APPENDIX A. COURSE SYLLABI

The following course syllabi are provided in the following order and grouping in this appendix:

Courses in the Metallurgical Engineering Curriculum

MET 110	Intro to Engineering
MET 220	Min Proc & Resource Rec
MET 220L	Min Proc & Resource Rec Lab
MET 231	Structures & Prop of Mat Lab
MET 232	Prop of Materials
MET 310	Aqueous Extract/Conc/Rec
MET 310L	Aq Extract/Conc/Rec Lab
MET 320	Metallurgical Thermodynamics
MET 321	High Temp Extract/Conc/Rec
MET 330	Physics of Metals
MET 330L	Physics of Metals Lab
MET 332	Thermomechanical Treatment
MET 351	Eng Design I
MET 352	Engineering Design II
MET 422	Transport Phenomena
MET 433	Process Control
MET 440	Mechanical Metallurgy
MET 464	Engineering Design III
MET 465	Engineering Design IV

Metallurgical Engineering Elective Courses

MET 426/526	Steelmaking
MET 430/430L	Weld. Engr. & Design of Welded Struct.
MET 443	Composite Materials
MET 450/550	Forensic Engineering
MET 455/545	Oxidation and Corrosion of Metals

Other Required Engineering Courses

EE 301	Intro Circuits, Machines, Sys
EM 214	Statics
EM 321 or	Mechanics of Materials
IENG 301	Basic Engineering Economics
ME 216	Intro to Solid Mechanics

Support Courses

CHEM 112	General Chemistry
CHEM 112L	General Chem Lab
CH EM 114	General Chemistry II
CHEM 114L	Gen Chem II Lab
ENGL 101	Composition I
ENGL 279	Technical Comm I
ENGL 289	Tech Comm II
GE 130	Intro to Engineering
MATH 123	Calculus I
MATH 125	Calculus II
MATH 225	Calculus III
MATH 321	Differential Eqs
MATH 373	Intro to Numerical Analysis
PHYS 211	University Physics I
PHYS 213	University Physics II
PHYS 213L	Univ Physics II Lab

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MET 330L	Physics of Metals Lab
MET 332	Thermomechanical Treatment
MET 351	Eng Design I
MET 352	Engineering Design II
MET 422	Transport Phenomena
MET 433	Process Control
MET 440	Mechanical Metallurgy
MET 464	Engineering Design III
MET 465	Engineering Design IV

MET 110: INTRODUCTION TO METALLURGICAL ENGINEERING DESIGN

CATALOG DATA:

MET 110/110L – INTRODUCTION TO METALLURGICAL ENGINEERING DESIGN; (1-1) Credits
1-1 credits. Prerequisites: none. An introductory design course for incoming freshman in metallurgical engineering covering fundamental engineering practices. The course will include group projects, problem solving (using spreadsheets and other current methods), and include engineering ethics.

TEXTBOOK: (OPTIONAL)

Textbook: ENGINEERING DESIGN, A Materials and Processing Approach, George E. Dieter, McGraw-Hill Company, Third Edition, 2000.

INSTRUCTOR:

Dr. Stanley M. Howard
Office: MI 114
Office Hours: MWF 10:00 to 11:00
Phone: (605) 394-1282, Fax: (605) 394-3369, e-mail: Stanley.howard.sdsmt.edu

REQUIRED/ELECTIVE

MET 110/110L is required for all B.S. Metallurgical Engineering students

EXPECTATIONS:

The course focuses on the presentation of two hours per week of design lectures and on the development of projects with vertical and horizontal integration of concepts from all areas of Metallurgical Engineering. The student is expected to begin to acquire the fundamental and applied knowledge of the engineering tenure. Specifically the student is expected to acquire a good working knowledge of:

- Principles of product and process design
- Problem solving skills
- Analysis skills on materials microstructure/property relationships
- Communication skills, both oral and written

COURSE OBJECTIVES:

The objectives of this course are to provide hands on practical initial experience on Metallurgical Engineering Design. Students develop their projects by working in interdisciplinary teams under the direction and supervision of one or more Faculty mentors. During the development of the course the students will demonstrate acquire skills to:

- Assessment of need
- Proposal preparation
- Definition of design requirements
- Gather information
- Conceptualize various solutions
- Evaluation of design concepts and select a candidate design
- Work in an interdisciplinary team environment
- Communicate the design effectively by written reports and oral presentations

CLASS SCHEDULE:

MET 110/110L classes will meet Mondays and Wednesdays 3:00-3:50 in MI 320 and MI 220.

TOPICS:

Orientation for the Design Sessions, Presentation and Discussion of the Design Program, Design Process and Projects, Literature Search , Brainstorming, Design of Experiments, Ethics, Creative Process, Process Analysis I.

COMPUTER USAGE:

As required by lectures and projects

COURSE OUTCOMES:

During this course students will demonstrate the ability to:

- Define the problem and establish the project specifications and constrains
- Gather information and establish the state of the art on the design science and technology
- Conceptualize various concept solutions to the design problem
- Use decision matrices for the selection of the candidate solution
- Establish the candidate design and the matrix of tasks needed to achieve this design
- Establish a project schedule
- Work effectively in a team environment
- Write progress and final design reports
- Make effective oral presentations

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (d), (e), (f), (g)

LABORATORY:

As required by projects

ASSESSMENT AND EVALUATION:

The course objectives are evaluated by the following methods:

- Written reports and oral presentations
- Self-assessment of Team Effectiveness

Student Performance is determined by the following methods:

- 15% Design Reviews
- 15% Design Fair/Review
- 15% Oral presentations
- 15% Written Reports
- 15% Professionalism
- 15% Progress Meeting Project Goals
- 10% Assessment Tool Performance and Participation (Team Assessment, Survey, and Exit Exam)

PREPARED BY:

Dr. Stanley M. Howard
Professor of Materials and Metallurgical Engineering

MET 220/220L MINERAL PROCESSING AND RESOURCE RECOVERY

CATALOG DATA:
MET 220 MINERAL PROCESSING AND RESOURCE RECOVERY (3-0) 3 credits. Prerequisite: Sophomore standing. An introductory course in mineral processing highlighting unit operations involved including comminution, sizing, froth flotation, gravity separation, electrostatic separation, magnetic separation and flocculation. Other topics discussed include remediation of contaminant effluents and the unit operations associated with recycling of post-consumer materials using mineral processing techniques. This course is cross-listed with ENVE 220.

TEXTBOOK:
Mineral Processing and Resource Recovery, K.N. Han and J.J. Kellar (an electronic text available in electronic form to the students)

INSTRUCTOR:
Dr. Jon J. Kellar, Office Hours: 2:00-3:00 p.m. M-Th

REQUIRED/ELECTIVE:
MET 220 is required for all B.S. Metallurgical Engineering, and Mining Engineering students. It is a required course for B.S. Environmental Engineering students taking the Metallurgical Engineering emphasis.

COURSE OBJECTIVES:
The objective of this course is to provide students with the working knowledge required to formulate and analyze problems in basic mineral process and particle technology. Students will be able to determine the effects of chemical and physical processes on particle liberation, separation and concentration. Upon completion of the course the students will be able to apply this knowledge in design and in subsequent upper-level courses.

COURSE OUTCOMES:
- Given a particular size reduction desired, the student will be able to construct a basic mineral processing flowsheet, including the definition of fundamental mineral processing terms.
- The student will be able to perform a simple mass balance, and calculate grade and recovery for basic mineral processing unit operations.
- Given sieve data the student will be able to generate a Gaudin-Shuhmann size distribution plot. From the Gaudin-Schuhmann diagram the student will be able to determine the size and distribution modulus for the system.
- The student will be able to calculate the specific surface area for regular and irregular shaped particles given the appropriate physical constants.
- Using a force balance approach, the student will be able to derive Stokes' and Newton's Equation for a particle settling in a liquid.
- The student will be able to distinguish the three regions of the electrical double layer, and their influence on particle electrokinetic phenomena.
- Given the specific gravities of the components of the system, the student will be able to use the concentration criterion as a first approximation to determine the efficacy of gravity concentration.

- By analyzing the movement of particles in a viscous fluid, the student will be able to interpret the effect of cyclic bed displacement, and particle separation in a jig.
- Given the relative magnetic susceptibilities, the student will be able to predict the general effectiveness of a magnetic based separation.
- By performing a force balance on a particle on a magnetic drum surface the student will be able to calculate the entrapment ratio, and the ease of separation from the drum surface.
- Knowing the influence of the electrical double layer on surface charge, the student will be able to determine the effect of cation charge on flocculation.

TOPICS COVERED:

- Abundance of the elements, domestic and world resources
- Mass balances
- Particle characterization
- Comminution
- Movement of solids in fluids
- Classification devices
- Froth flotation
- Gravity concentration
- Magnetic separation
- Electrostatic separation
- Thickening

CLASS SCHEDULE:
Lecture: 3 hours per week, 8:00-8:50 am, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (b), (e), (j), (k)

LABORATORY:
The course laboratory (MET 220L, required for Metallurgical Engineering students) parallels the lecture portion, both in terms of objectives and topics covered. In addition, the laboratory stresses hands-on applications of course content, and a large technical communication component.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basics of resource production and conservation and thereby provides the necessary basis for subsequent metallurgical engineering courses focused upon more advanced processes such as hydrometallurgy (MET 310/310L) and pyrometallurgy (MET 321/321L).

Ethical practice is a frequent discussion item in MET 220, specifically, the role engineer's play in sound development of natural resources. Student social skills are stressed while on laboratory field trips. Professional behavior is recognized, namely, attentiveness and punctuality associated with such field trips.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Jon Kellar, March 30, 2010

MET 232 PROPERTIES OF MATERIALS

CATALOG DATA:

MET 232 PROPERTIES OF MATERIALS (3-0) 3 credits. Prerequisite: MATH 123 and PHYS 111. A course in engineering materials and their applications. The different technological uses of metals, ceramics, plastics, and composite materials are discussed and explained in terms of their basic atomic structure, and mechanical, thermal, optical, electrical, and magnetic properties. Material selection in engineering design is emphasized.

TEXTBOOK:
Materials Science and Engineering: An Introduction, Eight Edition, William D. Callister, Jr., and David G. Rethwisch, John Wiley & Sons, Inc., 2010

INSTRUCTORS:
Dr. Jon Kellar, Office Hours: 2:00-3:00 p.m. M-Th
Dr. Michael West, Office Hours: 11:00-11:50 a.m. M, W, F

REQUIRED/ELECTIVE:
This course is required for all B.S. Metallurgical and Mechanical Engineering students. It is a technical elective for Industrial and Chemical Engineering students.

COURSE OBJECTIVES:
The objective of this lecture program is to relate the properties of engineering materials to the materials microstructure developed during thermal and mechanical processing. Students develop the understanding to make informed engineering material selection decisions that will be safe and economic. The laboratory exercises in MET 231 are timed to follow or coincide with lecture content.

COURSE OUTCOMES:
- Student will understand the basics of atomic bonding and the resulting structure of crystalline solids.
- Student will know and be able to identify the role imperfections in solids play in the development of mechanical and physical properties of materials.
- Students must be accomplished in using mass transport in solids as it pertains to design of alloys and the carburization of steels.
- Students will have experience in the interpretation of mechanical properties of materials, and apply these material properties in the design system components.
- Student will be introduced to dislocation theory and the role dislocations play in the development of mechanical and physical properties of materials.
- Student must be able to identify ductile, brittle, fatigue and high strain rate fractures.
- Student must be accomplished in the use of binary phase diagrams to predict equilibrium and non-equilibrium structures.
- Students must be accomplished in the thermal processing of ferrous and non-ferrous alloys.
- A design project beginning at midterm involves individual team research and the preparation of a technical style report.

TOPICS COVERED:

- Metal Structures
- Imperfections in Solids
- Solid State Diffusion
- Mechanical Behavior of Metals
- Strengthening Mechanisms
- Phase diagrams
- Kinetics of Phase Transformations
- Iron Carbon Alloys – Properties/Microstructure
- Nonferrous metals Alloys -- Properties/Microstructure
- Polymer Structures/Polymer Types/Mechanical Properties

CLASS SCHEDULE:
3 hours per week MWF, 1:00-1:50 p.m. (spring), 10:00-10:50 a.m. (fall)

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (c)

LECTURE:
The course lectures parallels the laboratory portion (MET 231L), both in terms of objectives and topics covered.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
One major team prepared design report is a critical part of this course.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Jon Kellar, March 30, 2010

MET 443 COMPOSITE MATERIALS

CATALOG DATA:
MET 443 COMPOSITE MATERIALS (3-0) 3 credits. Prerequisites: ME 316 or concurrent enrollment in MET 440. The course will cover heterogeneous material systems; basic design concepts and preparation; types of composite materials; advances in filaments, fibers and matrices; physical and mechanical properties; failure modes; thermal and dynamic effects; and applications to construction, transportation and communication. This course is cross-listed with ME 443.

TEXTBOOKS:
Introduction to Composite Materials Design, E.J. Barbero, Taylor & Francis, 1998
Composite Materials: Engineering and Science, F.L. Matthews and R.D. Rawlings, Chapman and Hall, 1999

INSTRUCTORS:
Dr. Jon J. Kellar, Office Hours: 2:00-3:00 p.m. M-F
Dr. Lidvin Kjerengtroen, Office Hourse, 8:00-9:00 a.m. M, Tu, W, Th

REQUIRED/ELECTIVE:
MET 443 is required for all B.S. Metallurgical Engineering students.

COURSE OBJECTIVES:
Students will be able to determine the effects of mechanics and materials chemistry on composite performance.

COURSE OUTCOMES:
Students completing this course satisfactorily will have

- Working knowledge of the crystal structures and defect structures of typical conventional ceramics and typical advanced ceramic materials.
- Working knowledge of the manufacturing processes of glasses, conventional and advanced ceramic materials.
- Working knowledge of five of the most important strengthening mechanisms in glasses and seven of the most important toughening mechanisms in advanced ceramics.
- Calculation of the thermal shock resistance of advanced ceramics using five thermal shock resistance parameters.
- Calculation of the spalling resistance of advanced ceramics based on appropriate properties.
- Establishment of relationships between crystal structure / microstructure / processing / fracture toughness / thermal shock resistance and spalling resistance of advanced ceramics.
- Working knowledge of metallic, ceramic and polymeric materials as matrix materials.
- Design, manufacturing and properties of advanced fibers: glass, boron, carbon, organic, ceramic and metallic.
- Working knowledge of the role of interfaces and interface phases and their properties in the design, manufacture and properties of PMCs, MMCs and CMCs.

- Working knowledge of the design, manufacture, microstructure, properties (stiffness, strength, fracture toughness and fatigue) and applications of PMCs, MMCs and CMCs.
- Applications of micromechanisms in PMCs, MMCs and CMCs for the prediction of their mechanical behavior: stiffness, strength, fracture toughness and fatigue.

TOPICS COVERED:
- Fibers
- Fibers and Whiskers and Nanocomposites
- Reinforcement/Matrix Interface
- Interfaces-Wettability
- Interfaces-Bonding
- The Interphase Methods for Measuring Bond Strength
- Single Fiber Tests, Kelly Tyson Model
- Anisotropic Stress strain relationships, material constants
- Stiffness
- Thermal and Moisture Expansion
- Strength
- Introduction to Visco – Elastic Material Behavior
- Polymer Matrices
- Polymer Matrix Composite Processing
- Polymer Matrix Composite Interfaces/Interphases
- Structure, Properties and Applications of PMCs
- Metal Matrix Composites: In Situ and Artificial
- Ceramic Matrix Composites
- Stress and Strain
- Off-Axis Stiffness
- Macromechanics and Stiffness Design
- Failure and Strength Design
- Failure and Strength Design

CLASS SCHEDULE:
Lecture: 3 hours per week, 1:00-1:50 am, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (c)

LABORATORY:
There is no associated laboratory with this course.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basics of materials selection and design.

Ethical practice is a frequent discussion item in MET 443, specifically, the role engineer's play in selection of materials for critical applications such as defense, crash protection and aerospace.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Jon Kellar, January 14, 2004

MET 220L MINERAL PROCESSING AND RESOURCE RECOVERY LABORATORY

CATALOG DATA:
MET 220L MINERAL PROCESSING AND RESOURCE RECOVERY LABORATORY (0-1) 14 credit.
An introductory laboratory course in mineral processing highlighting relevant unit operations. This course is cross-listed with ENVE 220L. [nb. ENVE is ending the cross-listing in an attempt to make things less conmfusing. Should we keep the cross-listing here?]

TEXTBOOK:
None

INSTRUCTOR:
Dr. William M. Cross, Office Hours: 11:00 AM - 12:00 PM MWF, 10 AM-11AM T, 9-10 AM Th

REQUIRED/ELECTIVE:
MET 220L is required for all B.S. Metallurgical Engineering.

COURSE OBJECTIVES:
The objective of this course is to provide students with the working knowledge of a variety of mineral processing equipment, formulas and concepts. Students will be able to better understand the chemical and physical processes on particle liberation, separation and concentration. Upon completion of the course the students will be able to apply this knowledge in design and in subsequent upper-level courses.

COURSE OUTCOMES:
- The student will be able to perform a simple mass balance, and calculate grade and recovery for basic mineral processing unit operations.
- The student will be able to comminute mineral samples and generate sieve data for a Gaudin-Schuhmann size distribution plot. From the Gaudin-Schuhmann diagram the student will be able to determine the size and distribution modulus for the system.
- The student will be able to correctly sample ore samples of various sizes and composition.
- The student will be able to determine particle shape and show how shape effects surface area and mineral processing unit operations.
- The student will be able to compare particle size measurements from a variety of measurement techniques and statistically examine this comparison.
- The student will understand the trade-offs associated with maximizing grade and recovery while minimizing costs.
- The student will be able to perform bench-scale flotation tests and understand the connection between comminution, adsorption, hydrophobic character and flotation response.

TOPICS COVERED:

- History of mineral processing and metallurgy
- Mass balances
- Comminution
- Sampling
- Particle characterization
- Movement of solids in fluids
- Froth flotation
- Gravity concentration
- Magnetic separation
- Basic statistics

CLASS SCHEDULE:
3 hours per week, T, 1:00-3:50 p.m.

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: This course is used for assessment (k) Use Engineering Techniques, Skills and Tools

LABORATORY:
The course laboratory parallels the lecture portion, both in terms of objectives and topics covered. In addition, the laboratory stresses hands-on applications of course content, and a large technical communication component.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basics of resource production and conservation and thereby provides the necessary basis for subsequent metallurgical engineering courses.

Written communication skills are stressed through individual and group laboratory reports and iterative rewriting of these reports. Teamwork is an important laboratory skills component. Student social skills are utilized and improved while on laboratory field trips. Professional behavior is recognized, namely, attentiveness and punctuality associated with such field trips.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
William M. Cross, March 29, 2010

MET 231 STRUCTURE AND PROPERTIES OF MATERIALS LAB

CATALOG DATA:

MET 231 STRUCTURE AND PROPERTIES OF MATERIALS LAB (0-1) 1 credit. Prerequisite: Concurrent registration in MET 232, or permission of instructor. A laboratory involving quantitative metallography, heat treating practice, mechanical property measurements and metallurgical design of the thermal mechanical treatment of metals.

TEXTBOOK:
Materials Science and Engineering: An Introduction, Eight Edition, William D. Callister, Jr., and David G. Rethwisch, John Wiley & Sons, Inc., 2010

INSTRUCTOR:
Dr. Michael West, Office Hours: 11:00-11:50 a.m. M, W, F

REQUIRED/ELECTIVE:
This course is required for all B.S. Metallurgical and Mechanical Engineering students. It is a technical elective for Industrial and Chemical Engineering students.

COURSE OBJECTIVES:
The objective of this laboratory program is to relate the properties of engineering materials to the materials microstructure developed during thermal and mechanical processing. Students will become familiar with mechanical testing and metallurgical evaluation of materials according to ASTM standards. Students will gain an understanding of the variability of material properties. Finally, students will also practice writing technical reports that detail experimental findings. The laboratory exercises in MET 231 are timed to follow or coincide with lecture content in MET 232.

COURSE OUTCOMES:
- Given a set of experimental measurements, students will be able to calculate the mean and standard deviation.
- Given proper instruction of a hardness tester, students will be able to perform Rockwell and microhardness tests on metals.
- Given a micrograph with a scale-bar, students will be able to determine the magnification of the micrograph.
- Given a micrograph of a metal, students will be able to determine the ASTM grain size number of the metal.
- Given proper safety instruction, students will conduct a tensile test on metal alloys. Given the results of load and displacement, students will be able to determine the elastic modulus, yield strength, and tensile strength of the alloy.
- Given proper safety instruction, students will conduct Charpy impact tests on metals. Given the results of energy absorption, students will be able to estimate the ductile to brittle transition temperature of the metal.
- Given a micrograph of a Charpy impact specimen, students will be able to determine the mode of failure: ductile or brittle.
- Given results from a heat treatment of steel test, students will be able to construct a Jominy curve.

TOPICS COVERED:

- Statistics
- ASTM Standards
- Hardness Testing
- Microhardness Testing
- Charpy Impact Testing
- Tensile Testing
- Strain Gages
- Optical Metallography
- Scanning Electron Microscopy
- Thermomechanical (Jominy) Testing

CLASS SCHEDULE:
3 hours per week, Recitation: 8:00-8:50 AM, Lab: 9:00-11:00 AM, 1:00-3:00 PM, or 3:00-5:00 PM. Tuesday (Fall), Thursday (Spring).

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES:
(b) Design and Conduct Experiments and Analyze and Interpret Data and Information
(g) Communicate Effectively

LECTURE:
The course consists of a recitation portion that parallels the lecture portion (MET 232), both in terms of objectives and topics covered.

LABORATORY:
The laboratory focuses on conducting hands-on experiments related to course content in the lecture. Students are required to write a large number of technical reports to satisfy the lab component.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

- The course prepares students in the basics of standards which govern materials testing and properties.
- Written and oral communication skills are improved through the iterative writing of technical reports and a final oral presentation.

ASSESSMENT AND EVALUATION
Six Team Technical Reports
Two Individual Technical Memoranda
One Lab Critique
One Team Oral Presentation/Seminar

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Michael West, April 18, 2010

MET 232 PROPERTIES OF MATERIALS

CATALOG DATA:

MET 232 PROPERTIES OF MATERIALS (3-0) 3 credits. Prerequisite: MATH 123 and PHYS 111. A course in engineering materials and their applications. The different technological uses of metals, ceramics, plastics, and composite materials are discussed and explained in terms of their basic atomic structure, and mechanical, thermal, optical, electrical, and magnetic properties. Material selection in engineering design is emphasized.

TEXTBOOK:
Materials Science and Engineering: An Introduction, Eight Edition, William D. Callister, Jr., and David G. Rethwisch, John Wiley & Sons, Inc., 2010

INSTRUCTORS:
Dr. Jon Kellar, Office Hours: 2:00-3:00 p.m. M-Th
Dr. Michael West, Office Hours: 11:00-11:50 a.m. M, W, F

REQUIRED/ELECTIVE:
This course is required for all B.S. Metallurgical and Mechanical Engineering students. It is a technical elective for Industrial and Chemical Engineering students.

COURSE OBJECTIVES:
The objective of this lecture program is to relate the properties of engineering materials to the materials microstructure developed during thermal and mechanical processing. Students develop the understanding to make informed engineering material selection decisions that will be safe and economic. The laboratory exercises in MET 231 are timed to follow or coincide with lecture content.

COURSE OUTCOMES:
- Given electronegativity data the student will understand the basics of atomic bonding and the resulting structure of crystalline solids.
- Given a specific type of defect the student will know and be able to identify the role the imperfection imparts in the development of mechanical and physical properties of materials.
- Given systems time, temperature data students will be able to perform using mass transport in solids as it pertains to design of alloys and the carburization of steels.
- Given basic input data such as stress and strain students will be able to determine the mechanical properties of materials, and apply these material properties in the design system components.
- Given an image of a fractured specimen the student will be able to identify ductile, brittle, fatigue and high strain rate fractures.
- Given binary phase information the student will be able to predict equilibrium and non-equilibrium structures.
- Given hardenability data for steel and a specified heat treatment schedule, the student will be able to predict if the material meets minimum strength requirements.

TOPICS COVERED:

- Metal Structures
- Imperfections in Solids
- Solid State Diffusion
- Mechanical Behavior of Metals
- Strengthening Mechanisms
- Phase diagrams
- Kinetics of Phase Transformations
- Iron Carbon Alloys – Properties/Microstructure
- Nonferrous metals Alloys -- Properties/Microstructure
- Polymer Structures/Polymer Types/Mechanical Properties

CLASS SCHEDULE:
3 hours per week MWF, 1:00-1:50 p.m. (spring), 10:00-10:50 a.m. (fall)

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (c)

LECTURE:
The course lectures parallels the laboratory portion (MET 231L), both in terms of objectives and topics covered.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
One major design report is a required part of this course.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Jon Kellar, March 30, 2010

MET/ENVE 310. AQUEOUS EXTRACTION, CONCENTRATION AND RECYCLING

CATALOG DATA:

MET 310. AQUEOUS EXTRACTION, CONCENTRATION AND RECYCLING (3-0) 3 credits. Prerequisites: MET 320 or CBE 321, or CHEM 342. Scientific and engineering principles involved in the winning of metals from ores and scrap. Areas covered include the unit operations of comminution, sizing, solid/liquid separations, leaching, ion exchange, solvent extraction, and surface phenomena as related to flocculation, froth floatation, and electrostatic separation. This course is cross-listed with ENVE 310.

TEXT BOOK:

K. N. Han, "Fundamentals of Aqueous Metallurgy", SME, 2002. p. 212

INSTRUCTOR:

Dr. William M. Cross, Office Hours: 11:00 AM - 12:00 PM MWF, 10 AM-11AM T, 9-10 AM Th

REQUIRED/ELECTIVE:

MET 310 is required for all B.S. Metallurgical Engineering. It is a required course for B.S. Environmental Engineering students taking the Metallurgical Engineering emphasis.

COURSE OBJECTIVES:

Students successfully completing this course will be able to: (1) identify fundamental governing principles in, (2) determine data required to and perform analysis of, and (3) design equipment and circuits for ore and scrap processing. In addition, students completing this course will write effectively and be able to discuss the global and societal context of metallurgical processing operations.

COURSE OUTCOMES

- The student will be able to understand the meaning of surface tension and apply this concept to various practical processes.
- The student will be able to understand how solids obtain the surface charges and understand the significance of the surface potential, potential determining ion, Stern potential and zeta-potential in relation to practical applications.
- The student will be able to estimate the adsorption density from the adsorption isotherm and comprehend the role of the surface charge and other adsorption driving forces on the adsorption density and be able to apply in practices.
- The student will be able to distinguish the major differences between sulfide and oxide froth flotation.
- The student will be able to correctly balance half-cell reactions.
- The student will be able to calculate the equilibrium activities of products for hydrometallurgical systems.
- The student will be able to make and utilize Pourbaix diagrams to understand equilibrium leaching and environmental phenomena.
- The student will be able to formulate and suggest tests to confirm the rate expression for given concentrations of reactants and products as a function of time.
- The student will able to understand and apply the effect of temperature on the rate of reaction.

- The student will be able to understand the solvent extraction/ion exchange mechanisms and the selectivity relationship between the elements to be separated.

TOPICS COVERED:
- Hydrometallurgy; Activity Coefficients, Solubility Calculations, Metal Complexation, Effect of Temp and Pressure on Equilibrium, Pourbaix Diagrams, Leachants, Leaching Techniques
- Leaching Kinetics: Kinetic Expression, Data Analysis, Temperature Effect on Leaching Kinetics.
- Removal of Metal Ions from Leach Liquor: Solvent Extraction, Electrowinning, Ion Exchange
- Interfacial Phenomena: Surface Tension, Wetting Phenomena, Spreading, Theoretical Aspects of Adsorption, Gibbs Adsorption Equation.
- Origin of Charges, Electrical Double Layer, Gouy Model, Stern and Grahame Approach, Electrokinetics: Zeta and Streaming Potentials, Electrokinetics, Flotation of Oxides and Sulfides.

CLASS SCHEDULE:
Classes: 9 AM-9:50 AM in MI 220, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (b), (e), (f), (g), (h), (i)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basics of resource recovery, concentration and recycling and therefore provides students with the necessary basis to design, operate and optimize metallurgical processes taking place in practice.

Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in the field of extractive metallurgy through writing assignments and iterative improvement of these writings.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
William M. Cross, March 29, 2010

MET/ENVE 310L. AQUEOUS EXTRACTION, CONCENTRATION **AND RECYCLING LABORATORY**

CATALOG DATA:
MET 310L AQUEOUS EXTRACTION, CONCENTRATION AND RECYCLING LABORATORY (0-1) 1 credit. Prerequisites: Concurrent registration in MET 310 or permission of instructor. Laboratory experiments in design of processing equipment and cost estimation, zeta potential, surface tension, leaching kinetics, electrowinning, and solvent extraction. This course is cross-listed with ENVE 310L.

TEXT BOOK:
None

INSTRUCTOR:
Dr. William M. Cross, Office Hours: 11:00 AM - 12:00 PM MWF, 10 AM-11AM T, 9-10 AM Th

REQUIRED/ELECTIVE:
MET 310L is required for all B.S. Metallurgical Engineering students.

COURSE OBJECTIVES:
The objective of this course is to provide students with the laboratory experience required to understand the principles governing, analyze the data produced from and design various pieces of equipment for unit operations of material dissolution/separation from ores and scrap.

COURSE OUTCOMES
- The student will be able to apply statistical design and analysis of experiments to optimize a process.
- The student will able to design a set of leaching process experiments which can be analyzed statistically to optimize the process response surface.
- The student will be able to measure surface tension of liquids contact angle of water with and without surfactants to identify a set of experimental parameters to optimize grade, recovery or their combination for a flotation system.
- The student will be able to calculate the Gibbs free energy of adsorption of metal ions on solid surface and examine the effect of charge of solids on the adsorption density of these ions.
- The student will be able to understand important parameters affecting the leaching of metals and calculate the activation energy.
- The student will be able to understand the principles of solvent extraction, cementation, ion exchange and solution precipitation.

TOPICS COVERED:
- Experimental Design
- Process Design
- Leach Kinetics
- Leaching Equilibrium
- Rocvery of Metal Ions from Solution
- Adsorption and Precipitation of Metal Ions

- Contact Angle Measurements
- Surface Tension Measurements
- Froth Flotation

CLASS SCHEDULE:
3 hours per week. Thursday 1:00 – 3:50 PM in Rm 220 and 126/MI

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (b), (c), (d), (e), (f), (g), (h), (k)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in performing, designing and analyzing metallurgical processes based on situations occurring in professional practice.

This preparation includes life-long learning components, communication skills, in addition to identifying, analyzing and solving engineering problems. Teamwork is emphasized throughout this course.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
William M. Cross, March 29, 2010

MET 320 - METALLURGICAL THERMODYNAMICS

(4-0) 4 credits. Prerequisites: PHYS 211, CHEM 112, MATH 125. The principles of chemical thermodynamics and their application to metallurgical engineering processes. Topics covered include the zeroth, first and second laws of thermodynamics, the fundamental equations of state for open and closed systems, criterion of equilibrium, heat capacities, reaction equilibrium constants and their dependence upon temperature and pressure, chemical potential, standard and reference states, stability diagrams, and solution thermodynamics. This course is cross-listed with ENVE 320.

TEXTBOOK

Introduction to the Thermodynamics of Materials, 5th Ed. by David Gaskell

INSTRUCTOR

Dr. S. M. Howard MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu Open Office Policy

REQUIRED/ELECTIVE

MET 310 is required for all B.S. Metallurgical Engineering. It is a required course for B.S. Environmental Engineering students taking the Metallurgical Engineering emphasis.

COURSE OBJECTIVES

Students who satisfactorily complete this course will be able to determine the effects of temperature, pressure, and concentration on chemical reactions.

COURSE OUTCOMES

Students who satisfy the following outcomes will receive a passing grade

- Given the initial state (i.e..- two of the following: T, P, V), the final state (i.e..- one of the following: T, P, V), and the path followed (isothermal, isochoric, isobaric, adiabatic, reversible, free expansion) by an ideal gas, the student will be able to calculate ΔU, ΔH, ΔS, q, and w.
- The student will be able to calculate ΔS_{total} when a body of given mass, heat capacity, and initial temperature equilibrates with a heat sink of specified temperature.
- The student will be able to calculate ΔS^{Mixing} when two or more pure components at the same temperature, pressure, and state form an ideal solution.
- Given a chemical reaction where the temperatures and amounts of reactants, the final temperature and amounts of the products, and corresponding enthalpies of formation at 298 K and the heat capacities are specified, the student will determine the heat added to or removed from the system.
- The student will be able to integrate the Clausius and the Clausius-Claperyon Equations and given all but one of the variables in the equation solve for the remaining variable using the equation. The student must recognize that melting or boiling point information constitutes a (T, P) set.
- The student will be able to calculate ΔG for a condensed-phase reaction at constant temperature as a function of pressure given the molecular weights and densities of the reactants and products and the ΔG at a specified pressure.
- The student will be able to determine the equilibrium constant for a reaction from $\Delta G°$ of formation data for the reaction and to correctly describe the standard state for each component involved in the reaction.
- The student will calculate the equilibrium state (partial pressures, moles) for a reaction involving known initial amounts of gases and pure condensed phases occurring at a given temperature and pressure. The student will be provided either the $\Delta G°$ or K_{Equil} for the reaction.
- The student will determine activities and activity coefficients for component i from the integral molar Gibbs energy of mixing and from the partial molar Gibb's energy of mixing for component i.
- The student will derive the Fundamental equations for an open system, the Maxwell Relations, the "Other" Thermodynamic relationships, the criterion of equilibrium for systems at constant temperature and pressure.
- The student will calculate the cell potential for electrolytic cells involving dissolved components in non-aqueous systems.
- The student will determine using the Ellingham Diagram relative oxide stabilities, equilibrium oxygen pressures, equilibrium H_2/H_2O and CO/CO_2 ratios for any reaction on the Ellingham Diagram.

TOPICS

- First Law of Thermodynamics (9 classes)
- Forms of Energy, Heat and Work, Joules Experiments, Conservation of Energy, Concept of Maximum Work, Isothermal Expansion, Reversible, Adiabatic Expansion, Constant Pressure Processes, Constant Volume Processes, Enthalpy
- Second Law of Thermodynamics (9 classes)
- 2nd Law Statement, Carnot Cycle, 4 Propositions
- Statistical Entropy (2 classes)
- Physical Meaning of Entropy, Boltzman Equation, Mixing Entropy, Stirling's Approximation
- Auxiliary Functions (3 classes)
- Fundamental Equations of State, Maxwell Relationships, Other Thermodynamic Relations, Chemical Potential, Gibbs-Helmholtz Equation, Criteria of Equilibria
- Heat Capacity and Entropy Changes (5 classes)
- Sensible Heats, Transformation Heats, Reaction Heats, ΔCp, $\Delta H=f(T)$, $\Delta S=f(T)$, Adiabatic Flame Temperatures, Heat Balances, JANAF Thermochemical Tables
- Phase Equilibria in One Component Systems (6 classes)
- Clausius-Claperyon Equation, Heats of Vaporization From Vapor Pressure Data, Shift in Transformation Temperature with Pressure
- The Behavior of Gases (3 classes)
- Compressibility Factor, Law of Corresponding States, Equations of State, Fugacity
- Reactions Equilibria (13 classes)
- Equilibria in Gaseous Systems, The Equilibrium Constant and $\Delta G°$, Reaction Extent Problems, Equilibria in Systems Containing Condensed Phases, Ellingham Diagram, Activities, F*A*C*T
- Solution Thermodynamics (9 classes)
- Absolute and Partial and Integral Molar Quantities, Relative and Partial Integral Molar Quantities, Ideal Solutions, Excess Quantities, Gibb's Duhem Equation, Tangent Intercept Method, a=f(T), Change in Reference State, 1 wt % Reference State Interaction Parameters
- Phase Equilibria and Electrochemistry (as time permits)
- Tests (5 classes)

CLASS SCHEDULE

9:00 – 9:50 MWRF   MI 220

RELATIONS OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (a), (c)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT

- This course prepares students in the basics of resource recovery, concentration and recycling and therefore provides students with the necessary basis to design, operate and optimize metallurgical processes taking place in practice.
- Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in the field of extractive metallurgy.

LABORATORY: none

ASSESMENT AND EVALUATION

One final exam (required of all students), three or four hour exams, daily short quizzes

EXPECTATIONS: College Calculus, Chemistry, Physics

COMPUTER USAGE: Microsoft Excel, ThermoCalc

PREPARED BY

S. M. Howard

MET 321 - HIGH TEMPERATURE EXTRACTION, CONCENTRATION, AND RECYCLING

(3-1) 4 credits. Prerequisite: MET 320. Thermodynamic principles involved in the winning of metals. Areas covered include calcination, oxidation, reduction processes, smelting, high -temperature refining, electrorefining, slags, and slag-metal interactions. This course is cross-listed with ENVE 321/321L.

TEXTS

- G. H. Geiger and D. R. Poirier, Transport Phenomena in Materials Processes, TMS, London, 1994.
- David R. Gaskell, Introduction to the Thermodynamics of Materials, 3rd ed., Taylor & Francis, Washington DC, 1995.

INSTRUCTOR:

Dr. S. M. Howard	MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu	Open Office Policy

REQUIRED/ELECTIVE:

MET 321 is required for all B.S. Metallurgical Engineering. It is a required course for B.S. Environmental Engineering students taking the Metallurgical Engineering emphasis.

COURSE OBJECTIVE:

Students who satisfactorily complete this course will be able to apply chemical thermodynamics to analyze chemical processes and compute phase equilibria associated with metal production and performance.

COURSE OUTCOMES:

Students who satisfy the following outcomes will receive a passing grade .

- Given sufficient but minimal mass flow information on an open process, the student shall calculate all unstated mass flows. Typical problems appear in Schuhmann's text in chapters 2, and 3.
- Given sufficient but minimal heat and mass flow information on an open process, the student shall calculate all unstated heat and mass flows. Typical problems appear in Schuhmann's text in chapter 4.
- Given isothermal activity data as a function of composition for a standard state, the student will be able to calculate ΔG° for a new standard state and the corresponding variation of activity coefficients in the new standard with respect to the new composition variable.
- Given liquidus temperature and composition data for a phase diagram in which a pure component A is in equilibrium with the liquid, the student will be able to derive the equation for finding the activity of the liquid component A in the solution relative to the pure, liquid A.
- Given the Fe-O-C phase diagram in which percent O_2 vs T is plotted, the student will be provided the underlying equations and cite the required data for calculating any equilibrium line on the diagram.
- The student will be able to calculate the cell potential for required for the reduction of any metal by molten salt electrolysis given ΔG^0 of formation for the salt. This includes combined reactions and reduction from molten salt solutions such as encountered in the Hall Cell.
- The student will be able to describe the fundamental problem of producing Zn from ZnO by carbothermic reduction and recommend at least two methods of effecting the recovery of metallic Zn.
- The student will sketch the silica slag network, show the effect of basic component additions on the network, and describe the effect such additions have on slag viscosity and conductivity. The student must be able to cite at least five basic slag components.
- Given a ternary phase diagram and the rules of interpretation, the student will determine the temperature and order of solidification from the liquid state at any specified bulk composition and will describe all phases present and their relative amounts at any given temperature.
- Given activity coefficient data for a component in a metal phase, the corresponding data for the component in the oxidized state in a slag in equilibrium with the metal, the standard Gibbs energy for the oxidation, and the chemical potential of the oxidation agent, the student will determine the slag-metal distribution ratio of the component.

- Given an Ellingham diagram, the student will provide the order of oxidation in a specified matte smelting process.
- The student will describe in detail all of the steps to performing a gold assay and the purpose of each step.
- The student will describe the differences in process in a mini steel mill and an integrated steel mill.
- The student will be able to determine the rate of free evaporation of liquid metals alloy components in vacuum using the Langmuir equation. The student will be given the solution composition, activity coefficient data for each component, their molecular weights, and the temperature.

TOPICS:

Lectures

- Cost, conservation, and concentration of mineral resources (2 classes)
  - Sampling
  - Process Outline
  - Library & Internet Resources
- Thermo Review (I class)
  - Phase Rule
- Ternary Phase Diagrams (4 classes)
  - (Handout)
- Roasting (10 classes)
  - Stability Diagrams (M-O-S, M-X-Y)•Roaster Diagrams•Mo Roasting
- Sintering and Calcination (1 class)
- Solution Thermodynamics (7 classes)
  - Temperature Dependence of Activity
  - Alternative Standard States
  - Activities From the Phase Diagram (Handout)
  - Gibbs-Duhem Integration using the Alpha Function (Handout)
  - Derivation and Application of the Gibb's Phase Rule (Handout)
- Processes by elemental group
  - Oxidation - reduction reactions (8 classes)
  - Smelting and converting reactions (6 classes)
  - Refining processes (3 classes)
  - Refractories and slags (2 classes)
  - Fused salt electrolysis (4 classes)
- Tests (3 or 4 classes)

Laboratory projects

- Calculations laboratory: Stoichiometric calculations; heat balances; and mass balances (7 classes)
- High temperature laboratory exercises: calorimetry (1); slags (1); temperature measurement (1); gold assay (2); de-silvering of lead (1); phase diagram (1); lead recycling (1)

CLASS SCHEDULE:

1:00 – 1:50 MWF   MI 220   1:00 – 3:50 R   MI 121

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (a), (b), (c), (e), (h), (i), (j), (k)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

LABORATORY: yes

ASSESSMENT AND EVALUATION:

One Final Exam – required by all students
Three or Four Hour Exams
Homework
Laboratory Reports

EXPECTATIONS:

Metallurgical Thermodynamics
College Calculus, Chemistry, Physics

COMPUTER USAGE:

Know Elementary Excel

PREPARED BY:

S. M. Howard

MET 330 PHYSICS OF METALS

CATALOG DATA:

MET 330 PHYSICS OF METALS (3-0) 3 credits. Prerequisite: MET 232. The fundamental principles of physical metallurgy with emphasis on the mathematical description of mechanisms that control the structure of materials. Topics are structure of metals, x-ray diffraction, elementary theory of metals, dislocations, slip phenomena, grain boundaries, vacancies, annealing and solid solutions.

TEXTBOOK:

Fundamentals of Physical Metallurgy, John D. Verhoeven, John Wiley & Sons, Inc., 1975.

INSTRUCTOR:

Dr. Michael West, Office Hours: 11:00-11:50 a.m. M, W, F

REQUIRED/ELECTIVE:

This course is required for all B.S. Metallurgical Engineering students. It is a technical elective for Mechanical and Chemical Engineering students.

COURSE OBJECTIVES:

The objective of this course is to introduce students to the physical structure of metals. Students will understand the basic crystal structures of most metals. Students will be able to draw the structure of a solidified pure metal and alloy ingot. Students will be able to quantify segregation in a metal casting. Students will understand the role of defects in crystals on diffusion in the solid state and mechanical properties. Students will also understand affects of grain size reduction, alloying, and dislocation density on strength and recrystallization temperature of a metal.

COURSE OUTCOMES:

- Given unit cell and crystal structure information, students will be able to determine volumetric, planar, and linear density within a crystal lattice.
- Given atomic and structure information for metals, students will be able to predict the degree of solubility of solid solutions.
- Given an x-ray powder diffraction intensity scan, students will be able to determine the crystal structure and lattice parameter for a metal.
- Students will be able to calculate the resolved shear stress to cause slip in a metal crystal structure.
- Given activation energy for vacancy formation, students will be able to calculate the equilibrium number of vacancies for a metal at high temperature.
- Given diffusivity data for solid state diffusion, students will be able to estimate the concentration profile of a diffusing species in a metal using Fick's 2^{nd} law.
- Given a distribution coefficient based on the phase diagram, students will be able to estimate the concentration gradient in a directionally solidified ingot.
- Students will understand the nature of the energy barrier associated with homogeneous nucleation. Given degree of subcooling, students will be able to estimate the critical nucleus size for a metal.
- Students will be able to describe the affects of grain size reduction, alloying, and dislocation density on strength and recrystallization temperature.

TOPICS COVERED:

- Crystal Structure
- Structure Determination
- Plastic Deformation
- Grain Boundaries
- Dislocations
- Vacancies
- Solid State Diffusion
- Solidification
- Nucleation and Growth
- Solid Solutions
- Phase Diagrams
- Recovery and Recrystallization
- Phase Transformations

CLASS SCHEDULE:
3 hours per week, MWF 8:00-8:50 AM (odd years)

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES:
(a) Apply Knowledge of Math, Science, and Engineering
(c) Optimally Select Material and Design Materials Treatment and Production Processes
(k) Use Engineering Techniques, Skills, and Tools Use Engineering Techniques, Skills, and Tools

LECTURE:
The course consists of a lecture portion that parallels the lab (MET 330L), both in terms of objectives and topics covered.

LABORATORY:
None

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

- The course prepares students in the basics of the structure of metals and provides students with the necessary basis to design important metallurgical processing techniques including casting, grain size reduction, homogenizing, cold working, and annealing.

ASSESSMENT AND EVALUATION
Two or Three Hour Exams
One Final Examination
Homework

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Michael West, April 18, 2010

MET 330L PHYSICS OF METALS LAB

CATALOG DATA:

MET 330L PHYSICS OF METALS LAB
(0-1) 1 credit. Prerequisites: MET 232 and MET 231
Practical laboratory exercises that involve (1) x-ray diffraction methods, (2) scanning electron microscopy techniques for materials evaluations, (3) recovery, recrystallization and grain growth as it applies to annealing of materials. (4) optical microscopy as it applies to the microstructure of materials, and (5)thermomechanical processing of metals with limited regions of solid solubility.

TEXTBOOK:

Fundamentals of Physical Metallurgy, John D. Verhoeven, John Wiley & Sons, New York, 1974.
Materials Science and Engineering: An Introduction, Seventh Edition, William D. Callister, John Wiley and Sons, 2003.

INSTRUCTOR:

Dr. Dana J. Medlin, Office Hours: 2:00-3:00 p.m. M-W-F

REQUIRED/ELECTIVE:

MET 330L is required for all B.S. Metallurgical Engineering Students

COURSE OBJECTIVES:

Professional level development of the relationship between microstructure structure of metals and alloys and mechanical & physical properties of materials. There is an emphasis on microstructural characterization and laboratory sessions where students create and evaluate various microstructures by heat treating and hot forging.

COURSE OUTCOMES:

- Given any binary phase diagram with any invariant reaction, the student can discuss the initial and final microstructure through drawings and words formed during solidification and/or solid-state invariant reactions. In addition students can compute the fraction of phases present at any specified temperature and alloy composition.
- Students will be able to identify microstructures in various steels, cast irons, aluminum alloys, and copper alloys.
- Students will be able to use phase diagrams, hardenability data, TTT curves, IT curves and other information to develop specific microstructures by heat treating and hot forging. Students will be able to metallographically prepare these samples and verify the microstructures and hardnesses. Some basic blacksmithing skills are required to complete portions of this work.
- Students are expected to derive the homogeneous nucleation model and relate this model to the heterogeneous spherical cap model of nucleation as they relate to the solidification of metals.
- Students will understand the subject of growth kinetics in the solid state. Specifically about mechanisms relating to diffusion controlled and interface controlled growth.
- Students will understand precipitation hardening of metal alloys. Given a phase diagram, students can discuss the possibility of precipitate formation by a three step (1) solution heat treatment, (2) quench and (3) aging process.
- Students will understand the crystallography of martensite formation and the difference between dislocated and twinned martensite. In addition, students will understand the volumetric changes, hardness and strength changes associated with these phase transformations.
- Students will understand the iron - carbon system, aluminum alloy systems, and copper alloy systems.
- Given the Iron - carbon phase diagram and a alloy composition, the student can sketch and discuss the equilibrium microstructure developed at any temperature. They will also be able to apply this to the aluminum copper phase diagram and explain solution annealing and precipitation strengthening.
- Given the TTT diagram for a steel alloy, the student can provide the cooling path for: Annealing, normalizing, austempering and martempering and sketch the resulting microstructure.

- Given the composition of a steel alloy and table of Hardenability Multiplying Factors, the student can compute the ideal critical diameter for a quenched bar as a function of the severity of quench.

TOPICS COVERED:

Labs Supporting MET 330 Lecture Content

- Manufacture binary solid solution alloy and eutectic alloys
  - Study microstructure as a function of the state of equilibrium
- Create microstructures based on fundamental materials data.
  - Heat treat and hot forge steel and aluminum alloy samples.
  - Evaluate the microstructures with metallography and hardness testing.
- Study properties of dislocation interacting with an interstitial atmosphere
  - Return of the yield point in low carbon steels
- Study Strain-rate dependence of the flow stress

Labs Supporting MET 332 Lecture Content

- Conduct complete heat treatment of a precipitation hardening aluminum alloy and measure tensile and hardness properties
- Conduct complete heat treatment of several steel alloys and measure the strengths and hardness peroperties.

CLASS SCHEDULE:

3 hours per week Tu, 1:00-3:50 p.m.

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (g)

LABORATORY:

The course laboratory parallels the lecture portion MET 330 and parts of MET 332, both in terms of objectives and topics covered. In addition, the laboratory stresses hands-on applications and a large technical communication component.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

Technical writing is emphasized requiring comprehensive reports on must topics covered in lecture/laboratory activities. All laboratory projects and technical writing exercises are conducted in a teaming environment.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Dana J. Medlin, March 23, 2010.

MET 332 THERMOMECHANICAL TREATMENTS

CATALOG DATA:

MET 332 THERMOMECHANICAL TREATMENTS (3-0) 3 credits. Prerequisite: Met 232 and concurrent registration in MET 320.
The relationship between the microstructure, crystal structure, and the properties of materials. Topics covered are the iron-carbon system, hardenability of iron base alloys, stainless steels, cast irons, aluminum, copper and magnesium. Concepts of heat treatment, age hardening, dispersion hardening, and hot and cold working correlated with the modification of the structure and physical and mechanical properties.

TEXTBOOK:

Structure and Properties of Engineering Alloys, Second Edition, William F. Smith, McGraw-Hill, 1993.

INSTRUCTOR:

Dr. Dana J. Medlin, Office Hours: 2:00-3:00 p.m. MWF

REQUIRED/ELECTIVE:

MET 332 is required for all B.S. Metallurgical Engineering students.

COURSE OBJECTIVES:

To study of the relationships between the crystal structure and the microstructure, and the physical and mechanical properties of materials and to achieve their control.

Calculation of free energies of solid solutions, quantitative prediction of solidification microstructures, homogenization and carburization of iron-based alloys, calculations of driving forces for homogeneous and heterogeneous nucleation, evaluation of casting defects, segregation and porosity, calculation of growth kinetics in diffusion and interface controlled transformations, evaluation of microstructure and strength of martensite, evaluation of microstructure and strength in precipitation hardening systems, evaluation of microstructure and strength in dispersion hardening systems, design of microstructures and thermomechanical treatments. Understanding similar processes in aluminum alloys, tool steels, aluminum alloys, copper alloys, titanium alloys, and nickel alloys.

COURSE OUTCOMES:

- Given any binary phase diagram with any invariant reaction, the student can discuss the initial and final microstructure through drawings and words formed during solidification and/or solid-state invariant reactions. In addition students can compute the fraction of phases present at any specified temperature and alloy composition.
- Students will understand the relationship between processing, microstructures, properties and performance of carbon steels, alloy steels, cast irons, aluminum alloys copper alloys, stainless steels, tool steels, titanium alloys, and nickel alloys.
- Students will understand the steel making process, ingot and continuous solidification processes, microstructures, heat treatments, mechanical processing, national and international alloy designations, and surface hardening processes.
- Students will understand basic technical terminology to specific alloy groups such as annealing, stress relief, normalizing, tempering, martempering, austempering, quenching, solution annealing, precipitation hardening, over aging, sensitization, work hardening, cold rolling, carburing, nitriding, etc.
- Students will understand diffusion topics such as homogenization and carburization. Several solutions to Fick’s second law are developed in class and used to solve engineering problems.
- Students will understand alloy steels and the affects of alloy composition on performance. In addition, students will understand how to use TTT curves, IT curves, hardenability data to design specific alloy thermo-mechanical processes.
- Students will understand the aluminum alloy designation system, aluminum refining processes, casting methods, work hardening operations, solution and aging treatments, and the affect of alloying on specific properties and processing.

- Students will know the stainless steel designation systems, types of stainless steels, thermo-mechanical processing methods, corrosion resistance issues, limitations, and processing cautions.
- Students will understand the above topics for cast irons, tool steels, copper alloys, titanium alloys and nickel based alloys.
- Students will be able to design and select alloys for specific engineering applications.

TOPICS COVERED:

- Binary phase diagrams
- Solidification of metals
- Nucleation and growth kinetics
- Precipitation Hardening
- Dispersion hardening
- Deformation twinning and martensite reactions
- The iron-carbon alloy system, aluminum alloy system, copper alloys system, titanium alloy system
- The processing of steels, aluminum alloys, tool steels, stainless steels, copper alloys, titanium alloys

CLASS SCHEDULE:

Lecture: 3 hours per week, 1:00-1:50 pm, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (c)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

The course concepts are applied to the design and manufacture of materials microstructures thermomechanical treatments and ranges of physical and mechanical properties.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:

Dana Medlin, March 23. 2010.

MET 351: METALLURGICAL ENGINEERING DESIGN I

CATALOG DATA:

MET 351 – METALLURGICAL ENGINEERING DESIGN I; (2-0) Credits
Prerequisites: Junior standing or graduation within five semesters, MET 220, MET 232
This course is the first semester of a two-course sequence in Junior Metallurgical Engineering Design that consist of both lectures and design practice sessions. The following topics are covered: Introduction to engineering design. Compare the scientific method with the engineering design method. Define the concept of need as it pertains to the design process. Develop skills associated with the use of modern and classical sources of information. Lectures on modeling and simulation, statistical process control, brainstorming, teaming, the creative process, economic evaluation, materials selection processes interaction of materials, and materials processing topics are presented. Focus on the design process, and the design method. The development of interdisciplinary teams is a high priority.

TEXTBOOK: (OPTIONAL)

Textbook: ENGINEERING DESIGN, A Materials and Processing Approach, George E. Dieter, McGraw-Hill Company, Third Edition, 2000.

INSTRUCTOR:

Dr. Stanley M. Howard
Office: MI 114
Office Hours: MWF 10:00 to 11:00
Phone: (605) 394-1282, Fax: (605) 394-3369, e-mail: Stanley.howard.sdsmt.edu

REQUIRED/ELECTIVE

MET 351 is required for all B.S. Metallurgical Engineering students

EXPECTATIONS:

The course focuses on the presentation of two hours per week of design lectures and on the development of Junior Mini Design Projects (JMDP) with vertical and horizontal integration of concepts from all areas of Metallurgical Engineering. The student is expected to put together the fundamental and applied knowledge acquired during the previous years of the engineering tenure. This means a comprehensive effort involving most of the components of real-world design projects. Specifically the student is expected to acquire a good working knowledge of:

- Principles of product and process design
- Problem solving skills
- Analysis skills on materials microstructure/property relationships
- Communication skills, both oral and written

COURSE OBJECTIVES:

The objectives of this course are to provide hands on practical experience on Metallurgical Engineering Design. Students develop their projects by working in interdisciplinary teams under the direction and supervision of one or more Faculty mentors. During the development of the course the students will demonstrate acquire skills to:

- Assessment of need
- Proposal preparation
- Definition of design requirements
- Gather information
- Conceptualize various solutions
- Evaluation of design concepts and select a candidate design
- Work in an interdisciplinary team environment
- Communicate the design effectively by written reports and oral presentations

CLASS SCHEDULE:

MET 351 classes will meet Mondays and Wednesdays 3:00-3:50 in MI 320 and MI 220. An exam in addition to an oral presentation and a written report on each JMDP are required.

TOPICS:

Orientation for the Design Sessions, Presentation and Discussion of the Design Program, Design Process and Projects, Literature Search , Brainstorming, Design of Experiments, Ethics, Creative Process, Process Analysis I, Junior Mini Design Projects.

COMPUTER USAGE:

As required by lectures and projects

COURSE OUTCOMES:

During this course students will demonstrate the ability to:

- Define the problem and establish the project specifications and constrains
- Gather information and establish the state of the art on the design science and technology
- Conceptualize various concept solutions to the design problem
- Use decision matrices for the selection of the candidate solution
- Establish the candidate design and the matrix of tasks needed to achieve this design
- Establish a project schedule
- Work effectively in a team environment
- Write progress and final design reports
- Make effective oral presentations

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (d), (e), (f), (g)

LABORATORY:

As required by projects

ASSESSMENT AND EVALUATION:

The course objectives are evaluated by the following methods:

- Written reports and oral presentations
- Self-assessment of Team Effectiveness

Student Performance is determined by the following methods:

- 15% Design Reviews
- 15% Design Fair/Review
- 15% Oral presentations
- 15% Written Reports
- 15% Professionalism
- 15% Progress Meeting Project Goals
- 10% Assessment Tool Performance and Participation (Team Assessment, Survey, and Exit Exam)

PREPARED BY:

Dr. Stanley M. Howard
Professor of Materials and Metallurgical Engineering

MET 352:METALLURGICAL ENGINEERING DESIGN II

CATALOG DATA:

MET 352 – METALLURGICAL ENGINEERING DESIGN I; 1 (1-0) Credits
Prerequisites: Junior standing or graduation within five semesters, MET 220, MET 232, MET 351. This course is the second semester of a two-course sequence in Junior Metallurgical Design that involve both lectures and design practice sessions. It is a continuation of MET 351. Topics are designed to incorporate engineering standards and realistic constrains, including most of the following considerations: economic, ethical, environmental and social. Focus on the design process, and the design method. The development of interdisciplinary teams is a high priority. The course integrates vertically and horizontally concepts from all areas of Metallurgical Engineering into a practical design project designed to train the students in the design practice. Fundamentals of the design process, specifications, decision-making, materials selection, materials process, experimental design, statistic process control and preliminary design are the focus. This course consists in the students playing the role of apprentices to design by teaming up with the interdisciplinary senior students in the senior capstone design projects.

TEXTBOOK:

Textbook: ENGINEERING DESIGN, a Materials and Processing Approach, George E. Dieter, McGraw-Hill Company, Third Edition, 2000.
Reference: THE ENGINEERING DESIGN PROCESS, Atila Ertas and Jesse C. Jones, John Wiley & Sons, Inc., 1993.

INSTRUCTOR:

Dr. Stanley M. Howard
Office: MI 114
Office Hours: MWF 10:00 to 11:00
Phone: (605) 394-1282, Fax: (605) 394-3369, e-mail: Stanley.howard.sdsmt.edu

EXPECTATIONS:

The course focuses on the development and completion of a Design Project with vertical and horizontal integration of concepts from all areas of Metallurgical Engineering. The students are expected to put together the fundamental and applied knowledge acquired during the previous years of the engineering tenure. This means a comprehensive effort involving most of the components of real-world industrial design projects. This means a comprehensive effort involving most of the components of real-world industrial design projects. Specifically the students are expected to have a good working knowledge of:

- Principles of product and process design
- Problem solving skills
- Analysis skills on materials microstructure/property relationships
- Communication skills, both oral and written
- Materials Design and Materials Manufacture

COURSE OBJECTIVES:

The objectives of this course are to provide hands on practical experience on Metallurgical Engineering Design. Students participate as apprentices to design in The Interdisciplinary Senior Capstone Design Projects (IDSCDP) by working in teams under the direction and supervision of one or more Faculty mentors. In addition Junior students have an opportunity to team up in Interdisciplinary Senior Capstone Design Projects were they play the role of apprentices to the design process. During the development of the course the students will demonstrate acquire skills to:

- Assessment of need
- Proposal preparation
- Definition of design requirements
- Gather information
- Conceptualize various solutions
- Evaluation of design concepts and select a candidate design
- Work in an interdisciplinary team environment
- Communicate the design effectively by written reports and oral presentations

CLASS SCHEDULE:

MET 352 classes will normally be scheduled Monday and Wednesday from 3:00-3:50 PM in MI 220; however much of the course work is performed in the various design laboratory staging areas throughout the MI Building and Foundry Laboratory.

TOPICS:

Students will play the role of apprentices to Design Interdisciplinary Junior/Senior Design Projects. Topics are designed to incorporate engineering standards and realistic constrains, including most of the following considerations: economic, ethical, environmental and social. Focus on the design process, and the design method. The development of interdisciplinary teams is a high priority.

COMPUTER USAGE:

As required by lectures and projects

COURSE OUTCOMES:

During this course students will demonstrate the ability to:

- Work effectively in a team environment
- Integrate knowledge, vertically and horizontal and apply analytical tools from a variety of courses.
- Develop and implement experimental plans to evaluate possible solutions.
- Produce archival design drawings
- Manage the project effectively by using a project schedule and other management tools.
- Develop and implement appropriate and detailed manufacturing plans.
- Write progress and final design reports, incorporating ethical, environmental and societal issues pertinent to the specific ISCDP.
- Make effective oral presentations incorporating in the discussion ethical, environmental and societal issues pertinent to the specific ISCDP.
- Test and Evaluate Prototype performance.

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (d), (e), (f), (g)

LABORATORY:

As required by projects

ASSESSMENT AND EVALUATION:

The course objectives are evaluated by the following methods:

- Written reports and oral presentations
- Self-assessment of Team Effectiveness

Student Performance is determined by the following methods:

- 15% Design Reviews
- 15% Design Fair/Review
- 15% Oral presentations
- 15% Written Reports
- 15% Professionalism
- 15% Progress Meeting Project Goals
- 10% Assessment Tool Performance and Participation (Team Assessment, Survey, and Exit Exam)

PREPARED BY:

Dr. Stanley M. Howard
Professor of Materials and Metallurgical Engineering

MET 422 TRANSPORT PHENOMENA

(4-0) 4 credits. Prerequisite: MATH 321 and concurrent enrollment in MET 320. The principles of momentum, heat and mass transfer and their application to metallurgical engineering. Topics covered include thermal conductivity, mass diffusion, mechanisms of transport, Fourier’s and Fick’s Laws, shell balance, boundary conditions, equations of change, unsteady-state transport, mass and heat distributions in turbulent flow, and interphase transport.

TEXTS

G. H. Geiger and D. R. Poirier, Transport Phenomena in Metallurgy, Addison-Wesley Publishing

INSTRUCTOR

Dr. S. M. Howard MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu Open Office Policy

REQUIRED/ELECTIVE

MET 422 is required for all B.S. Metallurgical Engineering. It is a required course for B.S. Environmental

COURSE OBJECTIVE

Students who satisfactorily complete this course will be able to determine velocity profiles in laminar flow systems, drag forces in turbulent flow systems, unsteady-state temperature profiles in isotropic simple solids, heat fluxes through boundary layers, net heat fluxes among gray surfaces from radiation, mass transfer rates across interphase boundaries.

COURSE INSTRUCTIONAL OUTCOMES

- Students are expected to write Newton’s Law, Fourier’s Law, and Fick’s Law and describe the analogies among them.
- Students will perform shell balances for momentum, heat, and mass transfer and obtain the differential equation describing the velocity, temperature, and concentration gradient.
- Students are expected to understand the difference between Newtonian and non-Newtonian flows.
- Students will be able to reduce the Equations of Continuity and Change for rectangular, cylindrical and spherical coordinates to the terms applicable for a specified condition.
- Students will be able to derive from linear, steady-state flow distributions in laminar flow volumetric and average flow equations.
- Students provided a set of independent variables upon which a dependent variable depends will reduce the set to a dimensionless set using Buckingham Pi Theory.
- Students will be able to design packed and fluidized beds for given system for uniform particles given their density, shape, and size and the fluid’s rheolgical properties.
- Students must determine the modes of heat transfer (conduction, convection, and radiation) and describe the governing equations for each mode.
- Students are expected to calculate the heat transfer rate for convective heat transfer given heat transfer correlation and its pertinent parameters.
- Students will determine heat loss from radiative systems using Kirchoff Loop electric analog solution method.
- Students will solve 1D USS and 2D SS heat transfer and mass transfer problems using spreadsheets.
- Students will determine the concentration dependency of diffusivity.
- Students will be able to derive differential equations describing diffusion through a stagnant gas film, a moving gas stream, and a falling liquid film.
- Students will describe the mathematical similarities between turbulent convective heat transfer and turbulent diffusion including the correspondence between dimensionless groups.

TOPICS

- Introduction to momentum, energy and mass transfer analogies between Newton's, Fourier's, and Fick's Laws (1)
- Theoretical and semi-empirical equations for viscosity of gases, liquids, and molten slags (3)
- Newtonian and non-Newtonian fluids (1)

- Laminar flow and momentum balances: flow of a falling film;flow through a circular tube (3)
- Equations of continuity: rectangular volume, arbitrary shape using vectors (3)
- Substantial time derivative; cf total and partial time derivatives (2)
- General equations of momentum transfer: Navier-Stokes, Euler equations (2)
- Applications of the general equation of motion: flow through a long vertical cylindrical duct
- Couette-Hatschek viscometer, creeping flow around a sphere; flow near the leading edge of a flat plate
- Dimensional analysis: Re, Fr numbers (1)
- Turbulent flow: time-smoothed quantities Interphase transport: friction factor (2)
- Flow through packed and fluidized beds (4)
- Theoretical and semi-empirical equations for thermal conductivity of fluid and solids (1)
- Heat conduction flat plates, cylinders through composite walls with generation (4)
- Heat transfer with forced and natural convection (4)
- Transient systems (4)
- Solidification heat transfer (2)
- Dimensional analysis: Nu, Gr numbers (1)
- Molar and mass flux Theoretical and semiempirical equations for diffusivity of gases, liquids and ionic species (3)
- Diffusion in solids of gas through thin film, concentration dependent diffusivity transient diffusion (3)
- Mass transfer in fluid systems diffusion through a stagnant gas film, diffusion in a moving gas stream, diffusion into a falling liquid film, forced convection (4)
- Dimensional analysis: Sh, Sc numbers (1)

CLASS SCHEDULE

11:00 – 11:50 MWF MI 222

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES

a) Apply Knowledge of Math, Science, and Engineering
b) Optimally Select Material and Design Materials Treatment and Production Processes
c) Identify, Formulate, and Solve Engineering Problems

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT

- This course prepares students in the basics of transport Phenomena and, therefore, provides students with the necessary basis to design, operate and optimize metallurgical processes.
- Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in engineering.

LABORATORY: None

ASSESSMENT AND EVALUATION

One Final Exam – required by all students
Three or Four Hour Exams
Homework

EXPECTATIONS

Metallurgical Thermodynamics
College Calculus, Chemistry, Physics

COMPUTER USAGE

- Excel
- VBA
- MathCad or MATLAB

PREPARED BY

S. M. Howard

MET 433 PROCESS CONTROL

CATALOG DATA:
MET 433 PROCESS CONTROL
(3-0) 3 credits.
Prerequisites: MATH 321 and senior standing.
Analysis and design of process control systems for industrial processes, including controller tuning and design of multivariable control schemes. This course is cross-listed with CBE 433.

TEXTBOOK:
"Principles and Practice of Automatic Process Control", C.A. Smith and A.B. Corripio, 3rd Ed, Wiley, 2006

INSTRUCTOR:
Jason C. Hower, EEP119, 394-2627 (w), Jason.Hower@sdsmt.edu
Office hours: 2:00-3:00pm MWF

EXPECTATIONS:
- Energy and material balances;
- Application of ordinary differential equations.

COURSE OBJECTIVES:
To provide students with a working knowledge required to understand and solve practical problems which require both process dynamic analysis, and basic process-control theory.

CLASS SCHEDULE:
12:00-12:50 pm MWF, C303

TOPICS:
- Dynamic process modeling in Laplace space
- Feedback control methods
- Control algorithms and tuning methods
- Feedforward and cascade control methods

COMPUTER USAGE:
Students are expected to use computer software (Excel, Polymath, EES, Maple) to assist in solving complicated equations involving numerical solutions, integration, and simple ODEs.

COURSE OUTCOMES:
After successful completion of this course a student is expected to be able to:
1. Model the dynamic behavior of physical processes and automatic control systems using algebraic and differential equations, and by using block diagrams representing the Laplace transforms of those equations.
2. Tune feedback controllers to produce a desired mode of response.
3. Identify and sketch graphs illustrating overdamped, critically damped, underdamped, undamped and unstable systems, and predict which response will occur based on the transfer functions describing a system.
4. Model complex process behavior using empirical first-order-plus-dead-time models, and tune automatic controllers based on those process models.
5. Illustrate control techniques and response modes using simulation software.
6. Explain advanced control techniques of feed-forward and cascade control using block diagrams, process and instrumentation diagrams, and time-domain graphs.
7. Explain and use concepts of statistical process including statistics of central tendency and variability, control charts, and hypothesis testing.

RELATION OF COURSE TO PROGRAM OUTCOMES: (a), (b), (c), (e), (g), and (k)

LABORATORY:
None

ASSESSMENT AND EVALUATION:
- Quizzes
- Homework
- Final Exam

PREPARED BY:
Jason Hower, March 12, 2010

MET 440/540 MECHANICAL METALLURGY

CATALOG DATA:
MET 440/540 MECHANICAL METALLURGY (3-0) 3 credits.
Prerequisite: Met 232and concurrent or completion in EM 217. A course concerned with the response of metals to loads. Areas covered include elastic and plastic deformation under different force systems, fracture, fatigue, creep, residual stresses, and general fundamentals of metal working. Students enrolled in MET 540 will be held to a higher standard than those enrolling in MET 440.

TEXTBOOK:
"Mechanical Metallurgy," by G. E. Dieter, McGraw Hill, Third Edition, 1986.

INSTRUCTOR:
Dr. Dana J. Medlin, Office Hours: 3:00-4:00 p.m. MWF

REQUIRED/ELECTIVE:
MET 440 is required for all B.S. Metallurgical Engineering students.

COURSE OBJECTIVES:
To rationalize, predict, control and change the response of metals and alloys to forces and loads in order to prevent failure, and control plastic flow (deformation processing).
Determine the state of stress using Mohr's circle, calculation of elastic stresses from elastic strains, stress distribution and stress concentration in mechanical components, strength theories for ductile and brittle materials, yield surfaces and yield envelops, calculation of final dimensions and final state of stress in mechanical components, design with linear elastic and elastic-plastic fracture mechanics, design for fatigue in structural components, determine stress concentrations and basic fracture mechanics, design for creep in structural components.

COURSE OUTCOMES:
- Graphical and analytical determination of a state of stress in mechanical components. Vector and tensor representation in different system of axis. Calculation of elastic stresses from elastic strains and elastic stress/strain relationships.
- Stress distribution and stress concentration in mechanical components.
- Strength theories for design in brittle and ductile materials. Yield surfaces and yield envelops.
- Given the original dimensions of a mechanical component and the original tridimensional state of stress, calculate the final dimensions and the final state of stress in the mechanical component.
- Calculation in engineering materials of the: (a) theoretical cohesive tensile strength, (b) cohesive tensile strength from the stress concentration point of view, establishment of the fracture stress by the Griffith's equations and (d) establishment of the fracture stress by the Griffith-Orowan equations.
- Measurement of the fracture toughness of engineering materials: Plane strain, COD, CTOD, J integral and R curves. Calculation of plasticity corrections.
- Calculation of dimensions, failure stresses and failure envelopes in mechanical components using linear elastic fracture mechanics and fracture theories for design.
- Criteria for the fatigue design of mechanical components including fatigue crack initiation and fatigue crack propagation. Calculation of the dimensions and fatigue life of mechanical components under specific fatigue parameters.
- Establishment of creep mechanisms and plotting of creep data for engineering design. Working knowledge of creep deformation maps.
- Calculation of constants in creep equations, creep stresses and life time, in the creep design of engineering components.
- Introduction to the methodologies for evaluating failure analysis of metallic components.
- Calculation of stress intensity factors, strain energy release rates, fracture toughness, plane strain toughness testing methods, and toughness of materials.

TOPICS COVERED:
- Introduction (Mechanical Behavior under 1D Stress)
- Macroscopic theory of elasticity
- Macroscopic theory of plasticity
- Strengthening mechanisms

- Fracture
- Fracture mechanics
- Fatigue of metals
- Creep and stress rupture
- Brittle fracture and impact testing

CLASS SCHEDULE:
Lecture: 3 hours per week, 8:00-8:50 am, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (b), (c), (e), (g), (k)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
The course concepts are applied to the design and manufacture of materials and structural components in order to prevent failure and control plastic flow in deformation processing.
Ethical practice is a frequent discussion item in MET 440, specifically, the role engineer's play in sound manufacture of materials and structural components.

PREPARED BY:
Dana Medlin, March 23, 2010.

MET 464: METALLURGICAL ENGINEERING DESIGN III

CATALOG DATA:

MET 464 – METALLURGICAL ENGINEERING DESIGN III; (0-2) Credits
Prerequisites: Senior standing or graduation within three semesters, MET 351, MET352
This course is the first semester of a two-course sequence in Interdisciplinary Senior Capstone Design Project (ISCDP) that involve both lecture and design practice sessions. The course integrates vertically and horizontally concepts from all areas of Metallurgical Engineering into a practical senior capstone design project design to train the students in the design practice. Fundamentals of the design process, specifications, decision-making, materials selection, materials process, experimental design, statistic process control and preliminary design are the focus. The major part of this course consists in the development of the senior capstone design project.

TEXTBOOK: (OPTIONAL)

Textbook: ENGINEERING DESIGN, A Materials and Processing Approach, George E. Dieter, McGraw-Hill Company, Third Edition, 2000.

INSTRUCTOR:

Dr. Stanley M. Howard
Office: MI 114
Office Hours: MWF 10:00 to 11:00
Phone: (605) 394-1282, Fax: (605) 394-3369, e-mail: Stanley.howard.sdsmt.edu

EXPECTATIONS:

The course focuses on the development and completion of Interdisciplinary Senior Capstone Design Projects (ISCDPs) with vertical and horizontal integration of concepts from all areas of Metallurgical Engineering. The students are expected to put together the fundamental and applied knowledge acquired during the previous years of the engineering tenure. This means a comprehensive effort involving most of the components of real-world industrial design projects. Specifically the students are expected to have a good working knowledge of:

- Principles of product and process design
- Problem solving skills
- Analysis skills on materials microstructure/property relationships
- Communication skills, both oral and written
- Materials design and materials manufacture

Both a Preliminary and Final Design Review will be required as part of the combined MET 464/465 sequence. Monthly oral presentation and written summary progress reports are required. Students will present Monthly Oral Report Presentation and submit Monthly Written Reports.

COURSE OBJECTIVES:

The objectives of this course are to provide hands on practical experience on Metallurgical Engineering Design. Students develop their projects by working in interdisciplinary teams under the direction and supervision of various faculty mentors from various departments as appropriate. During the development of the course the students will engage in the following activities:

- Assessment of need
- Definition of design requirements
- Gather information
- Conceptualize various solutions
- Evaluation of design concepts and select a candidate design
- Work in an interdisciplinary team environment
- Communicate the design effectively by written reports and oral presentations

CLASS SCHEDULE:

MET 464 classes will normally be scheduled Monday and Wednesday from 3:00-3:50 PM in MI 220; however much of the course work is performed in the various design laboratory staging areas throughout the MI Building and Foundry Laboratory.

TOPICS:

Interdisciplinary Senior Capstone Design Projects

COMPUTER USAGE:

As required by projects

COURSE OUTCOMES:

During this course students will demonstrate the ability to:

- Work effectively in a team environment
- Integrate knowledge, vertically and horizontal and apply analytical tools from a variety of courses.
- Develop and implement experimental plans to evaluate possible solutions.
- Produce archival design drawings
- Manage the project effectively by using a project schedule and other management tools.
- Develop and implement appropriate and detailed manufacturing plans.
- Write progress and final design reports, incorporating ethical, environmental and societal issues pertinent to the specific ISCDP.
- Make effective oral presentations incorporating in the discussion ethical, environmental and societal issues pertinent to the specific ISCDP.
- Test and Evaluate Prototype performance.

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (c), (d), (e), (f), (g), (h)

LABORATORY:

As required by projects

ASSESSMENT AND EVALUATION:

The course objectives are evaluated by the following methods:

- Written reports and oral presentations
- Self-assessment of Team Effectiveness

Student Performance is determined by the following methods:

- 15% Design Reviews
- 15% Design Fair/Review
- 20% Oral presentations
- 20% Written Reports
- 15% Professionalism
- 15% Progress Meeting Project Goals

PREPARED BY:

Dr. Stanley M. Howard
Professor of Materials and Metallurgical Engineering

MET 465:METALLURGICAL ENGINEERING DESIGN IV

CATALOG DATA:

MET 465 – METALLURGICAL ENGINEERING DESIGN IV; 1(0-1) Credits
Prerequisites: Senior standing or graduation within three semesters, MET 351, MET352, MET 465. This course is the second semester of a two-course sequence in Interdisciplinary Senior Capstone Design Project (ISCDP) that involves design practice sessions. It is the continuation of MET 464. The course integrates vertically and horizontally concepts from all areas of Metallurgical Engineering into a practical senior capstone design project design to train the students in the design practice. Fundamentals of the design process, specifications, decision-making, materials selection, materials process, experimental design, statistic process control and preliminary design are the focus. This course consists in the development and completion of the senior capstone design project.

TEXTBOOK: (OPTIONAL)

Textbook: ENGINEERING DESIGN, a Materials and Processing Approach, George E. Dieter, McGraw-Hill Company, Third Edition, 2000.
Reference: THE ENGINEERING DESIGN PROCESS, Atila Ertas and Jesse C. Jones, John Wiley & Sons, Inc., 1993.

INSTRUCTOR:

Dr. Stanley M. Howard
Office: MI 114
Office Hours: MWF 10:00 to 11:00
Phone: (605) 394-1282, Fax: (605) 394-3369, e-mail: Stanley.howard.sdsmt.edu

EXPECTATIONS:

The course focuses on the development and completion of Interdisciplinary Senior Capstone Design Projects (ISCDPs) with vertical and horizontal integration of concepts from all areas of Metallurgical Engineering. The students are expected to put together the fundamental and applied knowledge acquired during the previous years of the engineering tenure. This means a comprehensive effort involving most of the components of real-world industrial design projects. Specifically the students are expected to have a good working knowledge of:

- Business practices
- Entrepreneurialism
- Ethical practice and industrial safety
- Principles of product and process design
- Problem solving skills
- Analysis skills on materials microstructure/property relationships
- Communication skills, both oral and written
- Materials design and materials manufacture

Both a Preliminary and Final Design Review will be required as part of the combined MET 464/465 sequence. Monthly oral presentation and written summary progress reports are required. Students will participate in the Annual Design Fair, present a Final Oral Report Presentation, and submit a Final Written Report.

COURSE OBJECTIVES:

The objectives of this course are to provide hands on practical experience on Metallurgical Engineering Design. Students develop their projects by working in interdisciplinary teams under the direction and supervision of various faculty mentors from various departments as appropriate. During the development of the course the students will engage in the following activities:

- Assessment of need
- Definition of design requirements
- Gather information
- Conceptualize various solutions
- Evaluation of design concepts and select a candidate design
- Work in an interdisciplinary team environment
- Communicate the design effectively by written reports and oral presentations

CLASS SCHEDULE:

MET 465 classes will normally be scheduled Monday and Wednesday from 3:00-3:50 PM in MI 220; however much of the course work is performed in the various design laboratory staging areas throughout the MI Building and Foundry Laboratory.

TOPICS:

Interdisciplinary Senior Capstone Design Projects

COMPUTER USAGE:

As required by projects

COURSE OUTCOMES:

During this course students will demonstrate the ability to:

- Work effectively in a team environment
- Integrate knowledge, vertically and horizontal and apply analytical tools from a variety of courses.
- Develop and implement experimental plans to evaluate possible solutions.
- Produce archival design drawings
- Manage the project effectively by using a project schedule and other management tools.
- Develop and implement appropriate and detailed manufacturing plans.
- Write progress and final design reports, incorporating ethical, environmental and societal issues pertinent to the specific ISCDP.
- Make effective oral presentations incorporating in the discussion ethical, environmental and societal issues pertinent to the specific ISCDP.
- Test and Evaluate Prototype performance.

RELATIONSHIPS OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (c), (d), (e), (f), (g), (h)

ASSESSMENT AND EVALUATION:

The course objectives are evaluated by the following methods:

- Written reports and oral presentations
- Graduating Senior Exit exam
- Graduating Senior survey
- Self-assessment of Team Effectiveness

Student Performance is determined by the following methods:

- 15% Design Reviews
- 15% Design Fair/Review
- 15% Oral presentations
- 15% Written Reports
- 15% Professionalism
- 15% Progress Meeting Project Goals
- 10% Assessment Tool Performance and Participation (Team Assessment, Survey, and Exit Exam)

PREPARED BY:

Dr. Stanley M. Howard
Professor of Materials and Metallurgical Engineering

Metallurgical Engineering Elective Courses

MET 426/526	Steelmaking
MET 430/430L	Weld. Engr. & Design of Welded Struct.
MET 443	Composite Materials
MET 450/550	Forensic Engineering
MET 455/545	Oxidation and Corrosion of Metals

MET 426/526 STEELMAKING

(3-0) 3 credits. Prerequisites: MET 320 or graduate standing. Chemical reactions and heat and mass transport phenomena associated with the production of steel. Unit operations studied include the blast furnace, the basic oxygen furnace, the electric arc furnace, and selected direct reduction processes. Students enrolling in MET 526 will be held to a higher standard than those enrolling in MET 426.

TEXTBOOK:

The Making Shaping & Treating of Steel (Steelmaking and Refining Volume)11th ed., Iron & Steel Institute, Pittsburgh. http://www.steelfoundation.org/publications/msts.htm Stock Number R34, $95.

INSTRUCTOR:

Dr. S. M. Howard	MI 114 Ph. 394 -1282
Stanley.howard@sdsmt.edu	Open Office Policy

REQUIRED/ELECTIVE:

MET 326/526 is an elective course

COURSE OBJECTIVE:

Students who satisfactorily complete this course will be able to perform the thermochemical computations and analyses needed for iron and steel production.

COURSE OUTCOMES:

TOPICS

- Overview of Steel Industry (2 class)
- History, Integrated Mills, Mini Mills, Direct Reduction Plants
- Solution Thermodynamics (7 classes)
- Alternative Standard States(1 wt % Standard State), Interaction Coefficients
- Reduction Processes (7 classes)
- Oxygen Potential, Ellingham Diagrams, Blast Furnace, Kinetic Studies
- Refining Processes & Principles (10 classes)
- Impurity Treayment, Oxidation Potential, Basic Oxygen Furnace, Alternative Methods
- Deoxidation (3 classes)
- Deoxidant Addition, Sparging, vacuum
- Mini Mill Processing (3 classes)
- Tramp Elements, Ladle Metallurgy, Quality
- Direct Reduction Processes (3 classes)
- Tramp Elements, Ladle Metallurgy, Quality
- Specialty Steels (3 classes)
- Stainless Steel, AOD Process
- Continuous Casting (2 classes)
- Carburization (3 classes)
- Tests (3 classes)

CLASS SCHEDULE:

12:00 - 12:50 MWF MI 320

RELATION OF COURSE OUTCOMES TO PROGRAM OUTCOMES: (a), (e)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

This course contributes to the one and one-half years of engineering topics consisting of engineering sciences

LABORATORY:
None

ASSESSMENT AND EVALUATION:
One Final Exam – required by all students
Three Hour Exams
Homework

EXPECTATIONS:
College Calculus, Chemistry, Physics, Metallurgical Thermodynamics

COMPUTER USAGE
Intermediate Excel

PREPARED BY
S. M. Howard, 6/2010

MET 430/430L PHYSICS OF METALS

CATALOG DATA:

MET 430/430L WELDING ENGINEERING AND DESIGN OF WELDED STRUCTURES (2-1) 3 credits. Introduces the state-of-art in welding processes and technology. Discusses fundamentals of the fabrication welded structures by introducing basics of solidification in welds, metallurgy of welds, fatigue and fracture in welds, joint design and weld defects and inspection. Laboratory exercises will focus on advanced welding processes, characterization, and materials testing methods.

TEXTBOOK:

The Procedure Handbook of Arc Welding, 14th ed., James F. Lincoln Arc Welding Foundation, 1994.

INSTRUCTOR:

Dr. Michael West, Office Hours: 11:00-11:50 a.m. M, W, F

REQUIRED/ELECTIVE:

This course is technical elective for B.S. Metallurgical Engineering students and for B.S. Mechanical Engineering students.

COURSE OBJECTIVES:

The objective of this course is to provide students a working knowledge in welding processes and welding safety. Students will understand the affect of welding on the properties of metal alloys. Students will understand the differences between major solid state and fusion welding processes. Students will be able to select an appropriate welding process given a material. Students will understand the concept of "weldability" and will be able to select between different metal alloys that need to be joined. Students will become familiar with appropriate standards which govern welding processes.

COURSE OUTCOMES:

- Given a fusion welding process for aluminum alloys, students will be able to select an alloy to avoid hot cracking in welds.
- Given geometry and type of steel alloy, students will be able to determine welding parameters to avoid cold cracking.
- Given the thermal history for a fusion weld or solid state weld, students will be able to predict the microstructure in weld and heat-affected zones in steel and aluminum alloys.
- Students will understand the nature of segregation in fusion welds.
- Students will be able to appropriately size butt and fillet welds for required loading on a welded structure.
- Students will be able to choose an appropriate non-destructive evaluation method to detect defects in a welded structure.
- Students will be able to locate appropriate standards which govern welding processes.

TOPICS COVERED:

- Overview and classification of welding processes
- Fusion and non-fusion welding
- Flow of heat in welds
- Solidification theory basics
- Nature of residual stresses, shrinkage and distortion
- Review of metallurgy of steel, aluminum
- Review of microstructure development as a function of temperature

- Microstructure of the heat affected zone
- Nature of welding discontinuities/defects
- Weldability issues
- Welded joint design
- Introduction to fracture and fatigue in welded joints
- Corrosion in welds
- Inspection of welds

CLASS SCHEDULE:
3 hours per week, MWF 8:00-8:50 AM (even years)

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES:
(a), (b), (f), (k)

LECTURE:
The course consists of a lecture portion that parallels the lab both in terms of objectives and topics covered.

LABORATORY:
In the laboratory section, students are instructed in proper welding safety. The laboratory section is designed to introduce students to welding processes through a number of hands-on activities. Written reports are required.
Laboratory topics include:

- Gas Welding/Cutting
- GMA Welding
- GTA Welding
- Laser Welding
- Ultrasonic Welding
- Friction Stir Welding

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:

- The course and provides students with the necessary basis to design materials joining processing techniques including selecting between materials and available welding processes.
- The course prepares students to work with appropriate standards and codes within the engineering discipline.
- The course contributes to the design component. Student teams design their own weld evaluation project that involves making welds using a welding process, mechanical testing, and metallurgical evaluation.

ASSESSMENT AND EVALUATION
Two Hour Exams
One Mid-term Research Paper
One Weld Evaluation Design Project
Homework
Five Technical Lab Reports
One Final Exam

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Michael West, April 18, 2010

MET 443 COMPOSITE MATERIALS

CATALOG DATA:
MET 443 COMPOSITE MATERIALS (3-0) 3 credits. Prerequisites: ME 316 or concurrent enrollment in MET 440. The course will cover heterogeneous material systems; basic design concepts and preparation; types of composite materials; advances in filaments, fibers and matrices; physical and mechanical properties; failure modes; thermal and dynamic effects; and applications to construction, transportation and communication. This course is cross-listed with ME 443.

TEXTBOOK:
Engineering Mechanics of Composite Materials, 2nd Edition, Daniel and Ishai, Oxford 2006

INSTRUCTORS:
Dr. Jon J. Kellar, Office Hours: 2-3 pm M, Tu, W, Th
Dr. Lidvin Kjerengtroen, Office Hours, 2-3 pm M, Tu, W, Th

REQUIRED/ELECTIVE:
MET 443 is a Directed Technical Elective for B.S. Metallurgical Engineering students.

COURSE OBJECTIVE:
Students will be able to determine the effects of mechanics and materials chemistry on composite performance.

COURSE OUTCOMES:

- Given a particular matrix/reinforcement combination students will be able to identify a manufacturing process to produce a desired composite part.
- Given one of the major fibrous reinforcements the students will be able to describe the design, manufacturing and properties of advanced fibers.
- For a given matrix/reinforcement systems students will be able to determine the role of interfaces and interface phases and their properties in the design, manufacture and properties of PMCs, MMCs and CMCs.
- For a given matrix/reinforcement system student will be able to predict the microstructural properties (stiffness, strength, fracture toughness and fatigue).
- For a given composite system the student will be able to describe the fundamental properties/parameters such as anisotropic, orthotropic, and non-homogenous material behavior.
- For a given composite system the student will be able to carry out two dimensional transformations of stress, strain, and directional elastic parameters.
- For a given set of constituent properties the student will be able to estimate laminate material properties including laminate properties and strength estimates using common failure criteria.
- Given a laminate system the student will have basic understanding of the assumptions of laminate behavior and the significance of laminate stacking order.

TOPICS COVERED:
- Fibers

- Fibers and Whiskers and Nanocomposites
- Reinforcement/Matrix Interface
- Interfaces-Wettability
- Interfaces-Bonding
- The Interphase Methods for Measuring Bond Strength
- Polymer Matrices
- Polymer Matrix Composite Processing
- Polymer Matrix Composite Interfaces/Interphases
- Structure, Properties and Applications of PMCs
- Elastic behavior of composite lamina-Micromechanics
    - Basic concepts including RVE
    - Stiffness
    - Thermal and moisture expansion
    - Lamina Strength
- Ply Mechanics
    - Coordinate systems
    - Stress, strain, and constitutive relationships
    - Off-axis Stiffness and properties
- Macro Mechanics
    - Basic assumptions of laminates
    - Computation of stress
    - Common laminate types: symmetric, balanced, and quasi-isotropic, and specially orthotropic
    - Carpet plots
- Failure and Strength
    - Tsai-Hill
    - Tsai-Wu
    - Maximum Strain Criterion

CLASS SCHEDULE:
Lecture: 3 hours per week, 1:00-1:50 am, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (c)

LABORATORY:
There is no associated laboratory with this course.

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basics of materials selection and design.

Ethical practice is a frequent discussion item in MET 443, specifically, the role engineer's play in selection of materials for critical applications such as defense, crash protection and aerospace.

One major design report is a required part of this course.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Jon Kellar and Lidvin Kjerengtroen, May 6, 2010

MET/CHE/ME/ENVE 445/545. OXIDATION AND CORROSION OF METALS

CATOLOG DATA:

MET45/545 OXIDATION AND CORROSION OF METALS (3-0) 3 credits. Prerequisites. MET 320 or CHE 222 or ME 311 or graduate standing. Initially the thermodynamics of electrochemical processes are covered; use of the Nernst Equation and Pourbaix diagram is presented in this material. Fundamentals of electrode kinetics are then discussed with special emphasis on the derivation of the Butler-Volmer equation and application of the Evan's diagram. Following presentation of these fundamental concepts, phenomena observed in corrosion and oxidation such as uniform attack, pitting, stress corrosion cracking, and corrosion fatigue are discussed. Finally, selection of materials for site specific applications is covered. Students enrolled in Met 545 will be held to a higher standard than those enrolling in Met 445. This course is cross-listed with ENVE 445/545, CHE 445/545, ME 445/545.

TEXT BOOK:

Denny Jones, "Principles and Prevention of Corrosion" Second Edition, Prentice Hall, 1996.

INSTRUCTOR:

Dr. Dana J. Medlin, Office Hours: 3:00-4:00 p.m. MWF

REQUIRED/ELECTIVE:

MET 445/545 is an elective course to students pursuing for a B.S. or an M.S. degree in Metallurgical, Chemical, Mechanical and Environmental Engineering. Students taking the course under 545 are required to carry out additional work worthy for graduate standing.

COURSE OBJECTIVES:

The objective of this course is to provide students with the working knowledge required to understand the principles governing oxidation and corrosion of metals and other materials. Students are also able to analyze various corrosion problems. Identify the corrosion mechanism, and prevent or minimize oxidation of corrosion of metals and alloys.

COURSE OUTCOMES

- Students will be able to understand what oxidation, reduction, anodic and cathodic reactions are in relation to corrosion of metals and alloys.
- Students will be able to obtain the EMF values from the free energy information and vice versa.
- Students will be able to understand the effect of ionic activity on EMF and obtain the activity coefficient for ionic species if concentration is given.
- Students will be able to understand origin of galvanic corrosion and its practical implication.
- Students will be able to understand what passivation is and how this property is used in practice to prevent or minimize corrosion of various metals and alloys.
- Students will be familiar with how complexing agents affect the corrosion behavior.
- Students will be able to understand how to construct and use the Pourbaix diagram for simple systems and how it is used in relation to metal corrosion.
- Students will be able to apply the role of various ingredients in alloy systems in corrosion prevention.

- Students will be able to apply various corrosion mechanisms and their preventive measures to practical systems.
- Students will be familiar with basic corrosion testing procedures for typical systems.
- Students will be familiar with various materials used in corrosion related areas and to know how to select right materials for various corrosive media.
- Students will be able to select various metals, alloys and other materials used in corrosion applications.
- Students will be able to understand the major differences between wet and dry corrosion situations and know important variables affecting dry corrosion.

TOPICS COVERED:
- Introduction
- Electrochemical aspects of corrosion cell potentials; Electromotive force; Ionic activity; Steps involved in corrosion; Cell polarization
- Stability of ions, metals and alloys; Pourbaix Eh-pH diagrams;
- Stability of ions in solutions
- Different forms of corrosion; Galvanic, Erosion, Crevice, Pitting, Selective leaching, Intergranular corrosion, Stress corrosion
- Corrosion testing; Classification, Purposes; Surface preparation; Duration
- Material selection; Metals, Alloys; Thermoplastics; Coatings
- Effect of mineral acids; Sulfuric acid, Nitric acid; Hydrochloric acid
- High temperature corrosion; Mechanisms and kinetics
- High temperature materials

CLASS SCHEDULE:
3 hour lectures: 12 to 12:50 p.m. MWF.

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a)
Taking this course will help students to fulfill the following aspects of the expected program outcomes.
- Knowledge and skills required for a successful careers in metallurgical engineering
- Fundamental and practical knowledge required to meet societal needs through science and technology
- Tools for continued professional and personal development
- Critical reasoning, team, and effective written and oral communication skills
- Professional ethics foundation and awareness
- Commitment to professional and community activities

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basic and applied knowledge in corrosion mechanisms and preventative measures.
Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in the field of corrosion and oxidation metals and alloys.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Dana J. Medlin, March 23, 2010.

MET 450/550 Forensic Engineering

CATALOG DATA:
MET 450/550 FORENSIC ENGINEERING
(3-0) 3 credits. Prerequisites: MET 231, MET 232, EM 321 or ME 216, or permission of instructor. The principles of physical metallurgy, mechanical metallurgy, manufacturing processes, and service environments will be used to determine the cause(s) for failure of metallic, composite, and polymer engineering components. Analytical techniques and procedures to characterize fractographic features and microstructures will also be reviewed, such as optical metallography, macrophotography, and scanning electron microscopy. Actual failed engineering components from a variety of industrial applications will be used as examples and be evaluated in the course. Fundamental engineering concepts, legal procedures of forensic engineering, failure mechanisms, technical report writing, and remedial recommendations will also be discussed. Students enrolled in MET 550 will be held to a higher standard than those enrolled in MET 450.

TEXTBOOK:
"Failure Analysis of Engineering Materials" C.R. Brooks and A. Choudhury, McGraw-Hill, 2002. (required)
INSTRUCTOR:
Dr. Dana J. Medlin, Office Hours: 3:00-4:00 p.m. MWF

REQUIRED/ELECTIVE:
MET 450 is an elective course for B.S. Metallurgical Engineering and Mechanical Engineering students. Students taking this course for 550 credit are required to perform additional work.

COURSE OBJECTIVES:
The objective of this course is to cover both the methods of forensic engineering and the science of common modes of failure in engineering systems (failure analysis). This includes examination of case studies related to equipment analysis and system design failures, and accidents that derived from errors and omissions in the engineering process. In addition, we will cover the topic of "warnings" and "failure to warn" on engineering systems. We will also introduce methodology of forensic engineering from initial on-site investigation to final report and possible testimony as an expert witness.
COURSE OUTCOMES:

- Understand and implement the approach (methodology) of failure analysis to fractured materials.
- Understand the application of optical microscopy, stereomicroscopy, SEM, and other related techniques in the analysis of failed components.
- Be able to prepare and preserve fractured samples, clean samples for proper evaluation, and document samples future evaluation.
- Apply the mechanical aspects and macroscopic fracture surface orientation to failed components. This includes tensile testing, principle stresses, stress concentrations, plane stress, plane strain, strain rate, temperature, crack propagation, and fracture mechanics.
- Be able to identify fracture modes including ductile, brittle, and fatigue failures. This includes understanding the macroscopic features and characteristics.

- Be able to identify and explain the microscopic features and characteristics of fracture surfaces such as cleavage, river patterns, microvoid coalescence, quasicleavage, intergranular, striations, etc.
- Understand the application of governmental and industrial standards to failures and how to apply them to failure analysis.
- Review a variety of case studies in a forensic engineering analysis.
- Understand the basic legal issues involved with forensic engineering and the role of an engineer in the process.
- Understand the importance, purpose and legal issues associated with warnings and safety systems in mechanical devices.
- Be able to write a comprehensive forensic engineering report on an actual failed component including testing data and analysis.

TOPICS COVERED:

- Overview of Ductile, Brittle and Fatigue Failures
- Approach to Failure Analysis
- Mechanical Aspects of Failures
- Macroscopic Aspects of Failures
- Fracture Modes and Features
- Residual Stresses: heat treatment, thermal, mechanical, chemical, etc.
- Other Failures Modes: wear, corrosion, elevated temperature, etc.
- Fracture Mechanics: stress state, stress concentrations factors, cycles, predictions, etc.
- Warnings: purpose, requirements, logic, legal issues, failure to warn, etc.
- Report Writing: content, style, terminology, etc.
- Legal Issues: liability, terminology, lawyers, requirements, etc.
- Electronic Failures
- Case Studies: numerous case studies will be reviewed during the semester

CLASS SCHEDULE:
Lecture: 3 hours per week, 13:00-13:50 am, MWF

RELATIONSHIP OF COURSE TO PROGRAM OUTCOMES: (a), (b), (c), (e), (g), (k)

CONTRIBUTION OF COURSE TO MEETING THE PROFESSIONAL COMPONENT:
This course prepares students in the basic and applied knowledge of failure analysis of mechanical components used in engineering systems.
Ethical and professional conducts are emphasized throughout the course and also emphasized is global awareness in the field of metallurgical engineering.

PERSON WHO PREPARED THIS DESCRIPTION AND DATE OF PREPARATION:
Dana Medlin, March 23, 2010.

Other Required Engineering Courses

EE 301	Intro Circuits, Machines, Sys
EM 214	Statics
EM 321	Mechanics of Materials
ME 216	Intro to Solid Mechanics
IENG 301	Basic Engineering Economics

EE301/301L – Introductory Circuits, Machines and Systems

Spring Semester 2010
Elective/ Required Course
Catalog Data: (3-1) 4 credits. Prerequisite: Math 125 completed with a "C-" or better, and Math321 completed or concurrent. Not for majors in electrical engineering or computer engineering. Introduces the essential concepts of electrical engineering concerning circuits, machines, electronics, and systems.

Prerequisites: Math 125 completed and Math 321 Completed or concurrent:

Course Web Page: http://sdmines.sdsmt.edu/sdsmt/directory/courses/2010sp/ee301/301LM001

Textbook: *Principles and Applications of Electrical Engineering*, (5th ed.). Rizzoni, 2005.

Instructor: Elaine Linde EP 316 x5196 elaine.linde@sdsmt.edu

Office Hours: TBD, check schedule posted outside office

Lecture: Section 01 MWF 11:00-11:50 EP 254
Lab: Sections 51/52/53 Th 8:00-9:50/10:00-11:50/12:00-1:50 EP 342

Goals:

The objective of this course is to provide non-electrical engineering students with a solid understanding of circuit analysis as well as overview knowledge of a wide range of electrical engineering topics. The laboratory instruction is used to link theoretical concepts with experimental results as well as gaining ability to use electrical engineering laboratory equipment.

Tentative Grading:

Exams (30%), Final Exam (25%), Weekly Quizzes (15%), Lab Projects (10%), Homework (10%), Lab Exam (10%)

Topics:

- Fundamentals of Electric Circuits.
- DC Analysis Techniques
- AC Circuit Analysis
- Transient Analysis
- Frequency Analysis
- Semiconductors
- Digital Logic
- Electrical Machines and AC Power

Laboratory projects: Projects involving topic areas listed above. Includes instruction on basic equipment such as DMM's, power supplies, function generators, and oscilloscopes

OUTCOMES:

Upon completion of this course, students should demonstrate the ability to:

1. Apply the fundamentals of electric circuits including Ohm's Law, Kirchhoff's Current and Voltage Laws, and voltage and current division to analyze and build circuits.
2. Use DC circuit analysis techniques such as node analysis, mesh analysis, and Norton and Thevenin equivalent circuits to solve for circuit parameters.
3. Extend DC analysis techniques to AC networks using phasor notation and conversion of time domain sinusoidal voltages and currents..

4. Identify the characteristics of first and second order transients.
5. Have an awareness of the advantages of using the frequency domain by way of Bode plot, Fourier series and filtering..
6. Use the basic operation and applications of operational amplifiers including inverting, non-inverting, summing, differential amplifiers using ideal analysis and the limitations of real op-amps..
7. Be familiar with the basic operation and applications of semiconductor devices such as diodes, LED's, and BJT transistors.
8. Be familiar with the basic operation of digital logic gates and their application and link to other technologies (PLC, microcontrollers).
9. Have an awareness of electric machines and AC power and their uses.
10. Use basic laboratory measurement equipment including the power supplies, digital multimeters, function generators, and oscilloscopes to conduct experiments..

RELATION OF COURSE TO PROGRAM OBJECTIVES:

These course outcomes fulfill the following program objectives:

(a) An ability to apply knowledge of mathematics, science, and engineering.
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.
(c) An ability to design a system, component, or process to meet desired needs.
(d) An ability to function on multi-disciplinary teams.
(e) An ability to identify, formulate, and solve engineering problems.
(f) An understanding of professional and ethical responsibility.
(g) An ability to communicate effectively.
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context.
(i) A recognition of the need for, and an ability to engage in life-long learning.
(j) A knowledge of contemporary issues.
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The following table indicates the relative strengths of each course outcome in addressing the program objectives listed above (on a scale of 1 to 4 where 4 indicates a strong emphasis).

Objectives \ Outcomes	1	2	3	4	5	6	7	8	9	10
(a)	4	4	4	4	4	3	3	2	2	4
(b)	2	2	2	2	2	2	2	1		4
(c)	1	1	1	2	3	3	1	1	1	2
(d)	2	2	2	1	1					
(e)	1	1	2	2	2	2	2	1		2
(f)										3
(g)										4
(h)				1			2	2		1
(i)	2	2	2	2	2	2	2	2	2	2
(j)				2	2		2			
(k)	3	3	3	3	3	2	2	2	2	4

NOTES: Outcome (d) is emphasized in relation to teams that student will likely be a part of when on the job and how knowledge of other members' disciplines (EE in this case) can be of benefit. Outcome (i) is emphasized due to this being a course outside the students' discipline and discussions of how a basic knowledge could be turned into a deeper knowledge with further study

PREPARED BY: Elaine Linde, Date: last update January 15, 2010

EM 214 - Statics – Spring 2010

Lois Arneson-Meyer, Assistant Professor
South Dakota School of Mines & Technology

Credits: (3-0) 3 credits
CB 116
MWF 10-10:50 AM

Course Description: Prerequisite Math 125 completed with a grade of "C" or better. The study of external forces acting on stationary rigid bodies in equilibrium. Vector algebra is used to study two and three-dimensional systems of forces. Trusses, frames and machines, shear and moment in beams. Friction, centroids, moments of inertia and mass moments of inertia are discussed.

Course Objective: This course is designed to provide students with basic knowledge for the analysis of effects of external forces acting on stationary rigid bodies in equilibrium.

Course Outcomes: Students successfully completing this course will have the ability to:

1. Determine the components of a force in rectangular coordinates
2. Draw complete and correct free-body diagrams and write the appropriate equilibrium equations from the free-body diagram.
3. Evaluate forces acting on static bodies including determining resultants and 3D components
4. Calculate moments in 2D and 3D about a point and an axis utilizing cross products and dot products.
5. Determine the support reactions on a structure.
6. Determine the connection forces in trusses and in general frame structures.
7. Given standard shapes and corresponding centroids and or moment of inertia, be able to compute centroids and or moment of inertia for composite bodies.
8. Determine how to identify and solve problems involving dry friction, wedges and belt friction.
9. Determine the internal reactions in a beam, draw correct shear force and bending moment diagrams.

Text: Vector Mechanics for Engineers, Statics, 9th Ed., Beer & Johnston. You are required to bring your text to every class. Your book is your portable instructor. I suggest you use it – read the text and study the examples.

Supplies: Engineering paper for all homework, engineering pencil, straight edge, scientific calculator.

Homework: Homework will be due at the beginning of the next class period. Staple all pages together. Homework must be prepared in a professional manner. Use a straight edge for figures and free body diagrams. **An average score of 70% on the homework is required to pass the course**. Homework more than one week late will not be accepted. No homework accepted after the last day of class. Late homework is 20% off/calendar day. Quizzes will be occurring regularly over the semester.

Academic integrity: Cheating of any type will result in an F in the course; this includes the copying of homework.

Attendance: Students with five absences will be asked to withdraw from the class.

Grading: Tests (60%), Final (20%), Homework (20%)

Tests: Tests will be given at specific time and dates indicated in the syllabus. No low scores will be dropped. No makeup and no retakes on tests. You are allowed one 8.5 x 11 inch crib sheet.

Office: Civil Mechanical Building Rm: 121, Open door policy.Phone: 394-2446.

FBD's: Free Body Diagrams must be shown on all answers to homework and exam questions as appropriate. FBD's must include forces, distances, dimensions,angles, and directions as appropriate in addition to any other parameters necessary to understand and/or solve the problem. Answers without FBD's will not be graded and will count as zero.

Final Exam: All students are required to take the final exam at the assigned period during the final exam week.

Prepared by: Dr. Lois Arneson-Meyer, Civil and Environmental Engineering, May 2010

EM 216 – Statics & Dynamics – Spring 2010

Lois Arneson-Meyer, Assistant Professor

Credits: (4 - 0) 4 credits
CB 309 8-8:50 am
MTWF Section 01

Course Description: Prerequisite: Math 125 completed with a grade of "C" or better. STATICS: The study of effects of external forces acting on stationary rigid bodies in equilibrium. Frames and machines, friction, centroids and moments of inertia of areas and mass
are discussed. DYNAMICS: Newton's laws of motion are applied to particles and
rigid bodies. Topics considered are absolute and relative motion; force, mass and acceleration (of particles and rigid bodies); work and energy; impulse and momentum.

Course Objective: This course is designed to provide students with the basic knowledge for the analysis
of the effects of external forces action on stationary rigid bodies in equilibrium and
the study of particles and rigid bodies in motion.

Course Outcomes: The students successfully completing this course will have the ability to:

1. Determine the components of a force in rectangular coordinates
2. Draw complete and correct free-body diagrams and write appropriate equilibrium equations from the free-body diagrams.
3. Evaluate forces acting on static bodies including determining resultants and 3D components
4. Calculate moments in 2D and 3D about a point utilizing cross products.
5. Determine the support reactions on a structure
6. Determine the connection forces in trusses and in general frame structures.
7. Given standard shapes and corresponding centroids and or moment of inertia
   be able to compute centroids and or moment of inertia for composite bodies.
8. Determine forces required to overcome initial friction and calculate friction
   losses for bodies in motion.
9. List the principles of rectilinear and curvilinear kinematics and apply them to
   problems of particle motion.
10. List the principles of rectilinear and curvilinear kinematics and apply them to
    problems of rigid bodies in motion.
11. Explain and apply Newton's Second Law of Motion, Linear and angular momentum and motion under a central force for rigid bodies.
12. Explain work and energy principals for particles and rigid bodies.

Text: Vector Mechanics for Engineers STATICS & DYNAMICS, 9TH Ed., Beer & Johnston.

You are required to bring your text to every class. Your book is your portable instructor. It is available 24/7. I suggest you use it – read the text and study the examples.

Supplies: Engineering paper for all homework, engineering pencil, straight edge, scientific calculator.

Homework: Homework will be due at the beginning of the next class period. Staple all pages together. Homework must be prepared in a professional manner. Use a straight edge for figures and free body diagrams. Homework more than one week late will not be accepted. No homework accepted after the last day of class. Late homework is 20% off/calendar day.

Academic integrity: Cheating of any type will result in an F in the course; this includes the copying of homework.

Attendance: Students with five absences will be asked to withdraw from the class.

Grade basis:

Tests and Quizzes	60%	90-100	A
Final	20%	80 – 89	B
Homework	20%	70 – 79	C
		60 – 69	D

Tests: Tests will be given at normal class time. 4 exams (100 points each) will be given and one 50 point exam. No makeup on quizzes. No retakes on tests. You are allowed one 8.5 x 11 inch crib sheet.

Office: Civil Mechanical Building Rm: 121, hours will be posted on door. Phone: 394-2446. The instructor will be available for study table in the Library or Miners Shack during designated times as announced in class.

FBD's: Free Body Diagrams must be shown on all answers to homework and exam questions as appropriate. FBD's must include forces, distances, dimensions, angles, and directions as appropriate in addition to any other parameters necessary to understand and/or solve the problem. Answers without FBD's will not be graded and will count as zero.

Final Exam: If you have a 93 percent overall total on homework and tests and quizzes you will not be required to take the final. All other students will be required to take the final exam at the assigned period during final exam week.

Prepared by: Dr. Lois Arneson-Meyer, Civil and Environmental Engineering, May 2010

EM 321 - Mechanics of Materials

Required

Course Description: (3-0) 3 credits Basic concepts of stress and strain that result from axial, transverse, and torsional loads on bodies loaded within the elastic range. Shear and moment equations and diagrams; combined stresses; Mohr's circle; beam deflections; and column action and equations.

Prerequisite: EM 214 (Statics)

Textbook: Philpot, T.A., Mechanics of Materials: An Integrated Learning System, 1st Edition, John Wiley& Sons
Additional Required Materials: Course Packet, available at the bookstore

Course Learning Outcomes

By the end of the semester, students should be able to demonstrate their ability to:

1. Calculate a state of stress for a point on a loaded object, including normal stress (due to a combination of axial loads, flexure and/or internal pressure) and shear stress (due to a combination of torsion and transverse shear) (a,e);
2. Calculate section properties including area, centroid and moment of inertia for homogeneous cross-sections (a,e);
3. Calculate stresses and strains due to tension, compression, shear (direct and transverse), torsion, bending and combined loads (a,e);
4. Apply major concepts of equilibrium and compatibility and use them to solve simple indeterminate problems (a,e);
5. Calculate principal stresses and strains and transform states of stress to different orientations (a);
6. Apply major concepts to real world problems, including creating simple models of complex systems (a,e,k);
7. Design members or systems to withstand prescribed loadings based on a maximum allowable stress (c,e);
8. Draw shear and bending moment diagrams (a); and
9. Exhibit the ability to adequately explain core concepts orally and in writing (g).

Topics Covered: Average normal and direct shear stress; average normal and shear strain; material properties; axial stress and deformation; solution of interminate axial systems; torsional stress and angle of twist; section properties; shear and bending moment diagrams; flexural stresses; beam shear stress; stresses due to combined loadings; column buckling; pressure vessels; principal stresses and stress transformations.

Class schedule: Three lectures per week lasting one hour per lecture

Contribution to meeting criterion 5: The course provides 3 credits of engineering science

Relationship Between Program Objectives and Course Objectives:
(1 = min. 2 = avg. 3 = max)

Course Outcomes	ABET Program Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
1	3				2						
2	3				2						
3	3				2						
4	3				2						
5	3				2						
6	2				3						2
7	1		2		2						
8	3										
9							2				

Prepared by: Dr. Andrea E. Surovek, Civil and Environmental Engineering, May 2010

IENG 301 Basic ENGINEERING ECONOMICS 2 CR. HRS

Spring Term 2010
M,W,F: 12:00 PM – 12:50 PM CB 204W

Instructor Contact Information:

Instructor: Dr. Dean Jensen
Office Location: CM 322
Office Hours: M, W, F: 11:00 AM – 11:50 AM
E-mail for an appointment outside of office hours.
Office Phone: 394 – 1278 E-mail: dean.jensen@sdsmt.edu

Course Description:

Catalog Description: Introduces the concepts of economic evaluation regarding capital investments, including the time value of money ~~and income tax effects~~. Graduation credit cannot be given for both IENG 301 and IENG 302.

Additional Course Description: To develop a basic understanding of the methods of engineering economic study – problem solving using cash flow diagrams, table factors, and comparison of alternatives considering the time value of money. This is a service course for students in departments that do not require the completion of inflation, depreciation, and tax effect studies. This course will be co-located with IENG 302 until completing the third exam.

Course Prerequisites:

Junior standing preferred. Students may use spreadsheet software to complete portions of the course. It is expected that students will be able to access and download internet files.

Description of Instructional Methods:

This course utilizes electronic (PowerPoint, spreadsheet, …) and traditional (chalkboard, overhead, …) methods of lecture delivery. Students will solve problems using standard engineering economic practices both manually and electronically.

Course Requirements:

Required Materials:

- Blank, L. & Tarquin, A. (2005). ***Engineering Economy (6th ed.).*** New York NY: McGraw – Hill. 759pp. ISBN 0-07-320382-3.
- Engineering Problems Paper – 8-1/2" x 11", three hole drilled, ruled five squares/division, 50 pp. (approx.).
- Engineering Notebook – 9-3/4" x 7-1/2", 5x5 quad-ruled, 80-100 pp. (approx.).
- Engineering/Scientific calculator.

Supplementary Materials:

Course Website: http://webpages.sdsmt.edu/~djensen/IENG302

Student Learning Outcomes:

Students will demonstrate:

- the ability to move various cash flows across time while accounting for discrete or continuous compound interest, e.g., single payment factors, uniform-series factors, and arithmetic and geometric gradient factors.
- the ability to apply the concept of minimum attractive rate of return in economic decision-making.

- the ability to identify the most appropriate engineering economy tool for evaluating alternatives.
- the ability to evaluate asset alternatives using present worth analysis, annual worth analysis, rate of return analysis, and benefit / cost analysis.
- the ability to utilize computer spreadsheets and their functions to solve engineering economy problems.
- the ability to determine the economic service life of an asset that minimizes the total annual worth of costs.
- the ability to perform an asset replacement study between the defender and the best challenger.

Evaluation Procedures:

Tests: Three exams will be given, and missed exams are not normally made-up. If a single midterm is missed for an instructor-approved reason, then the weight of the final (third) exam will be doubled. All exams are open engineering notebook, and use of a scientific calculator is encouraged. Other materials, including graded and returned homework, may not be used. Access to PDAs, cell phones, and devices with QWERTY keyboards is not allowed during exams. These devices may be checked with the instructor prior to the exam, and recovered at the end of the exam period.

Assignments: Assigned problems should be turned in on engineering problem (EP) paper, and should be reasonably lettered. Word-processor/spreadsheet output is also acceptable. Illegible or poorly documented problems may not be graded – this decision is at the discretion of the grader. State all necessary assumptions. All portions of an assignment should be stapled together, and the student's name should appear on each page. Assignments are minimally graded. Each problem in an assignment set is scored on a 10 point basis, and the percentage earned out of the assignment total is recorded. All assignment sets are equally weighted.

Tentative Course Outline:

Topic Set 1

Time Value of Money
Cash Flow Patterns
Effective Interest Rates
Complex Cash Flows

Topic Set 2

Net Present Worth and Lifetime Issues
Annual Worth Analysis
Bonds and Perpetuity (Capitalized Costs)
Internal Rate of Return/Incremental Analysis

Topic Set 3

Benefit/Cost Analysis
Incremental Benefit/Cost Analysis
Replacement/Economic Service Life

See course website for current schedule at: **http://webpages.sdsmt.edu/~djensen/IENG302**

Support Courses

CHEM 112	General Chemistry
CHEM 112L	General Chem Lab
CHEM 114	General Chemistry II
CHEM 114L	Gen Chem II Lab
ENGL 101	Composition I
ENGL 279	Technical Comm I
ENGL 289	Tech Comm II
GE 130	Intro to Engineering
MATH 123	Calculus I
MATH 125	Calculus II
MATH 225	Calculus III
MATH 321	Differential Eqs
MATH 373	Intro to Numerical Analysis
PHYS 211	University Physics I
PHYS 213	University Physics II
PHYS 213L	Univ Physics II Lab

CHEMISTRY 112—General Chemistry I

Department: Chemistry

Designation: Required

Catalog Data: (3-0) 3 credits. Prerequisite: MATH 102. An introduction to the basic principles of chemistry for students needing an extensive background in chemistry (including chemistry majors, science majors, and pre-professional students). Completion of a high school course in chemistry is recommended.

Prerequisites:

1. A minimum of one year of high school chemistry.
2. Concurrent enrollment in, or completion of, Math 102 or a score on the math placement exam sufficient to place in Math 115 or higher.

Textbook: Chang, Raymond. *Chemistry,* 9th ed., McGraw-Hill: New York, 2007
Optional: Cruickshank, Brandon and Chang, Raymond. *Student Solutions Manual for use with Chemistry,* 9th ed., McGraw-Hill: New York, 2007.

Course Learning Outcomes:

1. Understand, and use correctly, the symbolic representations, chemical notation, formulas, and systematic rules of nomenclature that characterize the language of chemistry.
2. Understand and apply the mole concept in a variety of chemical calculations, including calculating the number of particles in a given mass of substance (and vice versa), and the quantitative relationships between reactants and products in a chemical reaction.
3. Recognize the different types of chemical transformations: acid-base, precipitation, combination, decomposition, single-replacement, oxidation-reduction, double replacement, and combustion.
4. Understand the basic principles of energy transfer involving chemical systems, including the transfer of heat and work between system and surroundings, the qualitative and quantitative interpretation of thermochemical equations, and the application of Hess's Law.
5. Understand the various models of atomic structure, the basic principles of quantum theory, and the experiments that led to those principles.
6. Write ground-state electron configurations for atoms and ions of any representative element and the 3d transition series elements.
7. Understand the fundamental aspects of chemical bonding, including writing Lewis structures, describing the bonding in molecules by simple valence-bond theory, and using Valence Shell Electron Pair Repulsion Theory to predict the geometries of molecules and ions.
8. Use modern atomic theory to understand and predict the properties of different elements.
9. Understand the properties of the different states of matter.
10. Qualitatively and quantitatively describe the properties of the gaseous state and the fundamental laws governing the behavior of gases.
11. Understand, qualitatively and quantitatively, the behavior of solutions and their colligative properties.
12. Understand how fundamental intermolecular interactions among particles determine the physical and chemical properties of a system.
13. Understand the fundamental postulates of kinetic-molecular theory and use them to explain the physical behavior of the three states of matter.

Topics: Topics treated in the first semester are: measurements, atomic theory, stoichiometry, thermochemistry, states of matter, periodicity, bonding, and physical properties of solutions.

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: 3 credits of math / basic sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Duane Hrncir, Ph.D. Chemistry and Provost and Vice President for Academic Affairs, June 1, 2010

CHEM 112L: General Chemistry I Lab

Department: Chemistry

Designation: Required

Catalog Data: (0-1) 1 credit. Prerequisite or corequisite: CHEM 112. Laboratory designed to accompany CHEM 112.

Prerequisites: CHEM 112

Textbook: Manual: General Chemistry I Lab – CHEM112L

Course Learning Outcomes:

Students will learn common chemical laboratory safety practices and the experimental methods used in investigating and analyzing the properties and the behavior of matter.

- Understand the basic concept of chemical experiments.
- Understand the distinction between qualitative and quantitative analysis.
- Identify sources of error in chemical experiments.
- Interpret experimental results and draw reasonable conclusions.
- Analyze data in terms of the precision and accuracy of results.
- Learn the importance of performing accurate and precise quantitative measurements.
- Lean and understand laboratory safety procedures.
- Keep complete experimental records.
- Reinforce and apply the knowledge learned in CHEM112.

Topics: Laboratory safety, experimental and analytical methods, and the properties and the behavior of matter.

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: basic sciences

Relationship of Course to ABET Outcomes (a) through (k)

	Level of Emphasis		
	Low	Medium	High
ABET Outcome			
(a) an ability to apply knowledge of mathematics, science, and engineering			X
(b) an ability to design and conduct experiments, as well as to analyze and interpret data			X
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as			

economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability			
(d) an ability to function on multidisciplinary teams			
(e) an ability to identify, formulate, and solve engineering problems			
(g) an ability to communicate effectively			
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context			
(i) a recognition of the need for, and an ability to engage in life-long learning			
(j) a knowledge of contemporary issues			
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.		X	

PREPARED BY: Dr. Duane Hrncir, Ph.D. Chemistry and Provost and Vice President for Academic Affairs, June 1, 2010

CHEM 114: General Chemistry II

Department: Chemistry

Designation: Required

Catalog Data: 3-0) 3 credits. Prerequisite: CHEM 112 and MATH 102. A continuation of CHEM 112. An introduction to the basic principles of chemistry for students needing an extensive background in chemistry.

Prerequisites: CHEM 112 and MATH 102.

Textbook: Brady, Senese; "Chemistry: Matter and Its Changes", Fifth edition, Wiley text with enrollment in WileyPLUS with CATALYST

Course Learning Outcomes:

Students will obtain a foundation in the fundamental principles and models of chemistry necessary for an understanding of the composition, structure, and properties of matter and the changes that matter undergoes.

- Understand rates of reaction and conditions affecting rates.
- Derive the rate equation, rate constant, and reaction order from experimental data.
- Use integrated rate laws.
- Understand the collision theory of reaction rates and the role of activation energy.
- Understand the nature and characteristics of chemical equilibria.
- Understand the significance of the equilibrium constant, K.
- Understand how to use the equilibrium constant in quantitative studies of chemical equilibria.
- Understand and use Le Châtelier's Principle in predicting the effects of stresses on equilibrium systems.
- Use the Brønsted-Lowry and Lewis concepts of acids and bases.
- Apply the principles of chemical equilibrium to acids and bases in aqueous solution.
- Understand the control of pH in aqueous solutions with buffers.
- Evaluate the pH in the course of acid-base titrations.
- Apply chemical equilibrium concepts to the solubility of ionic compounds.
- Understand the concept of entropy and how it relates to spontaneity.
- Use tables of data in thermodynamic calculations.
- Define and use free energy in predicting the spontaneity of chemical processes.
- Balance net ionic equations for oxidation-reduction reactions.
- Understand the principles of voltaic and electrolytic cells

Topics: An introduction to the basic principles of chemistry for students needing an extensive background in chemistry

Class/Laboratory Schedule: MWF 9:00-10:30 PM

Contribution to Criterion 5: 3 credits of basic sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Duane Hrncir, Ph.D. Chemistry and Provost and Vice President for Academic Affairs, June 1, 2010

CHEM 114L: General Chemistry II Lab

Department: Chemistry

Designation: Required

Catalog Data: (0-1) 1 credit. Prerequisite: CHEM 112L, Prerequisite or corequisite: CHEM 114

Prerequisites: CHEM 114.

Textbook: **Prepackaged set of experiments** Thomson Custom Solutions (ISBN- 10: 0-495-40783-6).

Course Learning Outcomes:

- Students will gain familiarity with the principles and techniques of inorganic qualitative analysis, chemical kinetics, and the synthesis of selected chemical compounds.
- Perform procedures for the analytical separation and qualitative determination of selected anions and cations in an aqueous solution.
- Understand the fundamental and operational principles upon which common methods of separation and purification of chemical substances are based.
- Identify sources of error in chemical experiments.
- Interpret experimental results and draw reasonable conclusions.
- Practice laboratory safety procedures.
- Anticipate, recognize, and respond to hazards of chemical materials and manipulations.
- Learn the importance of following correct laboratory procedures.
- Keep legible and complete experimental records.
- Collaborate with peers in obtaining and interpreting data.

Topics: Principles and techniques of inorganic qualitative analysis, chemical kinetics, and the synthesis of selected chemical compounds.

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: Basic sciences

Relationship of Course to ABET Outcomes (a) through (k)

	Level of Emphasis		
	Low	Medium	High
ABET Outcome			
(a) an ability to apply knowledge of mathematics, science, and engineering			X
(b) an ability to design and conduct experiments, as well as to analyze and interpret data			X
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability			

(d) an ability to function on multidisciplinary teams			
(e) an ability to identify, formulate, and solve engineering problems			
(g) an ability to communicate effectively			
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context			
(i) a recognition of the need for, and an ability to engage in life-long learning			
(j) a knowledge of contemporary issues			
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.		X	

PREPARED BY: Dr. Duane Hrncir, Ph.D. Chemistry and Provost and Vice President for Academic Affairs, June 1, 2010

ENGLISH 101 - COMPOSITION I

Department: Humanities and Social Science

Designation: Required

Catalog Data: (3-0) 3 credits. Appropriate student placement based on entry level assessment or completion of ENGL 031, 032, or 033. Practice in the skills, research, and documentation needed for effective academic writing. Analysis of a variety of academic and non-academic texts, rhetorical structures, critical thinking, and audience will be included.

Prerequisites: None

Textbook: Reid, Stephen. *The Prentice Hall Guide for College Writers*. 8th ed. Upper Saddle River, NJ: Prentice Hall, 2006.

Course Learning Outcomes

As a result of taking courses meeting this goal, students will

1. Write using standard American English, including correct punctuation, grammar, and sentence structure.
   - Recognize and repair common errors in grammar, punctuation, and usage in their papers.
   - Apply standard English grammar, punctuation, and other mechanical aspects to all written assignments.
   - Compose clear, effective sentences and combine them into focused, coherent paragraphs that match the assigned writing purpose.
   - Improve their mastery of punctuation, grammar, and sentence structure through class discussions and exercises, quizzes, instructor feedback, and the draft and revision process.
2. Write logically.
   - Recognize and repair common focus and organization errors in their papers.
   - Apply common organizational strategies to all written assignments.
   - Write clear, effective paragraphs and combine them into a logical sequence and focal pattern that match the assigned writing purpose.
   - Improve their mastery of organization and logical writing through class discussions, written exercises, instructor feedback, and the draft and revision process.
3. Write persuasively, with a variety of rhetorical strategies (e.g. expository, argumentative, descriptive).
   - Identify and repair common rhetorical and reasoning errors in their papers.
   - Apply common rhetorical and reasoning strategies to all written assignments.
   - Design and produce writing using appropriate rhetorical strategies that match audience needs and assigned writing purpose.
   - Improve their mastery of persuasion and rhetorical strategies through class discussions, written exercises, instructor feedback, and the draft and revision process.
4. Incorporate formal research and documentation into their writing, including research obtained through modern, technology-based research tools.
   - Identify and repair common documentation errors in their papers.
   - Apply common research strategies to all written assignments that require it.
   - Design and produce writing using appropriate research tools that match audience needs, proper documentation requirements, professional ethical standards, and assigned writing purpose.
   - Improve their mastery of research and documentation methods through class discussion, written exercises, quizzes, instructor feedback, and the draft and revision process.

Topics

Fundamentals of expository writing, including writing about observation, writing from reading, writing to explain, writing to evaluate, and writing an argument.

Class/Laboratory Schedule

Varies

Contribution to Criterion 5

General Education

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY

Dr. Sue Shirley, Department Chair, Humanities and Social Science, June 1, 2010

ENGL 279 TECHNICAL COMMUNICATIONS I

Department: Humanities and Social Sciences

Designation: Required

Catalog Data: (3-0) 3 credits. Prerequisites: ENGL 101 or equivalent and sophomore standing. Introductory written and oral technical communications with emphasis on research and explanations of scientific and engineering topics.

Prerequisites: ENGL 101 or equivalent and sophomore standing

Textbook: Brusaw, Charles T., Gerald J. Alred, and Walter E. Oliu. *Handbook of Technical Writing.* 9th ed. New York: Bedford/St. Martin's P, 2009;
Lannon, John. *Technical Communication.* 11th ed. New York: Pearson, 2008.
Instruction Manual

Course Learning Outcomes: As a result of taking courses meeting this goal, students will

1. Prepare and deliver speeches for a variety of audiences and settings.
   Assessment: Students will:
   a. analyze the relevant characteristics of their intended audience.
   b. prepare and deliver speeches of differing lengths, topics, and purposes for a variety of technical, professional, and general audiences.
   c. improve their mastery of audience and setting analysis through class discussion and exercises, peer review, instructor feedback, practice and final speeches.

2. Demonstrate listening competencies including choice and use of topic, supporting materials, organizational pattern, language usage, presentational aids, and delivery.
   Assessment: Students will:
   a. recognize the different speech goals and organizational patterns used for informational, demonstration, and/or persuasion speeches.
   b. demonstrate in individual and/or collaborative speeches their competency in selecting and using appropriate supporting materials and presentational aids for the intended type of speech and audience.
   c. demonstrate in individual and/or collaborative speeches their competency in using appropriate language for the intended type of speech and audience;
   d. incorporate effective delivery techniques, both vocal and nonverbal, for the intended speech and audience in individual and/or collaborative speeches;
   e. improve their mastery of choosing and using appropriate topics and organizational plans, supporting materials, language, presentation aids, and delivery techniques through class discussion and exercises, peer review, instructor feedback, practice and final speeches..

3. Demonstrate listening competencies by summarizing, analyzing, and paraphrasing ideas, perspectives, and emotional content.

Assessment: Students will

a. demonstrate listening competencies through peer review exercises.
b. improve their mastery of listening skills through class discussions and exercises, instructor and student feedback, practice and final speeches.

Topics: written and oral technical communications, research and explanations of scientific and engineering topics.

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: General Education, 3 credits

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Sue Shirley, Department Chair; June 1, 2010

ENGL 289 TECHNICAL COMMUNICATIONS II

Department: Humanities and Social Sciences

Designation: Required

Catalog Data: (3-0) 3 credits. Prerequisites: ENGL 279 or equivalent and sophomore standing. Advanced written and oral technical communications with emphasis on the research, preparation, and delivery of complex technical documents.

Prerequisites: ENGL 279 or equivalent and sophomore standing

Textbook:

- Brusaw, Charles T., Gerald J. Alred, and Walter E. Oliu. *Handbook of Technical Writing.* 9th ed. New York: Bedford/St. Martin's P, 2009;
- Lannon, John. *Technical Communication*. 11th ed. New York: Pearson, 2008.
- Instruction Manual: Pfeiffer, William S. *Pocket Guide to Technical Writing*. 4rd ed. New Jersey: Prentice Hall, 2007.
- Gurak, L. and J. Lannon. *A Concise Guide to Technical Communication*. 3rd Ed., 2007

Course Learning Outcomes: As a result of taking courses meeting this goal, students will

- Prepare and deliver speeches for a variety of audiences and settings. Assessment: Students will Analyze the relevant characteristics of their intended audience;
- Prepare and deliver speeches of differing lengths, topics, and purposes for a variety of technical, professional, and general audiences;
- Improve their mastery of audience and setting analysis through class discussion and exercises, peer review, instructor feedback, practice and final speeches.
- Demonstrate listening competencies including choice and use of topic, supporting materials, organizational pattern, language usage, presentational aids, and delivery.
- Assessment: Students will recognize the different speech goals and organizational patterns used for informational, demonstration, and/or persuasion speeches;
- Demonstrate in individual and/or collaborative speeches their competency in selecting and using appropriate supporting materials and presentational aids for the intended type of speech and audience;
- Demonstrate in individual and/or collaborative speeches their competency in using appropriate language for the intended type of speech and audience;
- Incorporate effective delivery techniques, both vocal and nonverbal, for the intended speech and audience in individual and/or collaborative speeches;
- Improve their mastery of choosing and using appropriate topics and organizational plans, supporting materials, language, presentation aids, and delivery techniques through class discussion and exercises, peer review, instructor feedback, practice and final speeches.
- Demonstrate listening competencies by summarizing, analyzing, and paraphrasing ideas, perspectives, and emotional content. ssessment: Students will 1) Demonstrate listening competencies through peer review exercises; Improve their mastery of listening skills through instructional practices and procedures.

Topics: Written and oral technical communications, research, and the preparation, and delivery of complex technical documents.

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: General Education, 3 credits

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Sue Shirley, Department Chair; June 1, 2010

GE 130: Introduction to Engineering

Department: Office of the Provost

Designation: Required

Prerequisites: MATH 102

Catalog Data: (1-1) 2 credits. Prerequisite: MATH 102. This course serves as an introduction to engineering profession and to its various disciplines. This course is designed to give students the opportunity to learn how to solve engineering analysis and design problems. Students will develop various computational skills, sharpen communication skills, and be exposed to professional development in the form of team building, technology tools, and project management. In addition, students will have the opportunity to learn from professional engineers and scientists through interaction with industry.

Text: ***GE 130 Introduction to Engineering***

Course Learning Outcomes:

1. Understand an engineering program enough to work with an Academic Advisor and commit to a major and create an education/career plan
2. Become an effective team member and campus leader
3. Develop the communication skills necessary to package their technical and professional skills to succeed in an engineering practice.
4. Be able to use Excel tools to analyze and solve engineering problems
5. Be able to understand the difference between analysis and design

Topics:

Introduction to the engineering profession and its various disciplines
Solving engineering analysis and design problems
Computational skills
Communication skills
Team building
The use of technology tools
Project management
Professional and ethical practice in engineering

Class Time T, R 10:00 – 11:00 a.m., 12:00-1:00 p.m. (EP 255)

Mentorship – In addition to class attendance you will be required to meet with one of the instructors twice during the semester.

Contribution to Criterion 5: 2 credits of "engineering topics"

Relationship of Course Outcomes and Assignments to the ABET (a) – (k)

The following table indicates the relative strengths of the 12 main course activities and assignments (detailed below) in addressing the ABET a through k outcomes. A designation of "3" indicates a strong level of emphasis.

GE 130		ABET Outcomes a-k										
		A	B	C	D	E	F	G	H	I	J	K
Course Assignments	1	1			1		2		2	1	1	
	2	2			2	2	3	1	2		2	
	3											1
	4											3
	5											3
	6	1		2		2						
	7	2			3	2		1				2
	8				2							
	9,a	1			3		2	3	2	1	3	
	9,b	1			3		1	2	3	1	3	1
	10	3	3	2	3	3		3				2
	11							3		1	2	
	12								1	1		

	Homework Assignments	**Outcomes of assignment or activity**
1	"Who Wants to Be An Engineer" - Responseware game with teams focused on reading "What is Engineering?," Engineering Careers & Disciplines," and "Studying Engineering: The Keys to Success." Game involves researching SDSM&T Engineering Department web pages and highlights great engineering feats .	1. Class begins to work in teams. 2. Effective method of presenting general information without lecturing. Students are actively involved. 3. Game allows for determination of topics that need further discussion during class and/or follow up. 4. Provides familiarization of department web sites. 5. Final round in game involve teamwork as students wager points on knowledge of great engineering feats.
2	Engineering Ethics Problem	Addresses subject of "Can you be an Engineer Without Studying Ethics?" Teams break up to discuss and determine best course of action to address engineering problem and discuss what engineering ethical theories were used to come up with course of action. Teams will present solutions to class and field questions.
3	Microsoft Excel Basics	Familiarization with Excel
4	Formulas and Functions	Create formulas in a worksheet, locate and use Excel's predefined functions, use absolute and relative cell references in formulas and functions and debug formulas. Extra Credit offered for those with prior Excel experience
5	Working with Excel Charts	Familiarization with which chart to use. Create and manipulate charts, determine best fit trend lines.
6	Engineering Design Problem Statement and Criteria for Success	Define engineering problems in clear and unambiguous terms. Determine specifications a design solution must meet or attributes it must posess to be considered successful. Students are encouraged to look at a need or problem within their anticipated field of study.
7	Trebuchet/Catapult Tournament - In conjunction with Project 2, students modify their designed trebuchet or catapult to launch a tennis ball into a garbage can 50 ft away.	Application of principles of physics and open-ended thinking to modify final design to reach target.
8	Team survey for Project 2	Determine individual involvement in team.

9	**Project 1** Part a: Greatest Challenge Affecting Engineers in the 21st Century part b: First semester classes have the choice of the above or Dollars and Ton game offered by the Metallurgy Department - (game developed & conducted by Nucor Steel over the course of 3 evenings)	a. First major team project involving research and formal PowerPoint presentation. Application of communication skills needed to give an effective presentation and field questions from the type of audience they are addressing. b. Dollars and Tons Game provides a team approach to project management and the interplay between engineering and finance.
10	**Project 2** Trebuchet or Catapult Design - Basic kit provided	Provide opportunity for hands-on application of the principles of physics (analysis) and the opportunity for creativity (design) in a team setting. Provides further opportunity to use communication skills and teamwork to design and analyze trebuchet/catapult, give presentation, field questions, and write engineering report.
11	Research Paper	Follow up to department presentations. Student answers the following questions: 1) What field do I want to become educated in? 2) Why have I chosen this field?, and 3) What kind of employment do I hope to gain in this field?
12	Mentorship Session	Determine students adjustment to SDSM&T. Encourage involvement with Academic advisors, Professors, and Peer Advisors. Encourage involvement in campus/community activities depending on their interests. Discuss any problems students might be experiencing. Answer questions or find answers to their questions.

PREPARED BY: Kathleen Hanley, Instructor; June 1, 2010

MATH 123 CALCULUS I

Department: Mathematics and Computer Science

Designation: Required

Catalog Data: (4-0) 4 credits. Prerequisite: MATH 115 with a minimum grade of "C" or appropriate mathematics placement or permission of instructor. Students who are initially placed into MATH 102 or below must complete MATH 102 and MATH 120 with a minimum grade of "C" before enrolling in MATH 123. Students who are placed in MATH 120 should consult their advisor to determine whether their placement score was sufficiently high to allow concurrent registration in MATH 123. The study of limits, continuity, derivatives, applications of the derivative, antiderivatives, the definite and indefinite integral, and the fundamental theorem of calculus.

Prerequisites: College Algebra (MATH 102) with a grade of C or better or an acceptable ACT score. Corequisite of Trigonometry (MATH 120) with a grade of C- or better or an acceptable score on the COMPASS Placement Exam.

Textbook: Calculus by Rogawski, published by Freeman, 2008.

Course Learning Outcomes: As a result of taking a course meeting this goal, students will:

1. Use mathematical symbols and mathematical structure to model and solve real world problems. Assessment: Students will
   - Identify, interpret, and correctly apply standard mathematics symbols to solve problems requiring the derivative. This will be demonstrated on quizzes, labs, homework, and/or exams.
   - Identify, interpret, and correctly apply standard mathematics symbols to solve problems requiring the integral. This will be demonstrated on quizzes, labs, homework, and/or exams.
2. Demonstrate appropriate communication skills related to mathematical terms and Assessment: Students will
   - Correctly use functional notation of algebra, trigonometry, and calculus. This will be demonstrated on quizzes, labs, homework, and/or exams.
3. Demonstrate the correct use of quantifiable measurements of real world situations Assessment: Students will
   - Apply their knowledge of the integral in applications such as area, volume, moments, work, arc length, and surface area. This will be demonstrated on quizzes, labs, homework, and/or exams.
   - Apply their knowledge of the derivative in applications such as related rates, linear approximations, curve sketching, optimization, velocity, and acceleration. This will be demonstrated on quizzes, labs, homework, and/or exams

Topics: The study of limits, continuity, derivatives, applications of the derivative, antiderivatives, the definite and indefinite integral, and the fundamental theorem of calculus.

Class/Laboratory Schedule: MWF 3:00-3:50 PM

Contribution to Criterion 5: basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Kyle Riley, Department Head; June 1, 2010

MATH 125 CALCULUS II

Department: Mathematics and Computer Science

Designation: Required

Catalog Data: (4-0) 4 credits. Prerequisite: MATH 120 completed with a minimum grade of "C" or appropriate score on departmental Trigonometry Placement Examination and MATH 123 completed with a minimum grade of "C." A continuation of the study of calculus, including the study of sequences, series, polar coordinates, parametric equations, techniques of integration, applications of integration, indeterminate forms, and improper integrals.

Prerequisites: MATH 120 (Trigonometry) completed with a grade of "C" or better or an acceptable score on the COMPASS Trigonometry Placement Examination, and MATH 123 completed with a grade of "C" or better. (Trigonometry is a critical prerequisite for this course. Students should ensure that they have passed MATH 120 or the COMPASS Trigonometry Placement Examination before enrolling in MATH 125.)

Textbook: Calculus by Jon Rogawski

Course Learning Outcomes:

- Use mathematical symbols and mathematical structure to model and solve real world problems.
- Students will identify, interpret, and correctly apply standard mathematics symbols to solve problems requiring differentiation and integration techniques. This will be demonstrated on quizzes, labs, homework, and/or exams.
- Demonstrate appropriate communication skills related to mathematical terms.
- Students will correctly use functional notation of algebra, trigonometry, and calculus. This will be demonstrated on quizzes, labs, homework, and/or exams.
- Demonstrate the correct use of quantifiable measurements of real world situations.
- Students will apply their knowledge of calculus in one-variable, infinite sequences and series, and parametric equations and polar equations in applications such as area computation, function approximation, and arc-length computation. This will be demonstrated on quizzes, labs, homework, and/or exams.
- Students will be able to produce indefinite integrals using Maple (int)
- Students will be able to compute definite integrals using Maple - including approximate numerical computation when necessary (int versus evalf(int(...)))
- Students will be able to compute Taylor approximations using the Taylor and normal commands in Maple

Topics:

- Integrals and Derivatives involving Exponential, Logarithmic, Inverse, and Hyperbolic functions.
- Integration techniques
- Indeterminate Forms and L'Hopital's rule
- Improper integrals
- Vectors and applications
- Matrices and linear algebra

- Infinite Series
- Tests for convergence Taylor Series, Fourier Series

Class/Laboratory Schedule: MTWF 9:00-9:50
MTWF 1:00-1:50

Contribution to Criterion 5: basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Kyle Riley, Department Head; June 1, 2010

MATH 225 CALCULUS III

Department: Mathematics and Computer Science

Designation: Required

Catalog Data: (4-0) 4 credits. Prerequisite: MATH 125 completed with a minimum grade of "C". A continuation of the study of calculus, including an introduction to vectors, vector calculus, partial derivatives, and multiple integrals.

Prerequisites: Math 125 with a grade of 'C' or better.

Textbook: Calculus with Analytic Geometry, Eighth Edition, Larson, Hostetler, and Edwards

Course Learning Outcomes:

A student who successfully completes this should, at a minimum:

1. know basic vector operations
2. know how to work with lines and planes in space
3. understand vector functions and their derivatives
4. be able to compute position, velocity and acceleration vectors
5. understand functions of several variables
6. be able to compute partial derivatives and gradients using multivariate chain rules
7. be able to find extremals of constrained and unconstrained functions
8. understand iterated integrals
9. be able to set up and evaluate double and triple integrals in various coordinate
10. systems
11. understand vector fields
12. be able to compute line integrals
13. understand the basic integral theorems of vector analysis

Topics: vectors, vector calculus, partial derivatives, and multiple integrals..

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

	Level of Emphasis		
	Low	Medium	High
ABET Outcome			
(a) an ability to apply knowledge of mathematics, science, and engineering			X
(b) an ability to design and conduct experiments, as well as to analyze and interpret data			
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability			
(d) an ability to function on multidisciplinary teams			

(e) an ability to identify, formulate, and solve engineering problems			
(g) an ability to communicate effectively			
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context			
(i) a recognition of the need for, and an ability to engage in life-long learning			
(j) a knowledge of contemporary issues			
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.		X	

PREPARED BY: Dr. Kyle Riley, Department Head; June 1, 2010

MATH 321 DIFFERENTIAL EQUATIONS

Department: Mathematics and Computer Science

Designation: Required

Catalog Data: (4-0) 4 credits. Prerequisite: MATH 125 with a minimum grade of "C". Selected topics from ordinary differential equations including development and applications of first order, higher order linear and systems of linear equations, general solutions and solutions to initial-value problems using matrices. Additional topics may include Laplace transforms and power series solutions. MATH 225 and MATH 321 may be taken concurrently or in either order. In addition to analytical methods this course will also provide an introduction to numerical solution techniques.

Prerequisites: Math 125 with a grade of 'C' or better.

Textbook: Differential Equations With Boundary Value Problems, 7th edition, Zill

Course Learning Outcomes:

1. know how to use separation of variables
2. be able to solve first order ordinary differential equations
3. be able to solve second order linear ordinary differential equations
4. understand the difference between homogeneous and non-homogeneous linear systems
5. be familiar with at least one science or engineering application of differential equations
6. be able to compute the Laplace transform and inverse Laplace transform for simple functions
7. understand the basic process of how to use the Laplace transform to solve an initial value problem
8. be familiar with a numerical technique for solving an initial value problem, such as Euler's Method or the Runge Kutta method
9. be able to carry out basic matrix addition and matrix multiplication
10. be able to solve a linear system in matrix form
11. be able to use matrices to solve simple linear first order systems of ordinary differential equations

Topics:

Topics for Exam 1

Basic definitions and terminology
Direction fields and solution curves
First order differential equations and their applications, including
1) separable, 2) Linear, 3) Exact, 4) Bernoulli, 5) Numerical Methods

Topics for Exam 2

Higher order differential equations…homogeneous and nonhomogeneous
Method of undetermined coefficients
Method of variation of parameters
Applications of higher order differential equations
Simple harmonic motion
Damped motion

Forced motion
Electric circuits and analogous systems

Topics for Exam 3
Basic LaPlace transforms and their inverses
Laplace transforms
Inverse Laplace transforms
Operational Properties
Applications

Topics for Exam 4
systems of linear first order equations
Matrices
Gauss elimination
Systems of ordinary differential equations
Eigenvalues
Variation of Parameters

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: Basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Kyle Riley, Department Head; June 1, 2010

MATH 373 INTRODUCTION TO NUMERICAL ANALYSIS

Department: Mathematics and Computer Science

Designation: Required

Catalog Data: (3-0) 3 credits. Prerequisite: MATH 321 and CSC 150 or permission of instructor. This course is an introduction to numerical methods. Topics include elementary discussion of errors, polynomial interpolation, quadrature, non-linear equations, and systems of linear equations. The algorithmic approach and efficient use of the computer will be emphasized. Additional topics may include: calculation of eigenvalues and eigenvectors, numerical differentiation and integration, numerical solution of differential equations.

Prerequisites: Math 321 and CSC 150..

Textbook:

- Optional: *Numerical Methods for Engineers (5 ed.)*, by Chapra and Canale, McGraw-Hill, 2006
- Optional: *Excel for Scientists and Engineers (Numerical Methods)*, by E. Joseph Billo, Wiley, 2007.
- There is also a wiki textbook on Numerical Methods
- We will also be using a text by Dr. Stan Howard

Course Learning Outcomes:

1. Students will be able to write **finite approximations** of the first and second derivatives.
2. Students will able to explain the **Mean Value Theorem** and its relationship to error estimation.
3. Students will be able to derive the **LaPlace Equation** in rectilinear, cylindrical, and spherical coordinates with a generation term.
4. Students will be able to solve on a spreadsheet
   - **1D SS HT problems**
     Explicitly
   - **1D USS HT problems**
     Explicitly, by Saul'yev, by Frankel-DuFort, and by Crank-Nicolson all with fixed, zero-flux, gradient, and convection BC's.
   - **2D SS HT problems**
     Explicitly by relaxation with fixed, zero flux, gradient, and convection BC's.
   - **2D USS HT problems**
     Explicitly and Implicitly by ADI methods with fixed, zero flux, gradient, and convection BC's.
5. Students will be able to perform numerical integration by **Rectilinear Rule, Trapezoid Rule, Simpson's 1/3 and 3/8 Rules, Gaussian Quadrature**
6. Students will be able to solve a system of Ordinary Differential Equation of any order by **Runge-Kutta Methods** including the Fourth Order form by hand and by using MathCad.

7. Students will be able to find roots by the following methods
   - **Interval Halving**
   - **False Position**
   - **Secant**
   - **Newton-Raphson**
   - **One-point Iteration**
8. Students will be able to construct objective functions necessary for **LP** and **Data Adjustment** problem solutions solved by **Excel Solver**.
9. Students will submit a written **project report** and orally present the numerical solution to an engineering problem.

Topics: Polynomial interpolation, quadrature, non-linear equations, systems of linear equations, the algorithmic approach, calculation of eigenvalues and eigenvectors, numerical differentiation and integration, and numerical solution of differential equations

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Kyle Riley, Department Head; June 1, 2010

PHYS 211: University Physics I

Department: Physics

Designation: Required

Catalog Data: (3-0) 3 credits. Prerequisite: MATH 123 or permission of instructor. This is the first course in a two semester calculus-level sequence, covering fundamental concepts of physics. This is the preferred sequence for students majoring in physical science or engineering. Topics include classical mechanics and thermodynamics. The School of Mines course covers classical mechanics only.

Prerequisites: MATH 123 or permission of instructor.

Textbook: Fundamentals of Physics, D. Halliday, R. Resnick, J. Walker, 8th Ed. Pt. 1

Course Learning Outcomes:

- Demonstrate the scientific method in a laboratory experience. This outcome will be achieved and assessed in Phys 213L course.
- Gather and critically evaluate data using scientific method. Assessment: Students will be able to critically evaluate data (given or obtained) with proper accuracy using appropriate laws and formulas of classical mechanics for scientifically sound presentation of laboratory reports, homework assignments, and of solutions on quizzes and exams.
- Identify and explain the basic concepts, terminology and theories of selected natural sciences. Assessment: Students will be able to identify and apply basic concepts and appropriate laws of classical mechanics in order to solve assigned problems in homework, quizzes, exams, and in oral presentation.
- Apply selected natural science concepts and theories to contemporary issues. Assessment: Students will be able to explain how physics concepts, laws, and phenomena relate to contemporary engineering and science in classroom discussions and written assignments.

Topics: Classical mechanics

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: 3 credits of math / basic sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

Prepared By: Dr. Andre Petukhov, Department Head; June 1, 2010

PHYS 213 UNIVERSITY PHYSICS II

Department: Physics

Designation: Required

Catalog Data: (3-0) 3 credits. Prerequisite: PHYS 211. This course is the second course in a two semester calculus-level sequence, covering fundamental concepts of physics. This is the preferred sequence for students majoring in physical science or engineering. Topics include electricity and magnetism, sound, light, and optics. The School of Mines course covers electricity and magnetism only.

Prerequisites: PHYS 211.

Textbook: *Fundamentals of Physics,* Part 3, Halliday, Resnick, Walker, 8th Ed. with Wiley Plus

Course Learning Outcomes:

As a result of taking courses meeting this goal, students will:

1. Critically evaluate data using the scientific method. **Assessment:** Students will be able to critically evaluate data (given or obtained), with proper accuracy, using appropriate physical laws and formulas for laboratory reports, homework assignments, and solutions on quizzes and exams.
2. Identify and explain the basic concepts, terminology, and theories of the selected natural sciences. **Assessment:** Students will identify and apply basic concepts and appropriate physical laws in order to solve assigned problems in homework, quizzes, exams, and oral presentations.
3. Apply selected natural science concepts and theories to contemporary issues. **Assessment:** Students will be able to explain how physics concepts, laws, and phenomena relate to contemporary engineering and science in classroom discussions and written assignments.

Topics:

Electric Charge, charge, conductors and insulators, Coulomb's Law
Applications of Coulomb's Law
Applications of Coulomb's Law
Electric Fields, electric field lines, electric field due to a point charge
Electric field due to a dipole, continuous charge distributions
Electric fields due to continuous charge distributions
Electric fields due to continuous charge distributions
Point charge and dipole in a electric field
Gauss' Law, **flux of an electric field, Gauss' Law**
Electric Potential , electric potential energy, electric potential, potential from the field
Potential due to a point charge
Potential due to continuous charge distributions

Field from potential
Capacitance, calculating the capacitance
Capacitors in parallel and in series
Energy stored in an electric field
Capacitor with a dielectric
Current and Resistance, current and current density
Resistance and resistivity

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Andre Petukhov, Department Head; June 1, 2010

PHYS 213L UNIVERSITY PHYSICS II LABORATORY

Department: Physics

Designation: Required

Catalog Data: (0-1) 1 credit. Prerequisite or corequisite: PHYS 213. This laboratory accompanies PHYS 213. Introduction to physical phenomena and measurements. Recording and processing data, determining uncertainties, reporting results. The experiments supplement the work in PHYS 211 and PHYS 213

Prerequisites: Concurrent registration in or completion of PHYS-213..

Textbook: ***Suggested Ref.:*** *Experimentation, D. C. Baird, 3d Edition*

Course Learning Outcomes:

As a result of taking courses meeting this goal, students will:

1. Demonstrate the scientific method in a laboratory experience. **Assessment:** Students will be able to relate obtained experimental data with corresponding physics laws and formulas and critically evaluate these data with proper accuracy using appropriate formulas, and present scientifically sound laboratory reports.

2. Gather and critically evaluate data using scientific method. **Assessment:** Students will be able to critically evaluate data (given or obtained) with proper accuracy using appropriate laws and formulas of classical mechanics for scientifically sound presentation of laboratory reports.

Topics: physical phenomena and measurements, recording and processing data, determining uncertainties, and reporting results

Class/Laboratory Schedule: Varies

Contribution to Criterion 5: basic math and sciences

Relationship of Course to ABET Outcomes (a) through (k)

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

PREPARED BY: Dr. Andre Petukhov, Department Head; June 1, 2010