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Course Outline for ENGR 46

MATERIALS OF ENGINEERING

Effective: Spring 2019

I. CATALOG DESCRIPTION:
ENGR 46 — MATERIALS OF ENGINEERING — 4.00 units

Application of principles of chemistry and physics to the properties of engineering materials; the relation of microstructure to mechanical, electrical, thermal and corrosion properties of metals; ceramics and polymers.

3.00 Units Lecture 1.00 Units Lab

Prerequisite
PHYS 1A - General Physics I
with a minimum grade of C

CHEM 1A - General College Chemistry I
with a minimum grade of C

Grading Methods:
Letter Grade

Discipline:
- Engineering

	MIN
Lecture Hours:	54.00
Expected Outside of Class Hours:	108.00
Lab Hours:	54.00
Total Hours:	216.00

II. NUMBER OF TIMES COURSE MAY BE TAKEN FOR CREDIT: 1

III. PREREQUISITE AND/OR ADVISORY SKILLS:

Before entering the course a student should be able to:

A. PHYS1A
1. Construct vectors in three dimensions to model physical phenomena, and perform algebraic calculations with these vectors.
2. Use algebra, trigonometry, geometry, and calculus to model physical phenomena and calculate relevant physical parameters.
3. Design, perform, analyze, and assess the effectiveness of simple experiments to demonstrate physical phenomena.
4. Operate standard laboratory equipment and analysis tools, including digital data acquisition systems, spreadsheet programs, and plotting programs.
5. Analyze real-world experimental data, including appropriate use of error propagation, units and significant figures.
6. Relate the results of experimental data to the physical concepts discussed in the lecture portion of the class.
7. Write comprehensive laboratory reports that describe the scientific basis of the experiment, clearly explain the experimental procedure, present a complete mathematical analysis of data and uncertainties, and evaluate the effectiveness of the experiment based on calculated uncertainties.

B. CHEM1A
1. Describe the different models of the atom;
2. Use standard nomenclature and notation;
3. Calculate enthalpies of reaction using calorimetry, Hess’s Law, heats of formation, and bond energies;
4. Describe bonding in compounds and ions;
5. Describe the nature of solids, liquids, gases and phase changes;
6. Describe metallic bonding and semiconductors;
7. Describe network covalent bonding;
8. Collect and analyze scientific data, using statistical and graphical methods;
9. Acquire and analyze data with a computer and appropriate software.

IV. MEASURABLE OBJECTIVES:

Upon completion of this course, the student should be able to:

A. Describe the atomic structure of metals (including defect types) and analyze how it can affect their engineering properties

B. Describe the properties for various engineering materials (metals, ceramics, and polymers)
C. Select appropriate engineering materials for a particular application
D. Analyze a stress-strain curve and predict the mechanical properties of a metal
E. Use equilibrium binary phase diagrams to discuss microstructure development
F. Describe the most common types of phases found in steel, analyze how these phases form, and determine the microstructure and mechanical properties of each
G. Describe how the microstructure of materials affects their electrical conductivity
H. Explain the differences between intrinsic and extrinsic semiconductors
I. Execute some common materials engineering related processing, testing and characterization techniques
J. Compile background information, experiment methods and materials, data and analysis, discussion of results and conclusion in a laboratory notebook using industry standards
K. Write comprehensive laboratory reports that describes the background behind why an experiment is being done, clearly describes the experimental procedure, presents data collected in an organized format, discusses what the data means including why results might not be what was expected, and draws conclusions

V. CONTENT:

A. Introduction to Materials of Engineering
    1. Five Basic Material Classes
    2. General understanding of relationship between
        a. Structure
        b. Properties
        c. Processing
        d. Performance
B. Structure of Materials
    1. Atomic Structure
    2. Interatomic Bonding
    3. Crystal Structure
C. Metals
    1. Metallic Crystall Structure Types
    2. Crystallography
    3. Linear and Planar Density
    4. Impurities and Imperfections
    5. Mechanical Properties and testing
    6. Elastic and plastic deformation in metals
    7. Stress-strain analysis
    8. Mechanical failure, fatigue, fracture and creep of Metals
    9. Strengthening, Toughening and Recovery Mechanisms
D. Atomic Diffusion
    1. Steady State
    2. Non-Steady State
E. Equilibrium Phase Diagram
    1. Binar Eutectic Phase Diagrams
        a. Number, Type, Composition of Phases Present
        b. Lever Rule to determine mass fraction of phases present
        c. Microstructure Development and Properties
    2. Steel (Fe-C) Phase Diagram Analysis
        a. Eutectoid Transition
        b. Steel Microstructure Development and Properties
F. Phase Transformation
    1. Nucleation and Growth of New Phases
    2. Rate of Phase Transformation
    3. TTT Diagrams
    4. Iron-Carbon (Steel) Phase Transformations
        a. Microstructure and Properties
G. Metals and Metal Alloys
    1. Forming and Fabrication
    2. Heat treatments
H. Ceramic Materials
    1. Crystal Structure
    2. Defects in Ceramics
    3. Mechanical Properties
I. Polymer Materials
    1. Polymerization
    2. Molecular Weight Calculation
    3. Basic Polymer Structure
    4. Thermoset vs Thermoplastic
    5. Mechanical Properties
J. Composite Materials (including wood and concrete)
    1. Particle Reinforced Composites
    2. Fiber Reinforced Composites
    3. Structure Composites
K. Corrosion
    1. Electrochemical Reactions
    2. Galvanic Series
    3. Forms of Corrosion
    4. Corrosion Prevention
L. Thermal, electrical and magnetic properties
    1. Electron Energy Band Structures
    2. Electron Resistivity
    3. Conductors
    4. Insulators
M. Semiconductors
    1. Intrinsic Semiconductors
    2. Extrinsic Semiconductors
        a. N-Type
        b. P-Type
N. Selection of materials in engineering design (optional)
O. Laboratory
    1. Manual vs Computerized Tensile Tests

2. Hardness Test
3. Impact Test
4. Metallography
5. Heat Treatment

VI. METHODS OF INSTRUCTION:

A. **Lab** - Work in teams using specialized equipment to study various materials engineering test methods.
B. **Lecture** - Utilized Power Point slides to instruct on materials engineering concepts
C. **Demonstration** - Provide time to complete example problems individually and then go over together as a class.
D. **Field Trips** - Visit local companies to see what materials engineering looks like in the “real world”.
E. **Discussion** - Groups discuss the results of experiments and draw conclusions based on what they are learning about materials engineering.
F. **Projects** - Study a materials engineering related topic and present findings as a group to class.

VII. TYPICAL ASSIGNMENTS:

A. Textbook Reading - Read text on material to be taught during next lecture, so prepared to ask questions.
B. Homework Assignments - Typical 10 - 20 word problems per assignment
C. Laboratory Assignments - Keep a laboratory notebook using industry standards to document lab experiements; Summarize results of in class experiement in a formal typed lab report; Use MS Excel (or Google Sheets) to create Stress-Strain curves from given sets of data and analyze the material's properties.
D. Oral Presentation - As a group, study a materials engineering related topic and present to class via an oral presentation, including Power Point slides (or similar)

VIII. EVALUATION:

Methods/Frequency

A. Exams/Tests
   two midterms that are short answer and problem solving based. One final exam that incudes matching, short answer and problem solving questions
B. Quizzes
   weekly or bi-weekly quizzes
C. Oral Presentation
   one group oral presentation
D. Group Projects
   one group oral presentation
E. Class Participation
   daily attendance and periodic in class assignments
F. Home Work
   weekly or bi-weekly homework assignments
G. Lab Activities
   keep a laboratory notebook using industry standards to document results on all lab related activities for 5-7 labs. Two group lab reports

IX. TYPICAL TEXTS:

1. Callister Jr., William, and David Rethwisch. *Materials Science and Engineering, An Introduction.* 9th ed., Wiley, 2014.
2. Askeland, Donald, and Wendelin Wright. *Essentials of Materials Science and Engineering.* 4th ed., Cengage, 2019.
3. Smith, William , and Javad Hashemi. *Foundation of Materials Science and Engineering.* 6th ed., McGraw-Hill, 2019.
4. Shackelford, James. *Introduction to Materials Science for Engineers.* 8th ed., Pearson, 2014.

X. OTHER MATERIALS REQUIRED OF STUDENTS:

A. Safety glasses
B. Calculator
C. Computer with access to Word and Excel (or similar)
D. Laboratory Notebook (without duplicate pages; composition notebook ok)
E. Computer file storage (e.g. USB Drive)