MSE 223R – Introduction to Materials Science and Engineering II

Credits and contact hours:	3 credits and 45 contact hours.
Indicate: math, basic science, engineering topic or other	Engineering Topic
Instructor's or course coordinator's name:	Dr. Krishna Muralidharan
Textbook, title, author and year:	Fundamentals of Materials Science and Engineering, 3rd Ed., William D. Callister, Jr. and David G. Rethwisch, John Wiley & Sons Inc., 2007.
Other Supplemental materials:	The Science and Engineering of Materials, Askeland and Phule
2021-2022 catalog description:	This course is the continuation of MSE 222 and covers mechanical properties of materials, mechanical testing, and strengthening mechanisms of materials. Also, phase diagrams and phase transformations pertaining to metals, metal-alloys, ceramics and glasses and polymers will be covered.
Prerequisites:	MSE 222 or 331R
Co-requisites:	None
Required, Elective, or Selected Elective:	Required
Instruction Outcomes:	1. To understand the fundamentals of mechanical properties and testing, including mechanical failure mechanisms and the mechanical testing of ductile and brittle materials. 2. To obtain a basic familiarity with metals, ceramics and polymers including their structure, properties, and processing. 3. To better understand the underlying thermodynamic basis of phase diagrams, and to understand the role of phase diagrams in predicting and interpreting microstructures. 4. To understand classical nucleation theory and, more broadly, the importance of surface energy in materials processing. 5. To understand the various strengthening mechanisms available in metals, including work hardening, solid-solution

	strengthening, grain-boundary strengthening, dispersion strengthening, and precipitation hardening.
Student Outcomes –	To produce graduates who can:
Listed in Criterion 3 or any other outcomes are addressed by the course:	✓1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics ✓6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions ✓7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Topics Covered

Review

- Structure of crystalline and non- crystalline materials: metals, ceramics and polymers

- **Mechanical properties of materials**
  - Elastic and plastic properties of metallic and ceramic materials: Elastic coefficients, Yield strength, Hardness, Slip and dislocations, Deformation by twinning
  - Materials failure: Ductile fracture, Brittle fracture, Fatigue, Creep
  - Deformation properties of polymers: Deformation of elastomers, Superelasticity, Viscoelasticity, Fracture of polymers
  - Composites: Polymer-matrix composites, Metal-matrix composites, Ceramic matrix composites, Carbon-carbon composites
- **Processing of metallic alloys, ceramics and polymers**
  - Phase diagrams: Isomorphous diagrams, Three phase reactions in binary systems, Phase diagrams of metals and ceramics, Microstructure interpretation based on phase diagrams
  - Classical Nucleation Theory: Homogeneous nucleation, Heterogeneous nucleation
  - Ferrous and non-ferrous alloys: Heat treatment, Transformation diagrams
  - Ceramics and glasses: Processing of ceramic powders: sintering, Glass transition temperature, clays
  - Polymers: Addition and condensation reactions, Thermoplasts and thermosets, Processing of polymeric materials
  - Thin films
  - Additive manufacturing and 3D printing
- **Thermal properties of materials**
  - Heat capacity
  - Thermal expansion
  - Thermal conductivity
  - Thermal stresses
- **Electrical properties of materials**
  - Electronic band structures
  - Electrical conductivity of metals:
    - Ohm's law

    - Electron mobility
  - Semiconductors
    - Intrinsic vs extrinisic
    - Temperature dependent conductivity
  - Ionic materials
  - Dielectric Properties
    - Types of polarization
    - Capacitance
    - Dielectric strength
  - Ferroelectricity
  - Piezoelectricity
  - Electrical properties of polymers
- **Optical properties of materials**
  - Reflection, refraction, absorption, transmission
  - Electronic interactions with electromagnetic radiation
    - Metals
    - Insulators
  - Luminescence
  - LASERS
  - Photoconductivity
  - Optical Fibers
- **Magnetic properties of materials**
  - Diamagnetism and paramagnetism
  - Ferromagnetism, ferrimagnetism and anti-ferromagnetism
  - Magnetic domains
  - Hysteresis
  - Soft vs hard magnetic materials
  - Superconductivity