| Course Code | Course Title | ECTS Credits |
|---|---|---|
| ECE-527 | Electronic Properties of Materials | 8 |
| **Department** | **Semester** | **Prerequisites** |
| Engineering | Fall or Spring | PHYS-305 |
| **Type of Course** | **Field** | **Language of Instruction** |
| Elective | Engineering | English |
| **Level of Course** | **Year of Study** | **Lecturer(s)** |
| 2nd Cycle | 1st | Dr Marios Nestoros |
| **Mode of Delivery** | **Work Placement** | **Co-requisites** |
| Face-to-face | N/A | None |

**Objectives of the Course:**

The main objectives of the course are to:

- Explore the fundamental physical laws governing electrons in solids and relate them to the optical, electrical and magnetic properties of materials
- Understand the variation of the above properties between different materials and realize why specific materials are better for different technological applications.
- Provide the necessary background to proceed in a deeper and more extended study of solid state electronic devices
- Widen the knowledge in material science and engineering and help graduates to meet industry demand

**Learning Outcomes:**

After completion of the course students are expected to:

- Understand the basic electrical and magnetic properties of crystalline solids and amorphous materials.
- Understand the difference between electronic structures and physical properties of semiconductors, metals, and dielectrics.
- Understand the physics of magnetic phase transitions and superconductivity.
- Explain and analyze transport characteristics semiconductors, metals, and dielectrics
- Explain and analyze the optical behavior of materials.
- Explain and analyze the magnetic behavior of materials.
- Present the results of study and research

**Course Contents:**

- Electrons and energy bands in crystals: one-dimensional zone schemes, Brillouin zones, reciprocal lattice, free electron band structures of metals and semiconductors, Fermi energy, Fermi surface, Fermi distribution, density of states, effective mass.
- Electrical conduction in metals and alloys: classical electron theory and quantum mechanical treatment of conductivity, experimental results, superconductivity.
- Electrical conduction in polymers, ceramics, and amorphous materials:

conducting polymers and organic metals, ionic conduction, conduction in metal oxides, amorphous materials.

- Optical properties of materials: optical constants, index of refraction, damping constant, penetration depth, absorbance, reflectivity, transmissivity, atomistic theory, free electrons, bound electrons, harmonic oscillators.
- Applications of the optical properties of materials: Kramers-Kronig analysis, reflection spectra, semiconductors, insulators, gas lasers, semiconductor lasers, light-emitting diodes, integrated optoelectronics, waveguides, modulators, switches, optical data storage
- Magnetic phenomena and their classical interpretation: basic concepts, diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferromagnetism, Langevin theory.
- Quantum mechanical considerations of the properties of materials and their applications: paramagnetism, diamagnetism, ferromagnetism, antiferromagnetism, soft and hard magnetic materials, permanent magnets, magnetic recordings, magnetic memories.
- Thermal properties of materials: classical and quantum mechanical theory of heat capacity, Einstein and Debye models, phonons, classical and quantum mechanical considerations of thermal conduction in metals and alloys, thermal conduction in dielectric materials, thermal expansion

**Learning Activities and Teaching Methods:**

Lectures (3 hours/week)

**Assessment Methods:**

Midterm Test, Homework, Final Examination

**Required Textbooks/Reading:**

| Authors | Title | Publisher | Year | ISBN |
|---|---|---|---|---|
| R.E. Hummel | Electronic Properties of Materials | Springer-Verlag | 2011 | 978-1-4419-8163-9 |

**Recommended Textbooks/Reading:**

| Authors | Title | Publisher | Year | ISBN |
|---|---|---|---|---|
| J. R. Hook, H. E. Hall | Solid State Physics | Wiley | 1991 | 978-0-471-92805-8 |
| J. Pankove | Optical Processes in Semiconductors | Dover | 2010 | 0486602753 |
| R. F. Pierret | Advanced Semiconductor Fundamentals | Prentice Hall | 2003 | 0-13-061792-X |