<table>
<thead>
<tr>
<th><strong>MSE 223R – Introduction to Materials Science and Engineering II</strong></th>
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<tbody>
<tr>
<td><strong>Credits and contact hours:</strong></td>
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<tr>
<td><strong>Indicate: math, basic science, engineering topic or other:</strong></td>
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<tr>
<td><strong>Instructor’s or course coordinator’s name:</strong></td>
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<td><strong>Other Supplemental materials:</strong></td>
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<td><strong>2021-2022 catalog description:</strong></td>
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<tr>
<td><strong>Prerequisites:</strong></td>
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<td><strong>Co-requisites:</strong></td>
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<td><strong>Required, Elective, or Selected Elective:</strong></td>
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| **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 extrinsic
  - 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