By utilizing this list, I acknowledge that:

* This list is *not* all-inclusive.
* Just because I *can* take a class, does not mean I *should* take a class.
* I am responsible for ensuring I meet pre-requisites.
  + Pre-reqs are enforced by the department offering the course.
* Class schedules and offerings may change; classes may not be available when I register.

**AER E 426: Design of Aerospace Structures**  
(Dual-listed with AER E 526). (2-2) Cr. 3. F.  
*Prereq: E M 324*  
  
Detailed design and analysis of aerospace vehicle structures. Material selection, strength, durability and damage tolerance, and validation analysis. Design for manufacturability.  
  
**AER E 433: Spacecraft Dynamics and Control**  
(3-0) Cr. 3. F.  
*Prereq: M E 345*  
  
Three-dimensional rotational kinematics and attitude dynamics of a rigid body in space. Classical stability analysis of spinning spacecraft with or without energy dissipation. Attitude dynamics, stability, and control of spacecraft in a circular orbit in the presence of gravity-gradient torques. Introduction to spacecraft attitude determination and control systems (ADCS) with emphasis on modern attitude determination algorithms. Simulation of spacecraft attitude dynamics and control problems of practical interest using programming and analysis software.  
  
**AER E 445: Experimental Flow Mechanics and Heat Transfer**  
(Dual-listed with AER E 545). (3-0) Cr. 3. F.  
*Prereq: A B E 378 or AER E 310 or M E 335*  
  
Similitude and dimensional analysis. Measurement uncertainty analysis; Fluid mechanical apparatus: wind tunnel and water tunnels. Various experimental techniques widely used for fluid mechanics, aerodynamics, heat transfer, and combustion studies: Pressure gauge and transducers; Pitot tube; hot wire anemometry; Shadowgraph and Schlieren Photography; laser Doppler velocimetry; particle image velocimetry (PIV); advanced PIV techniques (stereo PIV, 3-D PIV, Tomographic PIV, Holograph PIV and microscopic PIV); laser induced fluorescence; pressure sensitive painting, temperature sensitive painting; molecular tagging velocimetry; molecular tagging thermometry. Extensive applications and laboratory experiments will be included.  
  
**A B E 325: Biorenewable Systems**  
(Cross-listed with TSM). (3-0) Cr. 3. F.  
*Prereq: CHEM 163 or higher; MATH 140 or higher*  
  
Converting biorenewable resources into bioenergy and biobased products. Biorenewable concepts as they relate to drivers of change, feedstock production, processes, products, co-products, economics, and transportation/logistics.

**A B E 388: Sustainable Engineering and International Development**

(Cross-listed with C E, E E). (2-2) Cr. 3. F.  
*Prereq: Junior classification in an Engineering Major*  
  
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.

**A B E 413: Fluid Power Engineering**

(Cross-listed with M E). (2-2) Cr. 3. F.  
*Prereq: Credit or concurrent enrollment in (A B E 378 or M E 335); (A B E 216 or M E 270)*  
  
Fundamental fluid power principles, symbols and schematics. Hydraulic fluid properties. Function and performance of components such as connections and fittings, filtration, pumps, valves, actuators, hydrostatic transmissions. Hydraulic system dynamics. Modeling and simulation of circuits. Analysis and design of hydraulic systems. Hydrostatic transmission design. Hands-on construction of circuits, measurement of system variables, and electrohydraulic control.

**AFAS 341: Air Force Leadership Studies I**

(3-0) Cr. 3. F.  
  
Presents the complex issues of leadership and management in the U.S Air Force; a large and diverse organization. The theoretical aspects of leadership, management, communications, motivation and problem-solving are examined and studied against the backdrop of the U.S. Air Force.  
  
**AFAS 441: National Security Studies**  
(3-0) Cr. 3. F.

Traces constitutional roots of authority and responsibilities to the Air Force officer, to include development of national security and strategy that defines US military policy and priorities. Applies legislation, joint doctrine, and relationships of operational and administrative authority concepts in the US military in the context of regional studies.

**AGEDS 388: Agricultural Mechanics Applications**

(2-3) Cr. 3. F.S.SS.

Introduction to SMAW (Arc), GMAW (Mig), GTAW (Tig), Oxy-Fuel welding, Oxy-Fuel cutting, and Plasma cutting theories and applications. Emphasis will be on theoretical foundation of welding, safety, welding skill development, and management of equipment, and materials. Introduction to small engines and applications. Emphasis will be on theory of operating systems, maintenance, troubleshooting, failure analysis, and safety.

**AGRON 342: World Food Issues: Past and Present**  
(Cross-listed with ENV S, FS HN). (3-0) Cr. 3. F.S.SS.  
*Prereq: Junior classification*  
  
Issues associated with global agricultural and food systems including ethical, social, economic, environmental, and policy contexts. Investigation of various causes and consequences of overnutrition/undernutrition, global health, poverty, hunger, access, and distribution.  
Meets International Perspectives Requirement  
  
**AGRON 404: Global Change**  
(Dual-listed with AGRON 504). (Cross-listed with ENSCI, ENV S, MTEOR). (3-0) Cr. 3. F.S.  
  
Recent changes in global biogeochemical cycles and climate; models of future changes in the climate system; impacts of global change on agriculture, water resources and human health; ethical issues of global environmental change.  
  
**AGRON 452: Intro GIS for Geoscientists**  
(Dual-listed with AGRON 552). (Cross-listed with ENSCI, GEOL). (2-2) Cr. 3. F.S.

Introduction to geographic information systems (GIS) using ArcGIS Pro with particular emphasis on geoscientific data. Teaches typical GIS operations and analyses in the geosciences to prepare students for practical use of GIS in industry and academia. Includes a class project for GEOL 552. Sophomore classification or above recommended.  
 **AN S 305: Livestock Evaluation**  
(0-6) Cr. 3. F.  
*Prereq: Junior classification*  
  
Fall semester leads to 475A or D. Breeding animal and market animal evaluation of beef, swine and sheep using contemporary techniques and tools. Communication and decision-making skills are practiced in the context of making selection decisions. AN S 270L recommended.  
  
**ASTRO 342: Introduction to Solar System Astronomy**  
(3-0) Cr. 3. F.  
*Prereq: PHYS 222 or (PHYS 232 and 232L) or PHYS 242*  
  
An introduction to the physics of the Solar System and the planetary systems discovered around other stars. General characteristics of planetary systems: dynamics, thermodynamics, internal and surface structure of planets and minor bodies, physics of their atmosphere. Discovery techniques and characterization of extrasolar planets, and planetary systems formation models. "Grand tour" of the Solar System, using data and imagery from probes and telescopes that have visited these worlds. The origin and evolution of life on Earth, and the ongoing search for life in the Solar System and elsewhere in the universe.

**ASTRO 344L: Astronomy Laboratory**  
(1-6) Cr. 3. F.  
*Prereq: PHYS 222 or (PHYS 232 and 232L) or 242*  
  
Experiments in optical astronomy. Observational techniques, ranging from stellar photometry to CCD imaging. Data processing and analysis techniques. Astronomical software packages and online databases and resources. Available instruments include a variety of small telescopes and astronomical CCD cameras.  
  
**C E 332: Structural Analysis I**  
(2-2) Cr. 3. F.S.  
*Prereq: E M 324*  
  
Loads, shear, moment, and deflected shape diagrams for beams and framed structures. Deformation calculations. Approximate methods. Application of consistent deformation methods to continuous beams and frames. Application of displacement or slope deflection methods to continuous beams and frames without sway. Influence lines for determinate and indeterminate structures. Computer applications to analyze beams and frames. Validation of computer results.  
  
**C E 382: Design of Concretes**  
(2-3) Cr. 3. F.S.  
*Prereq: C E 274*  
  
Physical and chemical properties of bituminous, portland, and other cements; aggregate properties and blending; mix design and testing of concretes; admixtures, mixing, handling, placing and curing; principles of pavement thickness design.  
 **C E 388: Sustainable Engineering and International Development**  
(Cross-listed with A B E, E E). (2-2) Cr. 3. F.  
*Prereq: Junior classification in an Engineering Major*  
  
Multi-disciplinary approach to sustainable engineering and international development, sustainable development, appropriate design and engineering, feasibility analysis, international aid, business development, philosophy and politics of technology, and ethics in engineering. Engineering-based projects from problem formulation through implementation. Interactions with partner community organizations or international partners such as nongovernment organizations (NGOs). Course readings, final project/design report.  
Meets International Perspectives Requirement.  
  
**CON E 380: Engineering Law**  
(3-0) Cr. 3. F.S.  
*Prereq: Junior classification*  
  
Introduction to law and judicial procedure as they relate to the practicing engineer. Contracts, professional liability, professional ethics, licensing, bidding procedures, intellectual property, products liability, risk analysis. Emphasis on development of critical thinking process, abstract problem analysis and evaluation.

**DS 301: Applied Data Modeling and Predictive Analysis**  
Cr. 3. F.S.  
*Prereq: DS 202; 1 course from the following: STAT 101, STAT 104, STAT 105, STAT 201, STAT 226, STAT 231, STAT 305, STAT 322, STAT 330*  
  
Elements of predictive analysis such as training and test sets; feature extraction; survey of algorithmic machine learning techniques, e.g. decision trees, Naïve Bayes, and random forests; survey of data modeling techniques, e.g. linear model and regression analysis; assessment and diagnostics: overfitting, error rates, residual analysis, model assumptions checking; communicating findings to stakeholders in written, oral, verbal and electronic form, and ethical issues in data science. Participation in a multi-disciplinary team project.

**ECON 301: Intermediate Microeconomics**

(3-0) Cr. 3-4. F.S.SS.  
*Prereq: ECON 101; (ECON 207 or MATH 166)*  
  
Theory of consumer and business behavior; optimal consumption choices and demand; theory of firm behavior; costs, production, and supply; competitive and imperfectly competitive markets; theory of demand for and supply of factors of production; general equilibrium analysis. Fall and spring require recitation and are 4 credits; summer is 3.0 credits.

**ECON 302: Intermediate Macroeconomics**

(3-0) Cr. 3. F.S.  
*Prereq: ECON 101; ECON 102; (MATH 160 or MATH 165)*  
  
Theory of income, employment, interest rates, and the price level; fiscal and monetary policy; budget and trade deficits; money and capital inflows, interest rates, and inflation.

**ECON 313: Economics of Sports**

(3-0) Cr. 3.  
*Prereq: ECON 101*  
  
Application of economics to issues in sports, including franchising; rival leagues and barriers to entry; cooperative, competitive, and collusive behavior; player productivity and compensation; contracts, unions, and discrimination; antitrust, taxation, and subsidies. Economic concepts include supply and demand, costs, competition, time value of money, labor economics, pricing, public finance, production, game theory, risk analysis, and industrial organization.

**ECON 321: Economics of Discrimination**

(Cross-listed with WGS). (3-0) Cr. 3.  
*Prereq: ECON 101*  
  
Economic theories of discrimination. Analysis of the economic problems of women and minorities in such areas as earnings, occupations, and unemployment. Public policy concerning discrimination. Poverty measurement and antipoverty programs in the U.S.

**ECON 332: Cooperatives**

(3-0) Cr. 3.  
*Prereq: ECON 101*  
  
Survey of cooperative business structure, including historical developments in the United States, principles of cooperation, state and federal authorization for cooperative activity, economic motivations and foundations, governance, marketing and pricing strategies, and financing, capitalization and taxation considerations. Students will learn how the cooperative model is applied in a variety of markets.

**ECON 334: Entrepreneurship in Agriculture**

(3-0) Cr. 3. F.S.  
*Prereq: ECON 101*  
  
Introduction to the process of entrepreneurship within the agricultural and food sectors. Emphasis on opportunity recognition and creation of concept for new startup ventures. Students will develop a business plan for a startup business or non-profit organization.

**ECON 380: Energy, Environmental and Resource Economics**

(Cross-listed with ENV S). (3-0) Cr. 3.  
*Prereq: ECON 101*  
  
Natural resource availability, use, conservation, and government policy, with emphasis on energy issues. Environmental quality and pollution control policies.  
Course required for the Energy Systems minor; Will be offered F23 but not S24

**E E 303: Energy Systems and Power Electronics**  
(3-0) Cr. 3. F.S.  
*Prereq: MATH 267; PHYS 232; credit or concurrent enrollment in E E 230*  
  
Structure of competitive electric energy systems. System operation and economic optimization. Mutual inductance, transformers. Synchronous generators. Balanced three-phase circuit analysis and power calculations. Network calculations and associated numerical algorithms. Two-port circuits. Voltage regulation. Resonance and power factor correction. DC and induction motors. Power electronic circuit applications to power supplies and motor drives.

**E E 314: Electromagnetics for non Electrical Engineers**

(3-0) Cr. 3.  
*Prereq: PHYS 232 or equivalent*  
  
Conceptual study of electomagnetism and its application in engineering and related fields. EM fundamentals, EM spectrum, radiation, radiating systems, wireless, modern concepts of physics, quantum computing, transmission lines, high speed effects, waveguides, GPS and other related phenomena will be discussed and explained with the application in mind.

**E E 451: Engineering Acoustics**

(Cross-listed with E M, M E). (2-2) Cr. 3. Alt. F., offered even-numbered years.  
*Prereq: (MATH 266 or MATH 267); PHYS 231; PHYS 231L*  
  
The basics of acoustic wave propagation in fluids with an emphasis on sound propagation in air. Topics include transmission and reflection of sound at a boundary; role of acoustic sources in directing sound fields; diffraction of sound around solid objects; reverberation of sound in a room; and the measurement of sound fields.  
  
**EEOB 542E: Introduction to Molecular Biology Techniques: Proteomics**  
(Cross-listed with B M S, BBMB, FS HN, GDCB, HORT, NREM, NUTRS, V MPM, VDPAM). Cr. 1. Repeatable. F.  
  
Includes: two-dimensional electrophoresis, laser scanning, mass spectrometry, and database searching. Offered on a satisfactory-fail basis only.

**E M 327: Mechanics of Materials Laboratory**  
(0-2) Cr. 1. F.S.  
*Prereq: E M 324*  
  
Experimental determination of mechanical properties of selected engineering materials. Experimental verification of assumptions made in 324. Use of strain measuring devices. Preparation of reports.

**E M 362: Principles of Nondestructive Testing**

(Cross-listed with MAT E). (3-0) Cr. 3. S.  
*Prereq: PHYS 132 or PHYS 232*  
  
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of tests, materials to which applicable, types of defects detectable, calibration standards, and reliability safety precautions.  
  
**ENGR 430: Entrepreneurial Product Engineering**  
(Cross-listed with I E). Cr. 3. F.Alt. S., offered irregularly.  
*Prereq: Junior classification*  
  
Process of innovative product development in both entrepreneurial and intra-preneurial settings. Define, prototype and validate a product concept based on competitive bench-marking, market positioning and customer requirement evaluation in a target market into a product design that is consistent with defined business goals and strategies. Combination of lecture, discussion, problem solving and case study review.  
  
**ENSCI 402: Watershed Hydrology**  
(Dual-listed with ENSCI 502). (Cross-listed with GEOL, MTEOR, NREM). (2-3) Cr. 3. F.  
  
Examination of watersheds as systems, emphasizing the surface components of the hydrologic cycle. Combines qualitative understanding of hydrological processes and uncertainty with quantitative representation. Laboratory emphasizes field investigation and measurement of watershed processes.  
  
**FS HN 301: Nutrigenomics: From Basic Science to Translational Impact**  
(2-0) Cr. 1. F.  
  
Introduction to the concepts of nutrigenomics and nutrigenetics and how it affects consumers of food, as well as the implications for human diseases. The potential impact of personalized nutrition and full genome sequencing on health maintenance, chronic disease prevention, and the ethical implications of this knowledge will be explored.

**GEOL 315: Mineralogy and Earth Materials**  
(3-0) Cr. 3. F.  
*Prereq: Credit or concurrent enrollment in CHEM 163 or CHEM 167 or CHEM 177*  
  
Introduction to mineral classification, elementary crystal chemistry, crystal growth and morphology, mineral stability, and mineral associations. GEOL 100 or GEOL 101 or GEOL 201 or equivalent recommended.  
  
**GEOL 315L: Laboratory in Mineralogy and Earth Materials**  
(0-3) Cr. 1. F.  
*Prereq: Credit or concurrent enrollment in CHEM 163 or CHEM 167 or CHEM 177*  
  
Mineral identification methods, especially hand-specimen identification. GEOL 100 or GEOL 101 or GEOL 201 or equivalent recommended.  
  
**GEOL 316: Optical Mineralogy**  
(1-2) Cr. 1. F.  
*Prereq: Credit or concurrent enrollment in CHEM 163 or CHEM 167 or CHEM 177*  
  
Laboratory problems in mineral-identification methods utilizing optical microscopic techniques. GEOL 100 or GEOL 101 or GEOL 201 or equivalent recommended.  
  
**GEOL 426: Stable Isotopes in the Environment**  
(3-0) Cr. 3. Alt. F., offered odd-numbered years. (Dual-listed with GEOL 526). (Cross-listed with ENSCI).  
  
Introduction to the theory, methods and applications of stable isotopes. Primary focus on the origin, natural abundance, and fractionation of carbon, hydrogen, oxygen, nitrogen isotopes. Applications of isotopic occurrence for elucidation of physical, chemical, biological, and environmental processes. Effects of plant physiology, photosynthesis, trophic structure, diffusion, evaporation, chemical precipitation, soil and atmospheric processes, and environmental factors on isotope abundance.

**GEOL 479: Surficial Processes**  
(2-3) Cr. 3. F. (Dual-listed with GEOL 579). (Cross-listed with ENSCI).  
  
The study of physical processes that shape Earth's surface. Topics include weathering, sediment transport, and landform genesis with emphasis on fluvial, glacial, hillslope, eolian, and coastal processes. Applications to engineering and environmental problems. Laboratory includes topographic map interpretation and local field trips.  
  
**GEOL 489: Survey of Remote Sensing Technologies**  
(3-0) Cr. 3. F. (Dual-listed with GEOL 589). (Cross-listed with E E, ENSCI, MTEOR, NREM).  
  
Electromagnetic-radiation principles, active and passive sensors, multispectral and hyperspectral sensors, imaging radar, SAR, thermal imaging, lidar. Examples of applications. Also offered online S.  
  
**I E 305: Engineering Economic Analysis**  
(3-0) Cr. 3. F.S.SS.  
*Prereq: MATH 166*  
  
Economic analysis of engineering decisions under uncertainty. Financial engineering basics including time value of money, cash flow estimation, and asset evaluation. Make versus buy decisions. Comparison of project alternatives accounting for taxation, depreciation, inflation, and risk.

**I E 430: Entrepreneurial Product Engineering**  
(Cross-listed with ENGR). Cr. 3. F.Alt. S., offered irregularly.  
*Prereq: Junior classification*  
  
Process of innovative product development in both entrepreneurial and intra-preneurial settings. Define, prototype and validate a product concept based on competitive bench-marking, market positioning and customer requirement evaluation in a target market into a product design that is consistent with defined business goals and strategies. Combination of lecture, discussion, problem solving and case study review.

**IND D 320: Design Research Methods**  
(3-0) Cr. 3.  
  
Qualitative and quantitative methods with an emphasis on contextual user-centered research. Integration of user data collection, visualization, and synthesis as a source for design.  
  
**IND D 530: Design Thinking**  
(3-0) Cr. 3.  
*Prereq: Senior or graduate standing in any ISU program*  
  
Exploration of design thinking process, toolkits, and mindsets as creative problem solving approaches for systems, products, and processes, across diverse contexts. Strategies for problem-framing, creative solutions and co-evolution process, with a focus on collaborative and interdisciplinary design to investigate real-world problems and opportunities.  
  
**MAT E 362: Principles of Nondestructive Testing**  
(Cross-listed with E M). (3-0) Cr. 3. S.  
*Prereq: PHYS 132 or PHYS 232*  
  
Radiography, ultrasonic testing, magnetic particle inspection, eddy current testing, dye penetrant inspection, and other techniques. Physical bases of tests, materials to which applicable, types of defects detectable, calibration standards, and reliability safety precautions.  
  
**MAT E 452: Scanning and Auger Electron Microscopy**  
(Dual-listed with M S E 552). (2-3) Cr. 3. F.  
*Prereq: PHYS 232*  
  
Characterization of materials using scanning electron microscope (SEM), electron microprobe, and auger spectrometer. Compositional determination using energy and wavelength dispersive x-ray and Auger spectroscopies. Specimen preparation. Laboratory covers SEM operation.

**MGMT 320: Corporate Entrepreneurship**  
(Cross-listed with ENTSP). (3-0) Cr. 3. F.S.  
*Prereq: sophomore classification*  
  
Introduces entrepreneurial approaches aimed at the identification, development and exploitation of technical and organizational innovations, the management of new product or process developments, and the effective management of new ventures. Focuses on mid-size to large corporations, especially in the manufacturing and service industries. Develops an awareness and understanding of the range, scope, and complexity of issues related to the creation of a corporate environment that is supportive of entrepreneurial endeavors as well as the effective implementation of technological and organizational innovations in corporate settings.

**MGMT 370: Managing Organizations**

(3-0) Cr. 3. F.S.SS.

*Prereq: Sophomore Classification*  
Introduction to management as a field and function within organizations. Provides an overview of what managers do in organizations, including how they deal with multiple stakeholders; make decisions about organizational goals, strategies, and structures that align with the external and internal environment; as well as how they lead and manage human resources effectively.

**MGMT 371: Organizational Behavior**  
(3-0) Cr. 3. F.S.  
*Prereq: Sophomore classification*  
  
Introduction to the attitudes and behaviors of individuals and groups in organizations, as well as their antecedents: e.g., individual characteristics, interpersonal processes, manager and leader influences, and organizational characteristics and practices. Builds awareness of one's own and others' characteristics, attitudes, behaviors, and interpersonal and decision-making skills to improve as an employee and a manager.

**MGMT 381: Managing Family Businesses**

(Cross-listed with ENTSP). (3-0) Cr. 3.  
*Prereq: Sophomore classification*  
  
Introduction to the important role family businesses play in the domestic and global economies as well as the complex and unique challenges and opportunities encountered by such businesses and their family members and other employees. Explores best practices for successfully managing family businesses.

**MKT 340: Principles of Marketing**

(3-0) Cr. 3. F.S.SS.

*Prereq: credit or current enrollment in ECON 101*  
The role of marketing in society. Markets, marketing institutions, and marketing functions with emphases on product, price, marketing communication, and marketing channel decisions.

**MKT 342: Foundation Of Personal Selling**

Cr. 3. F.S.  
*Prereq: Sophomore status or above*  
  
The process of selling and how to sell effectively. Focus on selling in a business environment and applying to concepts to general interpersonal settings in personal life. Students will actively participate in class, collaborate with teammates to develop skills to sell ideas and become more effective in representing themselves and their company and its products and services. Develop skills necessary to build long-term, profitable relationships with clients.

**MKT 367: Consultative Problem Solving**

(Cross-listed with MIS). Cr. 3. F.S.  
*Prereq: Sophomore and above*  
  
Consultative problem-solving approach to address complex problems in marketing and related fields. Topics include problem definition, issue tree dis-aggregation, hypotheses development and the Pyramid Principle. Development of skills such as formulating problems, structuring and prioritizing problems, synthesizing results and communicating intuition from quantitative analyses.

**MATH 207: Matrices and Linear Algebra**  
(3-0) Cr. 3. F.S.SS.  
*Prereq: MATH 166*  
  
Systems of linear equations, determinants, vector spaces, linear transformations, orthogonality, least-squares methods, eigenvalues and eigenvectors. Emphasis on applications and techniques. Only one of MATH 207 and MATH 317 may be counted toward graduation.  
 **MATH 341: Introduction to the Theory of Probability and Statistics I**  
(Cross-listed with STAT). (3-2) Cr. 4. F.S.  
*Prereq: MATH 265 or MATH 265H*  
  
Probability; distribution functions and their properties; classical discrete and continuous distribution functions; multivariate probability distributions and their properties; moment generating functions; transformations of random variables; simulation of random variables and use of the R statistical package. Credit for only one of the following courses may be applied toward graduation: STAT 341, STAT 347, STAT 447, or STAT 588.

**MATH 373: Introduction to Scientific Computing**

(3-0) Cr. 3. F.  
*Prereq: MATH 265*  
  
Vector and matrix programming and graphing in MATLAB for scientific applications. Polynomial interpolation and approximation. Systems of linear equations and numerical linear algebra. Numerical differentiation and integration. Root-finding methods for solving nonlinear equations and optimization in one and several variables. Fast Fourier transform. Emphasis on effective use of mathematical software and understanding of its strengths and limitations.

**MATH 385: Introduction to Partial Differential Equations**  
(3-0) Cr. 3. F.S.  
*Prereq: MATH 265; (MATH 266 or MATH 267)*  
  
Method of separation of variables for linear partial differential equations, including heat equation, Poisson equation, and wave equation. Topics from Fourier series, Sturm-Liouville theory, Bessel functions, spherical harmonics, and method of characteristics.

**M E 280X. Design and Analysis of Cyber-Physical Systems**(3-0) Cr. 3. F. Prereq: ENGR 160 or equivalent; PHYS 221 (Or PHYS 231 and PHYS 231L).   
  
Introduction to the basic concepts of cyber-physical systems (CPS); physical and cyber considerations and constraints for design, analysis, performance monitoring and control of human-engineered physical systems; basic concepts of sensing, information processing and feedback actuation. Substantial hands-on computer programming activity relevant to CPS applications.

**M E 373X. Science and Practice of Brewing**

(Cross-listed with FS HN 373X). (1.5-4.5) Cr. 3. F.S.

Prereq: CHEM 167 or CHEM 177 and PHYS 221 or PHYS 231 or BIOL 211 or BIOL 212; or permission by the instructor; 21 years of age for all students.

Introduction to brewing science and technology. Understanding the role of malts, hops, water, and yeast in production of ale and lager beers. Unit operations in brewing. Health, safety, and environmental sustainability in alcohol production and consumption. Weekly laboratory in practical aspects of beer production.  
  
**M E 411: Automatic Controls**  
(2-2) Cr. 3. F.  
*Prereq: M E 370; credit or concurrent enrollment in M E 421*  
  
Methods and principles of automatic control. Pneumatic, hydraulic, and electrical systems. Representative applications of automatic control systems. Mathematical analysis of control systems.  
  
**M E 412: Ethical Responsibilities of a Practicing Engineer**  
(3-0) Cr. 3. F.  
*Prereq: Credit or concurrent enrollment in M E 325*  
  
The study of ethics in engineering design and the engineering profession. A comprehensive look at when ethical decisions must be made and an approach to make them. The approach takes into account moral, legal, technical, experiential, and standards to aid in ethical decision making. Each area will be studied through lectures, debates, guest speakers, class discussion, and case studies.  
  
**M E 417: Advanced Machine Design**  
(Dual-listed with M E 517). (3-0) Cr. 3. F.  
*Prereq: MAT E 273; M E 325*  
  
Stress life, strain life, and fracture mechanics approaches to fatigue life and design with metals, polymers and ceramics. Introduction to material selection in design of machine components. Thermal and structural considerations in design of machine components and hybrid materials. Course project and relevant literature review required for graduate credit.

**M E 419: Computer-Aided Design**  
(3-0) Cr. 3. F.S.  
*Prereq: M E 325*  
  
Theory and applications of computer- aided design. Computer graphics programming, solid modeling, assembly modeling, and finite element modeling. Mechanical simulation, process engineering, rapid prototyping and manufacturing integration.

**M E 433: Alternative Energy**  
(3-0) Cr. 3. F.  
*Prereq: CHEM 167; PHYS 232; PHYS 232L*  
  
Basic principles, performance, and cost analysis of alternative energy systems including biofuels, bioenergy, wind, solar, fuel cells, storage and other alternative energy systems. Performance analysis and operating principles of systems and components, and economic analysis for system design and operation will be taught. Emphasis is on alternative energy technologies needed to meet our future energy needs at various scales ranging from household to city to national levels.

**M E 441: Fundamentals of Heating, Ventilating, and Air Conditioning**

(3-0) Cr. 3. F.  
*Prereq: M E 332 (Note the change to an earlier pre-req course.)*  
  
Space conditioning and moist air processes. Application of thermodynamics, heat transfer, and fluid flow principles to the analysis of heating, ventilating, and air conditioning components and systems. Performance and specification of components and systems.  
 **M E 449: Internal Combustion Engines**  
(3-1) Cr. 3. F.  
*Prereq: M E 332*  
  
Basic principles, thermodynamics, combustion, and exhaust emissions of spark-ignition and compression-ignition engines. Laboratory determination of fuel properties and engine performance. Effects of engine components and operating conditions on performance. Written reports required.  
  
**M E 451: Engineering Acoustics**  
Cr. 3. Alt. F., offered even-numbered years. (Cross-listed with E E, E M). (2-2)  
*Prereq: (MATH 266 or MATH 267); PHYS 231; PHYS 231L*  
  
The basics of acoustic wave propagation in fluids with an emphasis on sound propagation in air. Topics include transmission and reflection of sound at a boundary; role of acoustic sources in directing sound fields; diffraction of sound around solid objects; reverberation of sound in a room; and the measurement of sound fields.

**M E 456: Machine Vision**

(Dual-listed with M E 556). Cr. 3. Repeatable. Alt. F., offered odd-numbered years.  
*Prereq: MATH 207 or MATH 317 or Permission of Instructor*  
  
Practical imaging processing techniques, geometric optics, and mathematics behind machine vision, as well as the most advanced 3D vision techniques. Experience with practical vision system development and analysis. Assignments include individual bi-weekly homework; weekly readings and lectures; and a semester-long research project on design and experiment vision systems.

**M S E 510: Fundamentals of Structure and Chemistry of Materials**  
(3-0) Cr. 3. F.  
*Prereq: MATH 165, PHYS 221, and CHEM 167*  
  
Geometric and algebraic representations of symmetry. Pair distribution function. Structure, chemistry, and basic properties of covalent, ionic, and metallic solids, glasses and liquids, and polymers. Interactions of materials with particles and waves. Relationships between direct and reciprocal spaces. The kinematical theory of diffraction, with an introduction to the dynamical theory.  
 **M S E 552: Scanning and Auger Electron Microscopy**

(Dual-listed with MAT E 452). (2-3) Cr. 3. F.  
*Prereq: PHYS 232*  
  
Characterization of materials using scanning electron microscope (SEM), electron microprobe, and auger spectrometer. Compositional determination using energy and wavelength dispersive x-ray and Auger spectroscopies. Specimen preparation. Laboratory covers SEM operation. **NREM 390: Fire Ecology and Management**  
(3-0) Cr. 3. F.

Characteristics and role of fire in forest ecosystems. Major topics covered include fuels, fire weather, fire behavior, fire danger rating systems, fire control, prescribed burning, and fire dynamics in major ecosystem types.

**NREM 446: Integrating GPS and GIS for Natural Resource Management**

(Dual-listed with NREM 546). (Cross-listed with ENSCI). (2-3) Cr. 3. F.  
*Prereq: 12 credits in student's major at 300 level or above*  
  
Emphasis on the use of GPS as a data collection tool for GIS. Basic theory of GPS. Use of Global Positioning System technology for spatial data collection and navigation. Post-processing and real-time correction of GPS data. GPS data transfer to GIS for mapping applications. Use of GIS to construct waypoints for use in GPS navigation.

**N S 320: Naval Ship Systems I (Engineering)**  
(3-0) Cr. 3. F.  
*Prereq: PHYS 231; PHYS 231L; Sophomore classification*  
  
An introduction to naval engineering with emphasis on the equipment and machinery involved in the conversion of energy for propulsion and other purposes aboard the major ship types of the U.S. fleet. Basic concepts of the theory and design of steam, gas turbine, diesel, and nuclear propulsion. Introduction to ship design, stability, hydrodynamic forces, compartmentalization, electrical and auxiliary systems.  
  
**PHYS 310: Electronic Instrumentation for Experimental Physics**(2-4) Cr. 4. F.  
*Prereq: MATH 166; ([PHYS 222 or PHYS 222H] or [PHYS 232 or PHYS 232H; PHYS 232L] or [PHYS 242 or PHYS 242H])*  
  
Common electrical instruments; power supplies; transducers; passive and active devices, analog integrated circuits, including filters and amplifiers; digital integrated circuits; signal transmission and enhancement.  
**PHYS 321: Introduction to Modern Physics I**  
(3-0) Cr. 3. F.  
*Prereq: Credit or concurrent enrollment in (MATH 266 or MATH 267); ([PHYS 222 or PHYS 222H] or [PHYS 232; PHYS 232L] or [PHYS 242 or PHYS 242H])*  
  
Quantum nature of matter: photons, de Broglie's postulate: wave-like properties of matter; Bohr's model of hydrogen atom; Schrodinger equations in one dimension: energy quantization; detailed solutions for potential steps, barriers and wells; one-electron atoms, spin and magnetic interactions; ground states, optical and x-ray excitations of multi-electron atoms.  
  
**PHYS 321L: Introductory Laboratory in Modern Physics I**  
(0-2) Cr. 1. F.  
*Prereq: Credit or concurrent enrollment in PHYS 321*  
  
Experiments related to the foundations of modern physics. The dual wave and particle character of electrons and photons, statistics, interferometry and x-ray spectroscopy.  
  
**PHYS 364: Electricity and Magnetism I**  
(3-0) Cr. 3. F.  
*Prereq: (MATH 266 or MATH 267); ([PHYS 222 or PHYS 222H] or [PHYS 232 or PHYS 232H; PHYS 232L] or [PHYS 242 or PHYS 242H])*  
  
Static electric and magnetic fields, potential theory; electromagnetism, Maxwell's equations.  
  
**STAT 301: Intermediate Statistical Concepts and Methods**  
(3-2) Cr. 4. F.S.  
*Prereq: STAT 101 or STAT 104 or STAT 105 or STAT 201 or STAT 226 or STAT 231 or STAT 305 or STAT 322 or STAT 330*  
  
Statistical concepts and methods used in the analysis of observational data. Analysis of single sample, two sample and paired sample data. Simple and multiple linear regression including polynomial regression and use of indicator variables. Model building and analysis of residuals. Introduction to one-way ANOVA, tests of independence for contingency tables, and logistic regression. Credit for only one of the following courses may be applied toward graduation: STAT 301, STAT 326, STAT 401, or STAT 587.  
  
**TSM 327: Livestock and Poultry Production: Facilities, Technology, and Management**  
(2-2) Cr. 3. F.

Systems-based planning and assessment of confined livestock facilities. Housing evaluation, planning, and management of ventilation, water, and feed systems. Principles of nutrient management planning, manure handling/storage design. Evaluating animal responses to their environment with traditional metrics and precision livestock technologies to enhance welfare and production. Species-specific assessment of production economics, environmental impact, and sustainability.

**TSM 376: Fire Protection and Prevention**  
(3-0) Cr. 3. F.

An overview of the current problems and technology in the fields of fire protection and fire prevention, with emphasis on industrial needs, focusing on the individual with industrial safety responsibilities.  
  
**TSM 433: Precision Agriculture**  
(Dual-listed with TSM 533). (2-2) Cr. 3. F.  
*Prereq: Junior classification*  
  
Geographic information systems (GIS) and global positioning systems (GPS). Hardware systems for precision farming emphasized. Autosteering and automatic implement control systems. Collection and management of yield data. Sampling strategies for precision farming. Introduction to building fertilizer prescriptions and recommendations. Economic benefits of precision farming systems.  
  
**TSM 455: Feed Processing and Technology**  
(Dual-listed with TSM 555). (2-3) Cr. 3. F.  
*Prereq: Junior classification*  
  
Introduction to formula feed manufacturing and the animal feed industry. Overview of feed ingredients and formulation, understanding and operation of feed production processing equipment including principles of conveying, grinding, mixing, conditioning, pelleting, and other processing techniques, and the formulation of concentrates, premixes, and rations. Students will become knowledgeable about the manufacturing of various animal feed types such as pelleted and extruded feed, aqua (fish) feed, liquid feeds, poured and pressed blocks, steam flaked feed, and pet food, and their effect on animal performance and health. Students will gain hands-on experience in feed manufacturing during weekly lab sessions at a full-scale university owned feed mill and grain science complex.