**OFFICIAL UNDERGRADUATE COURSE OUTLINE (page 1)**

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|---|---|
| COURSE IMPLEMENTATION DATE: | September 2003 |
| COURSE REVISED IMPLEMENTATION DATE: | May 2015 |
| COURSE TO BE REVIEWED: | May 2020 |
| *(six years after UEC approval)* | *(month, year)* |

## OFFICIAL UNDERGRADUATE COURSE OUTLINE INFORMATION

Students are advised to keep course outlines in personal files for future use.

Shaded headings are subject to change at the discretion of the department – see course syllabus available from instructor

| PHYS 455 | Faculty of Science / Physics | 3 |
|---|---|---|
| COURSE NAME/NUMBER | FACULTY/DEPARTMENT | UFV CREDITS |

Solid State Physics
COURSE DESCRIPTIVE TITLE

**CALENDAR DESCRIPTION:**

Binding of molecules and atoms, crystalline structures and Bravais lattices in 2 and 3 dimensions, symmetry operations, and the Miller indices; Bragg's law and scattering off of crystals, x-ray diffraction, Brillouin zones, and form factors; lattice vibrations and phonons, dispersion relationships, thermal properties of crystals and heat capacities; Fermi levels and electrical properties, Bloch's theorem and conduction bands.

PREREQUISITES: (PHYS 231) and (PHYS 351).
COREQUISITES:
PRE or COREQUISITES: PHYS 311 recommended.

**SYNONYMOUS COURSE(S):**
(a) Replaces: **n/a**
(b) Cross-listed with:
(c) Cannot take: **n/a** for further credit.

**SERVICE COURSE TO:** *(department/program)*

**TOTAL HOURS PER TERM:** **75**

STRUCTURE OF HOURS:

| | | |
|---|---|---|
| Lectures: | **75** | Hrs |
| Seminar: | | Hrs |
| Laboratory: | | Hrs |
| Field experience: | | Hrs |
| Student directed learning: | | Hrs |
| Other (specify): | | Hrs |

TRAINING DAY-BASED INSTRUCTION:
Length of course:
Hours per day:

**OTHER:**
Maximum enrolment: **36**
Expected frequency of course offerings: on demand
*(every semester, annually, every other year, etc.)*

| | | |
|---|---|---|
| WILL TRANSFER CREDIT BE REQUESTED? (lower-level courses only) | ☐ Yes | ☐ No |
| WILL TRANSFER CREDIT BE REQUESTED? (upper-level requested by department) | ☐ Yes | ☒ No |
| TRANSFER CREDIT EXISTS IN BCCAT TRANSFER GUIDE: | ☐ Yes | ☐ No |

| | | | |
|---|---|---|---|
| Course designer(s): | **Peter Mulhern (revised by Jeff Chizma)** | | |
| Department Head: | **Derek Harnett** | Date approved: | **August 26, 2013** |
| Campus-Wide Consultation (CWC) | | Date of meeting: | **September 27, 2013** |
| Curriculum Committee chair: | **David Fenske** | Date approved: | **October 18, 2013** |
| Dean/Associate VP: | **Lucy Lee** | Date approved: | **October 18, 2013** |
| Undergraduate Education Committee (UEC) approval | | Date of meeting: | **January 31, 2014** |

**LEARNING OUTCOMES:**

Upon successful completion of this course, students will be able to:

- Identify the types of Bravias lattices and explain the reason for the finite number of them
- Explain the organization of the periodic table of the elements
- Write out primitive lattice vectors for a variety of lattice types
- Determine the Miller indices and interplanar separation for various lattices
- Calculate the scattering maxima condition for simple crystals
- Derive Bragg's law using several different methods
- Apply Fourier transforms to work within the reciprocal lattice
- State the importance of Brillouin zones within crystals
- Calculate the reciprocal lattice vectors given the primitive lattice vectors of a given lattice
- Distinguish between the four main methods of binding within a crystal, and state the properties of each
- Derive dispersion relationships for modes of crystal vibrations
- Employ a variety of approximation methods to model scattering and vibrations
- Discern the different contributions to internal energy and heat capacities of crystals
- Provide simple explanations of Fermi levels and Fermi energies
- Perform calculations on thermal and electrical properties of crystals based on Fermi levels
- Show the importance of band gaps in the operation of semiconductors and transistors

**METHODS:** *(Guest lecturers, presentations, online instruction, field trips, etc.)*

This course will be taught using lectures, demonstrations, seminars, and student projects. Problems will be assigned and marked on a regular basis.

**METHODS OF OBTAINING PRIOR LEARNING ASSESSMENT RECOGNITION (PLAR):**

☐ Examination(s) ☐ Portfolio assessment ☐ Interview(s)

☒ Other (specify): Please see the Physics PLAR policy on the department's webpage

☐ PLAR cannot be awarded for this course for the following reason(s):

**TEXTBOOKS, REFERENCES, MATERIALS:**

*[Textbook selection varies by instructor. An example of texts for this course might be:]*

Introduction to Solid State Physics, Charles Kittel--most recent edition
Solid State Physics, Ashcroft & Mermin, Brooks/Cole (1976)

**SUPPLIES / MATERIALS:**

**STUDENT EVALUATION:**

*[An example of student evaluation for this course might be:]*

| | |
|---|---|
| Assignments: | 30% |
| Term test: | 20% |
| Project or presentation: | 10% |
| Final exam: | 40% |

**COURSE CONTENT:**

*[Course content varies by instructor. An example of course content might be:]*

1. **Review and Overview**
   - Size and distance scales, symmetrized states, Pauli exclusion principle, simple binding, atoms and molecules, periodic table, spectroscopic notation

2. **Crystal Structure**
   - Crystal lattice, symmetry operations, translation vectors, Bravais lattices in two and three dimensions, lattice vectors, basis vectors, crystal planes and Miller indices, interplanar distances, examples of crystal structures

3. **Scattering from Crystals**
   - Bragg's law, plane wave scattering, Fourier transforms, scattering amplitude, reciprocal lattice and reciprocal lattice vectors, scattering condition, Laue equations, Ewald construction, Brillouin zones, structure factors, atomic form factors, scattering peak examples

*Course Content continued:*

4. **Crystal Binding**
   - Cohesive energy, molecular bonding, Lennard-Jones potential and Van der Waals force, ionic bonding, Madelung constant, covalent bonding and symmetry, metallic bonding and electron gases, material properties based on bonding type

5. **Elastic Properties of Crystals**
   - Compression and shear forces, stress and strain relationship, Young's modulus, elastic waves (transverse and longitudinal), group and phase velocities, dispersion

6. **Lattice Vibrations**
   - Harmonic potential approximation, monatomic and diatomic lattices, coupled oscillators, plane wave solutions, dispersion relationship in one dimension, acoustic and optical modes, relationship to the 1$^{st}$ Brillouin zone, relationship to Bragg scattering, long wavelength limit and elastic properties, optical excitations, phonons, elastic and inelastic phonon scattering

7. **Thermal Properties of Solids**
   - Heat capacities, internal energy, phonon and electron contributions, quantum statistics, Bose and Fermi gases, Planck distribution, phase space, density of states, Einstein and Debye models, equipartition theorem and classical results, Fermi energy level, comparison to experiment

8. **Electrical Properties of Solids**
   - Conduction electrons, electron transport and the Drude model of metals, periodic potentials and Bloch's theorem, Fermi surface, energy bands, band gaps, pn junctions and semiconductors, the transistor

9. **Selected Topics** (time dependent)
   - Optical properties of materials, superconductivity, Bose-Einstein condensates, magnetic properties of materials