

## MSE 365– Physical Properties of Materials

<b>Credits and contact hours:</b>	3 credits and 45 contact hours
<b>Indicate: math, basic science, engineering topic or other</b>	Engineering Topic
<b>Instructor's or course coordinator's name:</b>	Dr. Krishna Muralidharan and Dr. Pierre Deymier
<b>Textbook, title, author and year:</b>	Online course material
<b>Other Supplemental materials:</b>	<ol style="list-style-type: none"><li>1. The Oxford solid state basics, Simon</li><li>2. Electronic properties of materials, <i>Hummel</i></li><li>3. Introduction to solid state physics, <i>Kittel</i></li><li>4. Introduction to the physics and chemistry of materials, <i>Naumann</i></li><li>5. The physics and chemistry of solids, <i>Elliot</i></li></ol>
<b>2021-2022 catalog description:</b>	Introductory solid-state theory for describing thermal, electrical, optical and magnetic properties of materials.
<b>Prerequisites:</b>	MSE 222 and 223R.
<b>Co-requisites:</b>	None
<b>Required, Elective, or Selected Elective:</b>	Required
<b>Instruction Outcomes:</b>	<ol style="list-style-type: none"><li>(1) Develop a physical and theoretical understanding of the properties of materials including thermal , electrical (conductors and semiconductors), dielectric and magnetic properties</li><li>(2) Know orders of magnitude of specific properties for various classes of materials</li><li>(3) Develop a working knowledge regarding the relationship between properties and structure, especially the electronic and atomic structure</li><li>(4) Improve student's material literacy</li></ol>
<b>Student Outcomes –</b>	To produce graduates who can: ✓ 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

**Listed in Criterion 3 or any other outcomes are addressed by the course:**

✓2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

✓5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

✓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:**

#### **1 Introduction**

- Mathematical concepts: solution to the wave equation
- lattice structure of solids: classification, reciprocal lattices, x-ray diffraction

#### **2. Thermal properties of materials**

- periodic systems: phononic band structure of solids using a mass-spring representation
- introductory statistical mechanics
- heat capacity: Einstein's model, Debye model
- thermal expansion
- thermal conductivity

#### **3. Electronic properties of materials**

- Elementary quantum mechanics: particle in a box.
- Fermi electron gas: electronic heat capacity, cohesive energy
- Drude-Lorentz models
- electrons in periodic solids: electronic band structure-materials classification
- superconductivity
- semiconductors: intrinsic and extrinsic semiconductors, **semiconductor devices**
- electron dynamics: scattering, electrical conductivity, thermal conductivity and thermoelectric materials
- dielectric materials: **capacitors, batteries**, polarization, ionic materials, piezoelectricity

#### **4. Optical properties of materials**

- optical properties of electrons in solids: photoluminescence, Laser, LEDs, quantum dots, photovoltaics

#### **5. Magnetic properties of materials**

- diamagnetism, paramagnetism, ferromagnetism
- Technological applications

#### **6. Special topic: Nano-materials**