MEGN416	ENGINEERING VIBRATION	3.0
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and

EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
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Choose 2 of the following ME Elective courses:

MATH332	LINEAR ALGEBRA	3.0
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI437	INTRODUCTION TO COMPUTER VISION	3.0
CSCI470	INTRODUCTION TO MACHINE LEARNING	3.0
CSCI473	ROBOT PROGRAMMING AND PERCEPTION	3.0
EENG383	EMBEDDED SYSTEMS	4.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG417	MODERN CONTROL DESIGN	3.0
EENG517	THEORY AND DESIGN OF ADVANCED CONTROL SYSTEMS	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	3.0
or MEGN585	NETWORK MODELS	
MEGN540	MECHATRONICS	3.0
MEGN544	ROBOT MECHANICS: KINEMATICS, DYNAMICS, AND CONTROL (BSME + MSNT program students only)	3.0
MEGN545	ADVANCED ROBOT CONTROL	3.0

Automotive

Choose 1 of the following four Advanced Engineering Science Elective courses:

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
or MEGN416	ENGINEERING VIBRATION	
or MEGN451	AERODYNAMICS	
or MEGN461	THERMODYNAMICS II	

Must take both:

MEGN391	INTRODUCTION TO AUTOMOTIVE DESIGN (Only offered in the Spring semesters. Prerequisite for MEGN417. Students in the Automotive track only.)	3.0
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and

MEGN417	VEHICLE DYNAMICS (Only offered in the Fall semesters.)	3.0
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Choose 1 of the following ME Elective courses:

EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
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MEGN423	APPLIED COMPUTATIONAL FLUID DYNAMICS	3.0
or MEGN523	APPLIED COMPUTATIONAL FLUID DYNAMICS	
MEGN465	ELECTRIC VEHICLE POWERTRAIN SYSTEMS	3.0
or MEGN565	ELECTRIC VEHICLE POWERTRAIN SYSTEMS	
MEGN466	INTRODUCTION TO INTERNAL COMBUSTION ENGINES	3.0
MEGN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
or MEGN569	FUEL CELL SCIENCE AND TECHNOLOGY	
MEGN566	COMBUSTION (BSME + MSNT program students only.)	3.0
FEGN525	ADVANCED FEA THEORY & PRACTICE (BSME + MSNT program students only.)	3.0

Biomechanics

Choose 1 of the following Advanced Engineering Science Elective courses:

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
or MEGN416	ENGINEERING VIBRATION	

Must take:

MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
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Choose 2 of the following ME Elective courses:

MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
or MEGN533	MUSCULOSKELETAL BIOMECHANICS	
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
or MEGN535	MODELING AND SIMULATION OF HUMAN MOVEMENT	
MEGN441	INTRODUCTION TO ROBOTICS	3.0
MEGN536	COMPUTATIONAL BIOMECHANICS	3.0
MATH324	STATISTICAL MODELING	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MTGN472	BIOMATERIALS I	3.0
FEGN525	ADVANCED FEA THEORY & PRACTICE (BSME + MSNT program students only.)	3.0

Energy

Advanced Engineering Science Elective

MEGN461	THERMODYNAMICS II	3.0
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ME Elective (select 3 courses)

Choose 1 of the following ME elective courses:

MEGN466	INTRODUCTION TO INTERNAL COMBUSTION ENGINES	3.0
MEGN467	PRINCIPLES OF BUILDING SCIENCE	3.0
or MEGN567	PRINCIPLES OF BUILDING SCIENCE	
MEGN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
or MEGN569	FUEL CELL SCIENCE AND TECHNOLOGY	

Choose 2 of the following ME elective courses:

MEGN475	INTRODUCTION TO NUCLEAR ENGINEERING	3.0
or ENGY475	INTRODUCTION TO NUCLEAR ENGINEERING	
ENGY419	THE PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
CEEN493	SUSTAINABLE ENGINEERING DESIGN	3.0

EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0
MEGN561	ADVANCED ENGINEERING THERMODYNAMICS	3.0

Materials and Manufacturing

Advanced Engineering Science Elective

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
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Choose 3 of the following ME Elective courses:

MEGN414	MECHANICS OF COMPOSITE MATERIALS	3.0
MEGN479	OPTIMIZATION MODELS IN MANUFACTURING	3.0
or MEGN579	OPTIMIZATION MODELS IN MANUFACTURING	
MEGN511	FATIGUE AND FRACTURE	3.0
AMFG501	ADDITIVE MANUFACTURING PROCESSES	3.0
AMFG522	LEAN MANUFACTURING	3.0
MTGN211	STRUCTURE OF MATERIALS	3.0
MTGN333	INTRODUCTION TO BLADESMITHING	3.0
MTGN350	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN464	FORGING AND FORMING (with co-requisite of MTGN464L)	3.0
MTGN475	METALLURGY OF WELDING	2.0

Business Management

A total of 4 courses are needed from the three groups below.

Choose 1 of the following four Advanced Engineering Science Elective courses:

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
or MEGN416	ENGINEERING VIBRATION	
or MEGN451	AERODYNAMICS	
or MEGN461	THERMODYNAMICS II	

Choose at least 1 of the following courses. (These courses are approved to serve as ME elective only for students in the track).

EBGN305	SURVEY OF ACCOUNTING	3.0
EBGN308	PRINCIPLES OF MARKETING	3.0
EBGN309	FUNDAMENTALS OF MANAGEMENT	3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3.0
EBGN346	INTRODUCTION TO INVESTMENTS	3.0
EBGN351	INTRODUCTION TO DECISION SCIENCE	3.0
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3.0

Choose at least 1 of the following ME Elective courses:

MEGN479	OPTIMIZATION MODELS IN MANUFACTURING	3.0
or MEGN579	OPTIMIZATION MODELS IN MANUFACTURING	
MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	3.0
or MEGN585	NETWORK MODELS	
MEGN486	LINEAR OPTIMIZATION	3.0
or MEGN586	LINEAR OPTIMIZATION	
MEGN487	NONLINEAR OPTIMIZATION	3.0
or MEGN587	NONLINEAR OPTIMIZATION	
MEGN488	INTEGER OPTIMIZATION	3.0
or MEGN588	INTEGER OPTIMIZATION	
EBGN453	PROJECT MANAGEMENT	3.0

EBGN525	BUSINESS ANALYTICS (ETM 4+1 students only)	3.0
EBGN553	PROJECT MANAGEMENT (ETM 4+1 students only)	3.0
EBGN563	MANAGEMENT OF TECHNOLOGY AND INNOVATION (ETM 4+1 students only)	3.0

Nuclear Energy

Advanced Engineering Science Elective:

MEGN461	THERMODYNAMICS II	3.0
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Must take:

MEGN475	INTRODUCTION TO NUCLEAR ENGINEERING	3.0
or ENGY475	INTRODUCTION TO NUCLEAR ENGINEERING	

Choose 2 of the following ME elective courses:

ENGY340	NUCLEAR ENERGY (ENGY340 is an UG version of NUGN506)	3.0
or NUGN506	NUCLEAR FUEL CYCLE	
NUGN510	INTRODUCTION TO NUCLEAR REACTOR PHYSICS	3.0
NUGN520	INTRODUCTION TO NUCLEAR REACTOR THERMAL-HYDRAULICS	3.0
MEGN487	NONLINEAR OPTIMIZATION	3.0
or MEGN587	NONLINEAR OPTIMIZATION	
MEGN488	INTEGER OPTIMIZATION	3.0
or MEGN588	INTEGER OPTIMIZATION	
MEGN592	RISK AND RELIABILITY ENGINEERING ANALYSIS AND DESIGN	3.0
MTGN593	NUCLEAR MATERIALS SCIENCE AND ENGINEERING	3.0

Combined Mechanical Engineering Baccalaureate and Masters Degrees

Mechanical Engineering offers a five year combined program in which students have the opportunity to obtain specific engineering skills supplemented with graduate coursework in mechanical engineering. Upon completion of the program, students receive two degrees, the Bachelor of Science in Mechanical Engineering and the Master of Science in Mechanical Engineering.

Admission into a graduate degree program as a Combined Undergraduate/Graduate degree student may occur as early as the first semester Junior year and *must be granted no later than the end of registration the last semester Senior year*. Students must meet minimum GPA admission requirements for the graduate degree.

Students enrolled in Mines' combined undergraduate/graduate program may double count up to six credits of graduate coursework to fulfill requirements of both their undergraduate and graduate degree programs. These courses must have been passed with "B-" or better, not be substitutes for required coursework, and meet all other University, Department, and Program requirements for graduate credit.

Students are advised to consult with their undergraduate and graduate advisors for appropriate courses to double count upon admission to the combined program.

The Mechanical Engineering Graduate Bulletin provides detail into the graduate program and includes specific instructions regarding required and elective courses. Students may switch from the combined program,

which includes a non-thesis Master of Science degree to a M.S. degree with a thesis option; however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

COURSES

MEGN200. INTRODUCTION TO MECHANICAL ENGINEERING: PROGRAMMING AND HARDWARE INTERFACE. 3.0 Semester Hrs.

Mechanical engineers need to know how to design, prototype, and instrument systems by combining programming, electronics, mechatronics, and mechanical design skills. This sophomore-level ME course introduces prototyping skills using an Arduino microcontroller with Arduino C code and an electronics kit to collect, analyze, and react to real-world data. This course builds on programming concepts from pre-req CSCI 128 and reinforces the engineering design process from EDNS 151 through a hands-on final design project that requires programming logic, electronics, and mechanical skills to build a functional prototype. Students will work to define the design problem, identify design constraints, consider multiple solutions, build a working prototype, analyze their design, and effectively communicate their design concept through written documentation and verbal presentation. This course will provide a foundation in programming logic and electronic prototyping to prepare students to instrument systems, develop experiments, collect data, analyze data, and react to data by sending outputs and controlling actuators. MEGN 200 is a required ME course, and students must earn a grade of at least C- (in MEGN 200) to proceed to MEGN 300. Prerequisites: EDNS151 or EDNS155 or HNRS105 or HNRS110; (CSCI101 & CSCI102) or CSCI128.

Course Learning Outcomes

- Develop effective code using programming logic, planning, and debugging techniques to solve engineering problems.
- Create functional electronic circuit prototypes to correctly wire sensor inputs and actuator outputs in a completed circuit.
- Assess appropriate components for mechatronic circuits and systems.
- Apply the engineering design process in collaboration with team members to identify user needs and guide prototyping through iteration.
- Create professional working prototypes with a microcontroller through iteration, testing, and good documentation.
- Justify your design process and final solution effectively through written, oral, and graphical communication.

MEGN201. INTRODUCTION TO MECHANICAL ENGINEERING: DESIGN & FABRICATION. 3.0 Semester Hrs.

This course reinforces basic drawing skills from Cornerstone Design, introduces SolidWorks tools to advance modeling skills, introduces machine shop skills (including safety and use of mill, lathe and CNC mill), provides fundamentals for effective technical drawings, introduces GD&T practices important in fabrication and manufacturing, and teaches use of basic manual measurement tools (including calipers, micrometers, gage blocks, gage pins, and height gages). 3 hours lecture; 3 semester hours. Prerequisite: EDNS151 or EDNS155 or HNRS115 or HNRS120.

Course Learning Outcomes

- Demonstrate basic drawing skills in orthographic views.
- Use SolidWorks to design an object and/or product and an assembly.
- Demonstrate good GD&T practice in technical drawings.
- Employ general shop safety skills.
- Demonstrate manual use of mill and lathe.

- Apply statistical methods relative to manufacturing and GDnT.
- Design (prototype) a part for manufacturability (tolerances, assembly, clearances, etc.).
- Demonstrate ability to implement quality control on designed parts.
- Communicate technical information through drawings.
- Collaborate with team members to design a derby car and manufacture the derby car.

MEGN212. INTRODUCTION TO SOLID MECHANICS. 3.0 Semester Hrs.

Equivalent with MEGN312,

This course introduces students to the principles of Solid Mechanics. Upon completion, students will be able to apply Solid Mechanics theories to analyze and design machine elements and structures using isotropic materials. The skills and knowledge learned in this course form the required foundation for Intro to Finite Element Analysis, Advanced Mechanics of Material, Machine Design and other advanced topics in engineering curricula. Practically, it enables students to solve real-world mechanical behavior problems that involve structural materials. This course places an early focus on ensuring students have mastered the creation of free body diagrams given a mechanical system, then moves on to introduce and reinforce learning of stress and strain transformations, and failure theories. In practicing this knowledge, students will be able to analyze and design machine elements and structures of homogenous and heterogeneous geometries under axial, torsional, bending, transverse shear, internal pressure loads, and non-uniform loads. Students will be able to quantitatively communicate the outcomes. May not also receive credit for CEEN311. Prerequisite: CEEN241 (C- or better).

Course Learning Outcomes

- Apply the appropriate equations for simple loading cases – a) axial, b) thermal, c) torsional, d) bending, e) transverse shear, and f) thin-walled pressure vessels - to characterize the stress state at a given point of interest. Document the resulting stress state on the stress element.
- Construct stress-strain diagrams based on given experimental data. The diagram should identify the regions and points of interest and estimate mechanical properties relevant to the analysis and design of components.
- Use transformation equations or Mohr's circle for plane stress to transform the stress components associated with a particular coordinate system into components related to a rotated system and illustrate the results on the stress element. These skills will be essential for the future application of Failure Theories.
- Apply the appropriate failure theory for a ductile or brittle material and assess the safety of the design.
- Determine deflections and support reactions for both statically determinate and indeterminate beams using the integration and superposition methods.
- Determine the critical buckling load for long, slender members subjected to axial compressive force.
- Document your solution process of an analysis or design problem with free body diagrams, clearly stated assumptions and equations, consistent use of appropriate units and significant figures, and clearly stated and marked final results and conclusions.

MEGN261. THERMODYNAMICS I. 3.0 Semester Hrs.

This course is a comprehensive treatment of thermodynamics from a mechanical engineering point of view. Topics include: Thermodynamic

properties of substances inclusive of phase diagrams, equations of state, internal energy, enthalpy, entropy, and ideal gases; principles of conservation of mass and energy for steady-state and transient analyses; First and Second Law of thermodynamics, heat engines, and thermodynamic efficiencies; Application of fundamental principles with an emphasis on refrigeration and power cycles. May not also receive credit for CBEN210. Prerequisite: MATH213 (C- or better).

Course Learning Outcomes

- Identify the boundary of a system by drawing a control surface and label the transfer of mass and energy across the control surface for a given process.
- Apply balance equations (mass, energy, and entropy) to analyze steady and unsteady processes, relating a system's inputs and outputs (heat, work, and mass transfer) and material properties (temperature, pressure, etc.) with one another.
- Determine the properties of pure substances using equations of state, property tables, software tools, or thermodynamic surfaces, choosing an appropriate method.
- Use the 1st and 2nd law of thermodynamics to identify possible and impossible processes.
- Apply the concept of isentropic efficiency to compare actual and ideal devices.
- Use the concepts of thermal efficiency and coefficient of performance to analyze the performance of power cycles (power plants and internal combustion engines), and assess the performance by comparing to other cycles, to theoretical limits, and to practical material and economic limitations.
- Represent thermodynamic processes in multiple formats, by drawing process schematics, drawing thermodynamic property (P-v and T-s) diagrams, applying balance equations, and writing for diverse audiences (science and non-science).
- Design and analyze thermodynamic systems (cycles and other devices) to meet heating, cooling, and/or power needs for a specified application.

MEGN298. SPECIAL TOPICS. 1-6 Semester Hr.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MEGN298. SPECIAL TOPICS. 1-6 Semester Hr.

MEGN299. INDEPENDENT STUDY. 1-6 Semester Hr.

(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MEGN299. INDEPENDENT STUDY. 0.5-6 Semester Hr.

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MEGN300. INSTRUMENTATION & AUTOMATION. 3.0 Semester Hrs.

This course will explore instrumentation and automation of electro-mechanical systems. Students will utilize LabView and electro-mechanical instrumentation to solve advanced engineering problems. Class activities and projects will highlight the utility of LabView for real-time instrumentation and control. Prerequisite: MEGN200 (C- or better). Corequisite: MEGN201.

Course Learning Outcomes

1. Recognize the strengths and limitations of the software and hardware platforms for instrumentation, data collection and analysis
2. Create customized instrumentation systems and user interfaces
3. Explore software architectures for instrumentation and control
4. Explore various sensor and actuator technologies
5. Apply probability and statistics in large data sets
6. Design an instrumentation system for a specific application
7. Communicate testing procedures and analysis in a technical report
8. Discuss hardware platforms for embedded industrial instrumentation and control, including NI myRIO and CompactRIO

MEGN301. MECHANICAL INTEGRATION & DESIGN. 3.0 Semester Hrs.

Students will utilize the engineering design process and knowledge in systems level design to produce a mechanical product/process. Students will reverse engineer a product/process to emphasize the steps in the design process. Students will select a longer course project, which is intended to reinforce engineering skills from other courses. The project topics would parallel one of the four research disciplines in ME, and students would be able to choose a topic pathway that emphasizes opportunities for mechanical engineering graduates. Prerequisite: MEGN200 (C- or better), MEGN201 (C- or better), MEGN300 (C- or better). Corequisite: MEGN 381.

Course Learning Outcomes

1. apply the engineering design process, from recognition of client needs to release of a fully-tested mechanical/electromechanical product
2. apply a systems-level approach in the design of a product
3. incorporate regulatory requirements and/or standards and additional realistic constraints pertinent to mechanical/electromechanical devices, products or systems into the design process
4. apply technical knowledge in engineering, mathematics, and the sciences to design and benchmark mechanical/electromechanical products
5. use modern engineering software tools in mechanical product design (e.g. Matlab, SolidWorks, or LabView)

- 6. demonstrate use of statistics and probability in the analysis of test results
- 7. professionally document and communicate design efforts

MEGN315. DYNAMICS. 3.0 Semester Hrs.

This course will cover particle kinematics (including 2-D motion in x-y coordinates, normal-tangential coordinates, & polar coordinates), rigid body kinematics (Including relative velocities and accelerations), rigid body kinetics (including the equation of motion, work and energy, linear impulse-momentum, & angular momentum), and introduction to vibrations. Prerequisite: CEEN241 (C- or better). Co-requisites: MATH225.

Course Learning Outcomes

- Apply principles of kinematics of a particle to calculate the motion of the particle
- Calculate the velocities and accelerations of rigid bodies in translation
- Calculate velocities and acceleration of rigid bodies in rotation about a fixed axis
- Calculate the velocities and accelerations of rigid bodies in general plane motion
- Solve kinetics problems using the Equations of Motion method
- Solve kinetics problems using the Work-Energy method
- Solve kinetics problems using the Impulse-Momentum method
- Draw free body diagrams to communicate your problem-solving process

MEGN324. INTRODUCTION TO FINITE ELEMENT ANALYSIS. 3.0 Semester Hrs.

Equivalent with MEGN424,

This course aims to teach basic proficiency with Finite Element Analysis (FEA), which is the most widely used computer aided engineering tool in industry, academia, and government. Fundamentals of FEA theory are introduced, but the majority of the course is spent learning practical skills with commercial FEA software. Students will work interactively with the instructor and with their peers to complete hands-on FEA examples based primarily on problems in structural mechanics. Applications of FEA for heat conduction, natural frequency analysis, and design optimization are covered briefly. The course will conclude with a mini project on which students use FEA skills for engineering analysis and design. The importance of verification and validation (V&V) for critical evaluation of FEA predictions is emphasized, and students will make frequent use of statics and solid mechanics principles to corroborate their FEA results. Prerequisite: MEGN212 (C- or better) or CEEN311 (C- or better).

Course Learning Outcomes

- Understand the basic concepts of the global stiffness force-displacement matrix equations in the displacement finite element method.
- Use a commercial finite element software package (SW Simulation), associated CAD modeling software (SolidWorks) and an engineering math software (MATH CAD) to perform engineering analysis.
- Apply classical engineering methods such as statics and mechanics of materials to check whether the results of a finite element analysis are sensible.
- Apply finite element analysis in the engineering design process. For example, design a simple truss structure and perform finite element analyses to determine the dimensions of the structural members based on specified design constraints.

- Write clear and concise technical memoranda and reports describing the results of an engineering analysis and their use in an engineering design if appropriate.

MEGN330. INTRODUCTION TO BIOMECHANICAL ENGINEERING. 3.0 Semester Hrs.

The application of mechanical engineering principles and techniques to the human body presents many unique challenges. The discipline of Biomedical Engineering (more specifically, Biomechanical Engineering) has evolved over the past 50 years to address these challenges. Biomechanical Engineering includes such areas as biomechanics, biomaterials, bioinstrumentation, medical imaging, and rehabilitation. This course is intended to provide an introduction to, and overview of, Biomechanical Engineering and to prepare the student for more advanced Biomechanical coursework. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply various mechanical engineering principles to the human body. Prerequisite: CEEN241.

Course Learning Outcomes

- Understand the basic concepts in applying material learned in other Mechanical Engineering classes (statics, mechanics of materials) to analysis of the human body

MEGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.

(I,II,S) Supervised, full-time engineering- related employment for a continuous six-month period in which specific educational objectives are achieved. Students must meet with the Engineering Division Faculty Co-op Advisor prior to enrolling to clarify the educational objectives for their individual Co-op program. 3 semester hours credit will be granted once toward degree requirements. Credit earned in EGGN340, Cooperative Education, may be used as free elective credit hours or a civil specialty elective if, in the judgment of the Co-op Advisor, the required term paper adequately documents the fact that the work experience entailed high-quality application of engineering principles and practice. Applying the credits as free electives or civil electives requires the student to submit a 'Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements' form obtained from the Career Center to the Engineering Division Faculty Co-op Advisor. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00.

MEGN351. FLUID MECHANICS. 3.0 Semester Hrs.

This course will cover principles of fluid properties, fluid statics, control-volume analysis, Bernoulli equation, differential analysis and Navier-Stokes equations, dimensional analysis, internal flow, external flow, open-channel flow, and turbomachinery. May not also receive credit for CEEN310 or PEGN251. Prerequisite: CEEN241 with a grade of C- or better or MNGN317 with a grade of C- or better.

Course Learning Outcomes

- Solve mass conservation, momentum, and energy equations for steady-state fluid-flow systems (control-volume analyses).
- Apply differential conservation-of-mass and linear-momentum equations and material derivatives to the solution of flow problems (differential analysis).
- Establish non-dimensional groupings of fluid properties, and apply them in the design of experiments that scale between models and prototypes (dimensional analysis).
- Model fully developed laminar and turbulent pipe flow systems (internal flow).

- Develop the relationships for lift and drag on bodies moving through a fluid (external flow).
- Convey understanding of course materials through homework assignments and exams.
- Distinguish what physical aspects are most critical and have greatest impact on a given problem and design.
- Establish an intuition of fluid behavior, analyze its effects in a given problem, and apply your knowledge to propose design solutions.

MEGN381. MANUFACTURING PROCESSES. 3.0 Semester Hrs.

Equivalent with MEGN380,

Manufacturing Processes is a survey course, that introduces a wide variety of traditional and advanced manufacturing processes with emphasis on process selection and hands-on experiences. Students are expected to have basic knowledge in material science, basic machining and GD&T before entering the class. Throughout the course students analyze the relationships between material properties, process variables and product functionality. Students design and evaluate processes for identifying value while eliminating waste using learned skill-sets including lean methodologies, six-sigma and statistical process control. Quality, cost, standards and ethics related to manufacturing are discussed throughout the semester. Prerequisite: MEGN201 (C- or better) AND MEGN212 (C- or better) AND MTGN202.

Course Learning Outcomes

- Identify manufacturing methods and processes used to create various plastic, metal, and composite parts and products.
- Create CAD drawings and apply appropriate tolerances on parts based on the material, manufacturing process, and dimension of the part.
- Identify the capabilities and limitations of a given process in terms of a workpiece, tool, material properties, and process settings.
- Select a reasonable process to manufacture a given part or product based on customer demand (fast, low cost, quality).
- Make estimates of resource consumption, material, labor, and energy consumption during processing.
- Redesign a part to be more efficiently manufactured with regards to design, assembly, cost, and material.
- Identify and eliminate waste in manufacturing processes utilizing Lean concepts.
- Interpret and use in a meaningful way, manufacturing quality control concepts and practices with Six Sigma concepts (Statistical Process Control, SPC).

MEGN385. INTRODUCTION TO CNC AND CAM PROGRAMMING. 1.0 Semester Hr.

This course will guide students through the process of machining parts on a 3-axis CNC (computer numeric-controlled) milling machine. The code for the CNCs will be generated with a CAM (computer aided-machining) program. We will machine parts with multiple setups and discuss strategies for complicated parts. Prerequisite: MEGN 201.

Course Learning Outcomes

- 1. Utilize CAM programming to create the machine code for CNCs.
- 2. Apply milling tool datasheets to optimize the machining performance.
- 3. Select tooling based on the characteristics of specific tools and material setups for creating unique part features.
- 4. Evaluate and select tool operations for efficient material removal and precisely detailed part features.

- 5. Set up and operate 3 axis vertical CNC milling machines
- 6. Design parts for CNC manufacturability
- 7. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

MEGN391. INTRODUCTION TO AUTOMOTIVE DESIGN. 3.0 Semester Hrs.

Automotive engineering involves the design and implementation of complex systems. This course introduces students to the workings of the automotive industry, including its history, future, and the stakeholders that determine its direction. The course also covers the major vehicle subsystems and their functionality, interfaces, components, and recent advancements. Students will apply theoretical and practical systems engineering principles to perform a design of a vehicle subsystem to gain perspective of how the automotive design process is executed and how it fits into the larger scope of the automotive industry. Prerequisite: MEGN200.

Course Learning Outcomes

- Analyze the history and recent advancements in the automotive industry, specifically focusing on energy use and advanced mobility.
- Map out the stakeholders in the automotive industry and their needs, their ability to influence its trajectory, and their interactions and influence over the other stakeholders.
- Integrate the basic functions, components, and interfaces of major vehicle subsystems (such as powertrain, suspension, chassis, body, etc) in a vehicle design.
- Implement the system engineering design process, including the iterative "V-model" development cycle.
- Create requirements for a vehicle system, and cascade vehicle requirements to vehicle subsystems using course profiles and system targets in a point-mass vehicle model.
- Develop and articulate design solutions through written and verbal reports.
- Perform tests to characterize and verify top-level vehicle parameters such as drag coefficients, mass distribution, system power and efficiency, and tire friction.
- Rationalize decisions balancing the outcomes of various constraints, bounds, and requirements of a design and the effects of design decisions on vehicle performance and other sub-components.

MEGN398. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 0-6 Semester Hr.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.

(I, II) Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

MEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**MEGN412. ADVANCED MECHANICS OF MATERIALS. 3.0 Semester Hrs.**

This Advanced Mechanics of Materials course builds upon the learning outcomes of the pre-requisite Mechanics of Materials (Solid Mechanics)

course to teach students the fundamentals of elastic deformations. Introduction to energy methods, strain and stress transformations, constitutive relations for isotropic and orthotropic materials, and to fracture mechanics is realized through theory development, application examples, and numerical solutions. Knowledge from this course will enable students to work on variety of engineering applications in Mechanical, Materials, Aerospace, Civil and related engineering fields. Prerequisite: MEGN212 (C- or better) or CEEN311 (C- or better).

Course Learning Outcomes

- Define, and apply, displacement-strain relationships. Calculate principal strains, maximum shear strain in 2D and 3D.
- Use gauges and rosettes for strain measurements.
- Find stresses at a point, principal stresses and max shear stress.
- Define, and apply, the generalized form of Hooke's Law for isotropic materials.
- Define, and apply, the generalized form of Hooke's Law for orthotropic materials.
- Apply theories of failure for ductile and brittle materials.
- Use energy methods to compute strain energy, determine the effect of impact loading, determine displacements due to single or multiple loads, and solve statically indeterminate problems.
- Define crack modes and stress intensity factor. Estimate stresses in the "near-field".
- Apply plastics zone size correction to the crack length.
- Starting from external loads, calculate stresses at an arbitrary location for circular and rectangular cross-sections that are non-orthogonal to a global coordinate system.

MEGN414. MECHANICS OF COMPOSITE MATERIALS. 3.0 Semester Hrs.

Introductory course on the mechanics of fiber-reinforced composite materials. The focus of the course is on the determination of stress and strain in a fiber-reinforced composite material with an emphasis on analysis, design, failure by strength-based criteria, and fracture of composites. Anisotropic materials are discussed from a general perspective then the theory is specialized to the analysis of fiber-reinforced materials. Both thermal and hygroscopic sources of strain are introduced. Classical laminated plate theory is next developed, and design of laminated composite structures is introduced. The analysis of helically reinforced composite tubes concludes the course. Prerequisite: MEGN212 (C- or better).

Course Learning Outcomes

1. Apply concepts of the mechanics of composite materials to the analysis of fiber-reinforced lamina
2. Use transformation equations to analyze fiber-reinforced lamina with arbitrary fiber orientation
3. Predict overall elastic properties of a fiber-reinforced lamina from micromechanics models
4. Choose and apply an appropriate failure criterion to assess safety of fiber-reinforced lamina
5. Apply classical laminated plate theory to calculate stresses in laminated composites
6. Design a laminated plate structure given mechanical and thermal loads
7. Determine the stress state in helically reinforced composite tubes

MEGN416. ENGINEERING VIBRATION. 3.0 Semester Hrs.

This course introduces linear theory of mechanical vibrations as applied to single- and multi-degree-of-freedom systems. Specifically, students learn to analyze and measure free and forced vibrations of spring-mass-damper systems in response to different types of loading including harmonic, impulse, and general transient loading. Force balance and energy methods are introduced as means to create models of vibrating mechanical components. Ultimately, students learn to apply these theories to design vibration isolators and dampers for machines subject to translational and rotational vibrations, including machines with rotating unbalances and two or more vibrating masses. Prerequisite: MEGN315 (C- or better).

Course Learning Outcomes

- Understand vibration features of natural frequencies, resonance, and mode shapes.
- Analyze theoretically and numerically free and forced vibration responses.
- Apply theory for vibration-based design, as well as isolation and control of vibration.

MEGN417. VEHICLE DYNAMICS. 3.0 Semester Hrs.

Vehicle Dynamics focuses on the principles of rigid body vehicle dynamics with an emphasis on longitudinal, lateral, and vertical motion combined with pitch, yaw, and roll. Students will study how these dynamics influence ride quality, handling, stability, and overall vehicle performance, connecting theoretical models to practical vehicle behavior. Powertrain fundamentals, including energy flow and efficiency, will be introduced and linked to dynamic performance. Laboratory sessions provide students with hands-on experience with instrumentation, data acquisition, and experimental methods for evaluating vehicle performance at both the system and subsystem level. Prerequisite: MEGN391.

Course Learning Outcomes

- Students will use fundamental lateral and longitudinal dynamic equations to design the proper suspension setup for various road and racing scenarios
- Students will be able to identify key components of a vehicle's suspension and powertrain system and describe their respective function to the performance of the vehicle
- Students will perform relevant calculations and numerical modeling related to vehicle design and handling characteristics (e.g. roll, over/under-steer)
- Students will solve basic engine performance calculations related to power and torque and determine which final drive ratio is adequate for certain racing applications

MEGN423. APPLIED COMPUTATIONAL FLUID DYNAMICS. 3.0 Semester Hrs.

The Applied Computational Fluid Dynamic course introduces the student to modeling and analysis of fluid mechanics problems via the finite difference and finite volume method. Fundamentals of CFD theory, solution, procedures, techniques, and analysis are discussed. Students will use ANSYS/Fluent CFD software to solve various fluid mechanics problems. Prerequisites: MEGN351 (C- or better).

Course Learning Outcomes

- The student will demonstrate the ability to use modern CFD software tools to build flow geometries, generate an adequate mesh for an accurate solution, select appropriate solvers to obtain a flow solution, and visualize the resulting flow field.

- The student will demonstrate the ability to analyze a flow field to determine various quantities of interest, such as flow rates, heat fluxes, pressure drops, losses, etc., using flow visualization and analysis tools.
- The student will demonstrate an ability to recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate model equations to investigate the flow.
- The student will demonstrate an ability to describe various flow features in terms of appropriate fluid mechanical principles and force balances.
- The student will demonstrate the ability to simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behavior, and to understand the results.
- The student will demonstrate the ability to communicate the results of this detailed fluid-flow study in a written format.

MEGN430. MUSCULOSKELETAL BIOMECHANICS. 3.0 Semester Hrs.

This course is intended to provide mechanical engineering students with an in-depth course in musculoskeletal biomechanics. At the end of the semester, students should have the knowledge and understanding necessary to apply mechanical engineering principles such as statics, dynamics, and mechanics of materials to applications involving musculoskeletal tissues and structures of the human body. The course will discuss conditions of physiological loading of the musculoskeletal system as well as the biomechanics of injury when musculoskeletal structures experience failure. Further, students will hone skills that are critical to biomechanical engineers, including collaboration, communication, and analysis of past and current research in the field of musculoskeletal biomechanics. Prerequisite: MEGN212 OR CEEN311; MEGN315; MEGN330 (C- or better).

Course Learning Outcomes

- Recall musculoskeletal tissues and structures of the human body and describe their structure and function in joint motion
- Apply mechanics principles from Statics, Dynamics, and Solid Mechanics to applications involving musculoskeletal tissues of the human body, including cases of injury and intervention.
- Apply appropriate assumptions to define musculoskeletal tissue properties based on the parameters of specific applications including physical and temporal scales.
- Understand use of biomechanics measurement tools for appropriate design of effective experiments to characterize loading and tissue response in relevant populations and mechanical conditions
- Identify and interpret current literature in the musculoskeletal biomechanics field via peer reviewed journal articles.
- Clearly communicate principles of musculoskeletal biomechanics in writing and verbally to audiences of different levels of technical expertise.

MEGN435. MODELING AND SIMULATION OF HUMAN MOVEMENT. 3.0 Semester Hrs.

Introduction to modeling and simulation in biomechanics. The course includes a synthesis of musculoskeletal properties, interactions with the environment, and computational optimization to construct detailed computer models and simulations of human movement. Prerequisite: MEGN315 with a grade C- or better, MEGN330 with grade of C- or better.

Course Learning Outcomes

- Develop and implement musculoskeletal models using contemporary computational tools.
- Identify the assumptions, challenges, and opportunities in biomechanical modeling.
- Critically evaluate scholarly articles in biomechanical modeling and simulation literature.

MEGN441. INTRODUCTION TO ROBOTICS. 3.0 Semester Hrs.

Overview and introduction to the science and engineering of intelligent mobile robotics and robotic manipulators. Covers guidance and force sensing, perception of the environment around a mobile vehicle, reasoning about the environment to identify obstacles and guidance path features and adaptively controlling and monitoring the vehicle health. A lesser emphasis is placed on robot manipulator kinematics, dynamics, and force and tactile sensing. Surveys manipulator and intelligent mobile robotics research and development. Introduces principles and concepts of guidance, position, and force sensing; vision data processing; basic path and trajectory planning algorithms; and force and position control. EENG307 is recommended to be completed before this course. 2 hours lecture; 3 hours lab; 3 semester hours. Prerequisite: (MEGN200 or CSCI261 or CSCI200) and (EENG281 or EENG282 or PHGN215).

Course Learning Outcomes

- To be completed at a later time (course coordinator on leave)

MEGN451. AERODYNAMICS. 3.0 Semester Hrs.

Review of elementary fluid mechanics and engineering; Two-dimensional external flows, boundary layers, and flow separation; Gas dynamics and compressible flow: Isentropic flow, normal and oblique shocks, rocket propulsion, Prandtl-Meyer expansion fans; Application of computational fluid dynamics. Prerequisite: MEGN351(C- or better).

Course Learning Outcomes

- Apply control-volume conservation-of-mass, linear-momentum, and energy equations to the solution of flow problems.
- Apply differential conservation-of-mass and linear-momentum equations and to the solution of flow problems.
- Understand development and analysis of boundary layers.
- Comprehend analysis of compressible and supersonic flows, including shock waves.

MEGN452. INTRO TO SPACE EXPLORATION AND RESOURCES. 3.0 Semester Hrs.

Overview of human and robotic space exploration, including its history, current status, and future opportunities. Course topics cover the space environment, space transportation systems, destinations (Low-Earth orbit, Moon, Mars, asteroids, other planets), the aerospace industry, space commerce and law, and the international space activity. Emphasis is placed on the field of space resources, including their identification, extraction, and utilization to enable future space exploration and the new space economy.

MEGN453. AEROSPACE STRUCTURES. 3.0 Semester Hrs.

This course covers advanced mechanics of materials relevant to the analysis and design of aerospace structures. Focused topics include multiaxial stress states, nonsymmetric loading, composites, airframe loads, and shear flow emphasizing lightweight, often thin-walled structures common in aerospace applications. Other advanced topics will be introduced, time permitting. Prerequisite: MEGN212.

Course Learning Outcomes

- Understand physical & mathematical relationship(s) between displacement, stress, and strain.
- Apply concepts of compatibility, equilibrium, and constitutive relations on geometries prevalent in aerospace structural analysis.
- Distinguish appropriate failure criteria and assumptions under various airframe loading conditions.
- Solve basic boundary value problems on plane stress, plane strain, torsion, beam bending, and shear flow for thin-walled structures.
- Gain team experience through a design/build/test project that utilizes concepts learned in the course

MEGN454. ORBITAL MECHANICS. 3.0 Semester Hrs.

Orbital Mechanics introduces students to the dynamics that govern motion of bodies in space and the utilization of these dynamics in spacecraft orbit and trajectory design. This course develops the mathematical foundation of propagating, describing, and manipulating the motion of a spacecraft in orbit. Throughout the semester students will script their own (basic) universe simulators to examine the various forces and geometries in orbit. Prerequisite: MEGN315 or PHGN350.

Course Learning Outcomes

- Calculate the position of a body (satellite) under Keplerian dynamics as a function of time.
- Interpret the state and orbit type of a body (satellite) in an elliptical orbit using classic orbital elements.
- Implement a state propagator for a body (satellite) in an elliptical orbit in Keplerian dynamics and under common perturbation models.
- Calculate the impulsive delta-V maneuvers required to manipulate a body's (satellite) orbit state in common transfers

MEGN455. AEROSPACE SYSTEMS ENGINEERING. 3.0 Semester Hrs.

An introduction to aerospace systems engineering. This course is designed for students to explore both theoretical and practical systems engineering concepts and knowledge using examples drawn from the aerospace and defense industries. Starting with the systems engineering V-model, students will gain hands on experience working with modern Model Based Systems Engineering (MBSE) software and develop systems engineering deliverables such as Concepts of Operations (ConOps) documents as part of a semester long project. Prerequisite: Best taken just before Senior Design or as a co-req with Senior Design I.

Course Learning Outcomes

- 1. Students will be able to describe the most important systems engineering standards and best practices as well as newly emerging approaches using the systems engineering V-model.
- 2. Students will be able to write and decompose multi-level system requirements
- 3. Students will learn applied model-based systems engineering and demonstrate their understanding using an industry standard Model Based System Engineering (MBSE) software
- 4. Students will develop and demonstrate applied model-based engineering, through development of support document for their semester long project
- 5. Students will demonstrate their understanding of system mission and operating environments through the development of a concept of operations (ConOps) document
- 6. Students will be able to identify system risks and opportunities and appropriately rank and defend their approach

- 7. Students will demonstrate their understanding of interfaces, constraints, and system specifications/figures of merit/technical performance metrics/measure of performance through the drafting of an Interface Control Document (ICD)
- 8. Students will visually communicate their understanding of project execution via the development of a system engineering management plan (SEMP)
- 9. Students will demonstrate understanding of the value of appropriate test procedures and test plans through the development of a project test plan
- 10. Students will be able to differentiate between validation and verification in the systems engineering context

MEGN456. SPACE OPERATIONS AND MISSION DESIGN. 3.0 Semester Hrs.

Space Operations and Mission Design (SOMD) is a course for upper level undergraduate and graduate students at Mines who are interested in expanding their knowledge of astrodynamics, spacecraft and space mission design, project management, and systems engineering. Upon leaving the course, students will have a head start on potential internships/careers in the aerospace industry armed with key vocabulary and terms, experience with industry relevant software and tools, and core skills and knowledge gained through practice addressing real-world problems in the space domain.

Course Learning Outcomes

- Students shall develop and defend their mission risk/opportunity assessment, applying risk matrices and mitigation plans as tools.
- Students shall collaboratively define, design, and plan a simulated mission considering stakeholders, associated space laws/regulations, and resource management.
- Students shall develop and assess technical resource budgets. Examples include: mass, power, thermal, telecommunications, and data volume.
- Students shall apply appropriate terminology associated with space flight operations
- Students shall execute space mission planning principles such as: Orbit determination, Orbital maneuvering, Launch windows, Orbital rendezvous, and Proximity operations
- Students shall analyze orbital motion by visualizing from both inertial and relative perspectives
- Students shall synthesize the effects of launch, orbital maneuvers, rendezvous, and proximity operations on space situational awareness and space mission design and operations

MEGN461. THERMODYNAMICS II. 3.0 Semester Hrs.

This course extends the subject matter of Thermodynamics I (MEGN261) to include the study of exergy, ideal gas mixture properties, psychrometrics and humid air processes, chemical reactions, and the 1st, 2nd and 3rd Laws of Thermodynamics as applied to reacting systems. Chemical equilibrium of multi-component systems, and simultaneous chemical reactions of real combustion and reaction processes are studied. Concepts of the above are explored through the analysis of advanced thermodynamic systems. 3 hours lecture; 3 semester hours. Prerequisite: MEGN351 (C- or better), MEGN261 (C- or better).

Course Learning Outcomes

- Ability to solve and analyze physical processes that include: Exergy (2nd Law) analysis of energy systems
- Mixtures of ideal gases
- Psychrometrics including mass and energy balances of humid air processes
- Chemical reactions, combustion, and fuel/air

stoichiometry • Phase and chemical equilibrium • Simultaneous reactions and ionization • Thermodynamics of compressible flow in nozzles including shock • Advanced thermodynamic cycles including cascaded and absorption refrigeration systems, cryogenics, and gas turbine and combined cycles.

MEGN465. ELECTRIC VEHICLE POWERTRAIN SYSTEMS. 3.0

Semester Hrs.

In the fast-evolving world of sustainable transportation, it is essential for engineers in the automotive industry to understand energy conversion, storage, utilization, and optimization of vehicle powertrains. Electric Vehicle Powertrain Systems (EVPS) is designed to provide students with a comprehensive understanding of the essential powertrain components in battery-electric vehicles (BEVs) including motors, controllers, and battery packs. Through a combination of theoretical modeling and hands-on projects, students will gain knowledge and skills in powertrain system design to achieve vehicle objectives, encompassing energy analysis, power requirements, and efficiency considerations. The course will also explore the state-of-the-art in safety measures, management strategies, control systems, charging/balancing techniques, and State of Charge (SOC)/State of Health (SOH) estimation for EV battery packs. Prerequisite: MEGN300 or EENG282.

Course Learning Outcomes

- Articulate the functions and interrelationships of the core powertrain components in electric vehicles, including the motor, controller, and battery pack.
- Design a vehicle powertrain architecture and select powertrain components that meet the overarching goals of an electric vehicle, incorporating top-level requirements such as energy use, power output, and efficiency optimization.
- Explain the operating principles and fundamental characteristics of Li-ion batteries using underlying electrochemical processes and implement them in an equivalent circuit battery cell model.
- Apply experimental methods used to characterize the performance of Li-ion cells in automotive applications, while elucidating the principles and significance of these techniques in assessing battery behavior and performance.
- Critically assess and compare the state of the art in safety protocols, management strategies, control systems, and charging/balancing techniques for battery packs in electric vehicle powertrain systems.
- Devise a functional design for a battery pack tailored to the specific requirements and constraints of a full-size electric vehicle, integrating considerations such as energy storage capacity, thermal management, safety measures, and space utilization

MEGN466. INTRODUCTION TO INTERNAL COMBUSTION ENGINES.

3.0 Semester Hrs.

Introduction to Internal Combustion Engines (ICEs); with a specific focus on Compression Ignition (CI) and Spark Ignition (SI) reciprocating engines. This is an applied thermo science course designed to introduce students to the fundamentals of both 4-stroke and 2-stroke reciprocating engines ranging in size from model airplane engines to large cargo ship engines. Course is designed as a one-semester course for students without prior experience with IC engines, however, the course will also include advanced engine technologies designed to deliver more horsepower, utilize less fuel, and meet stringent emission regulations. Discussion of advancements in alternative fueled engines will be covered as well. This course also includes an engine laboratory designed to provide hands-on experience and provide further insight into the material

covered in the lectures. Prerequisite: MEGN351 with a grade of C- or better, MEGN261 with a grade of C- or better.

Course Learning Outcomes

- ABET j and k outcomes will be measured through homework assignments and projects.

MEGN467. PRINCIPLES OF BUILDING SCIENCE. 3.0 Semester Hrs.

This course covers the fundamentals of building heating, ventilation, and air conditioning (HVAC) systems and the use of numerical heat and moisture transfer models to analyze or design different building envelope and HVAC systems. Prerequisite: MEGN351 with a grade of C- or better, MEGN261 with a grade of C- or better.

Course Learning Outcomes

- Apply fundamental principles to HVAC design.
- Describe components in HVAC systems.
- Understand how building HVAC loads are calculated and calculate building HVAC loads.
- Contrast residential systems with commercial systems and use appropriate design techniques for each type of system.
- Conduct building energy analyses using computer simulation tools.
- Evaluate the performance of building systems considering their impact on total building energy consumption.
- Evaluate the probability of infection due to aerosol transmission for different virus including SARS-CoV-2.

MEGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.

Equivalent with CBEN469, MTGN469,

Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials- science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisite: MEGN261 with a grade of C- or better or CBEN357 with a grade of C- or better.

MEGN471. HEAT TRANSFER. 3.0 Semester Hrs.

Engineering approach to conduction, convection, and radiation, including steady-state conduction, nonsteady-state conduction, internal heat generation conduction in one, two, and three dimensions, and combined conduction and convection. Free and forced convection including laminar and turbulent flow, internal and external flow. Radiation of black and grey surfaces, shape factors and electrical equivalence. 3 hours lecture; 3 semester hours. Prerequisite: MEGN351 (C- or better), MEGN261 (C- or better), and MATH307.

Course Learning Outcomes

- Apply energy balances to control volumes/surfaces to calculate temperatures and heat transfer rates;
- Derive and solve differential equations for thermal energy conservation to assess spatial and/or temporal distribution of temperature within a component or system;
- Analyze systems to identify and model the dominant modes of heat transfer (i.e. conduction, convection, and/or radiation);
- Choose appropriate convection correlations and calculate heat transfer coefficients for forced external flows, forced internal flows, and natural convective flows;
- Calculate average surface properties (absorption, emission, reflection, transmission) using blackbody emission concepts;

- Evaluate view factors and calculate net radiation exchange between surfaces;
- Apply heat transfer concepts and computational tools to analyze thermal systems under constraints.

MEGN475. INTRODUCTION TO NUCLEAR ENGINEERING. 3.0 Semester Hrs.

An overview of major concepts and themes of nuclear engineering founded on the fundamental properties of the neutron, and emphasizing the nuclear physics bases of nuclear reactor design and its relationship to nuclear engineering problems. Major topics that introduce fundamental concepts in nuclear engineering include the physics and chemistry of radioactive decay, radiation detection, neutron physics, heat transfer in nuclear reactors, and health physics. Nuclear engineering topics relevant to current events are also introduced including nuclear weapons, nuclear proliferation, and nuclear medicine. Prerequisite: MATH225, PHGN200.

Course Learning Outcomes

- 1) Apply concepts of radioactivity to solve problems
- 2) Relate neutron production and consumption to aspects of the lifecycle of the nuclear fuel and nuclear power production
- 3) Apply the basics of nuclear reactor physics and heat transfer to reactor design and operation
- 4) Understand the biological effects of radiation and use basic radiation shielding equations

MEGN479. OPTIMIZATION MODELS IN MANUFACTURING. 3.0 Semester Hrs.

We address the mathematical formulation and solution of optimization models relevant in manufacturing operations. The types of deterministic optimization models examined include: (i) network models; (ii) linear programs; (iii) integer programs; and, (iv) nonlinear programs. Application areas include scheduling, blending, equipment replacement, logistics and transportation, among other topics. Students learn not only how to mathematically formulate the models, but also how to solve them with a state-of-the-art modeling language (Ampl) and appropriate solver (e.g., Cplex or Minos). Algorithms for each problem class will be briefly discussed.

MEGN481. MACHINE DESIGN. 3.0 Semester Hrs.

In this course, students develop their knowledge of machine components and materials for the purpose of effective and efficient mechanical design. Emphasis is placed on developing analytical methods and tools that aid the decision making process. The course focuses on determination of stress, strain, and deflection for static, static multiaxial, impact, dynamic, and dynamic multiaxial loading. Students will learn about fatigue failure in mechanical design and calculate how long mechanical components are expected to last. Specific machine components covered include shafts, springs, gears, fasteners, and bearings. 3 hours lecture; 3 semester hours. Prerequisite: MEGN315 (C- or better) or PHGN350 (C- or better), and MEGN324 (C- or better).

Course Learning Outcomes

- Illustrate the usage and functionality of a variety of the following machine components and connections: Rods, Columns, Beams, Shafts, Bearings, Gears, Springs, Fasteners, Keys, Couplings, Gear Systems.
- Locate, evaluate and utilize design parameters (material properties, stress concentrations, availability, etc) from numerous sources.
- Formulate machine problems for analysis and design in terms of: a) Describing the problems at hand with known information and necessary assumptions; b) Creating models for load transmission

(feature-captured structure of machine components, simplified boundary/connection conditions, and idealized static and dynamic loadings).

- Calculate responses (e.g., stresses and deflections) of machine components and system to the loadings.
- Identify the following major static and dynamic failure modes and determine safety factors for the machine components and whole system: a) Strength-based material failure, Buckling failure, Resonance, Surface wear failure; b) Finding static and fatigue strengths of the material under external loadings, and critical loadings and stresses to failure.
- Use a systematic approach and apply computer tools (e.g., SolidWorks) for designing machine components and system in terms of wear and material-fatigue life.
- Estimate cost, schedule, and quality, among many others, for evaluating and selecting the machine design.
- Communicate with written design-project reports and with oral-presentation of the final design product .

MEGN485. MANUFACTURING OPTIMIZATION WITH NETWORK MODELS. 3.0 Semester Hrs.

Equivalent with EBGN456,

We examine network flow models that arise in manufacturing, energy, mining, transportation and logistics: minimum cost flow models in transportation, shortest path problems in assigning inspection effort on a manufacturing line, and maximum flow models to allocate machine-hours to jobs. We also discuss an algorithm or two applicable to each problem class. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. 3 hours lecture; 3 semester hours. Prerequisite: MATH111, MATH 112.

Course Learning Outcomes

- Mathematically formulate optimization models to reflect real-world manufacturing settings.
- Study algorithms and software to solve associated optimization problems.
- Use skills from other engineering courses to identify manufacturing problems and set them up as optimization models.

MEGN486. LINEAR OPTIMIZATION. 3.0 Semester Hrs.

This course addresses the formulation of linear programming models, linear programs in two dimensions, standard form, the Simplex method, duality theory, complementary slackness conditions, sensitivity analysis, and multi-objective programming. Applications of linear programming models include, but are not limited to, the areas of manufacturing, energy, mining, transportation and logistics, and the military. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. Offered every other year. Prerequisite: MATH332 or EBGN509.

Course Learning Outcomes

- 1. Understand how to formulate linear optimization models.
- 2. Understand how to solve linear optimization models, both by hand and with the computer through an algebraic modeling language and a state-of-the-art solver.
- 3. Understand the special structure underlying linear optimization models and how this affects their ability to be solved.
- 4. Understand sensitivity and post-optimality analysis.

MEGN487. NONLINEAR OPTIMIZATION. 3.0 Semester Hrs.

Equivalent with MEGN587,

This course addresses both unconstrained and constrained nonlinear model formulation and corresponding algorithms (e.g., Gradient Search and Newton's Method, and Lagrange Multiplier Methods and Reduced Gradient Algorithms, respectively). Applications of state-of-the-art hardware and software will emphasize solving real-world engineering problems in areas such as manufacturing, energy, mining, transportation and logistics, and the military. Computer use for modeling (in a language such as AMPL) and solving (with an algorithm such as MINOS) these optimization problems is introduced. This is an undergraduate version of the graduate course MEGN 587; students may not take both MEGN 487 and MEGN 587. Prerequisite: MATH111 and MATH112.

Course Learning Outcomes

- Understand how to formulate nonlinear optimization models.
- Understand how to solve nonlinear optimization models, both by hand and with the computer through an algebraic modeling language and a state-of-the-art solver.
- Understand the special structure underlying nonlinear optimization models and how this affects their ability to be solved.

MEGN488. INTEGER OPTIMIZATION. 3.0 Semester Hrs.

Equivalent with MEGN588,

This course addresses the formulation of integer programming models, the branch-and-bound algorithm, total unimodularity and the ease with which these models are solved, and then suggest methods to increase tractability, including cuts, strong formulations, and decomposition techniques, e.g., Lagrangian relaxation, Benders decomposition. Applications include manufacturing, energy, mining, transportation and logistics, and the military. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. This is a graduate version of the undergraduate course MEGN 488; students may not take both MEGN 488 and MEGN 588. Prerequisites: MATH111 and MATH112.

Course Learning Outcomes

- Understand how to formulate linear-integer optimization models.
- Understand how to solve linear-integer optimization models, both by hand and with the computer through an algebraic modeling language and a state-of-the-art solver.
- Understand the special structure underlying linear-integer optimization models and how this affects their ability to be solved.
- Understand decomposition techniques to aid in solution.

MEGN497. SPECIAL SUMMER COURSE. 0-15 Semester Hr.**MEGN498. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 1-6 Semester Hr.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MEGN498. SPECIAL TOPICS. 1-6 Semester Hr.

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MEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.

Individual research or special problem projects supervised by a faculty member, when a student and instructor agree on a subject matter, content, and credit hours. Note that MEGN499 does not count as an MEGN Technical Elective, though the course does count as a Free Elective. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

MEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.

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