Phys - 625 **SOLID STATE PHYSICS I** **Spring - 2009**

- **Instructor: Dr. Igor Ostrovskii**
- **Lecture: T, Th 11:00 – 12:15, Room 126 Lewis Hall**
- **Office: Room 207 Lewis Hall, Email: iostrov@phy.olemiss.edu**
- **Office Hours: M,W,Th 3:00 – 4:00 p.m. (207 Lewis Hall)**

- **TEXTS**

- **Main reading:**

1)"Introduction To Solid State Physics" by Charles Kittel, 8-th edition, 2005.
We cover chapters 1 through 9.

- **Additional reading:**

2) "Condensed Matter Physics" by Michael P. Marder, John Wiley & Sons, 2000.

- **Course objectives:**

1. Introduce the physics graduate students to Solid State Physics I.
2. Advance an understanding of the ideas of quantum physics applications to the solid state and condensed matter physics.
3. Expand an awareness of the current basis of knowledge in physics of solids including crystal structure, crystal binding, phonons and electrons in crystals, semiconductors, basic properties of solids including energy bands and Fermi surfaces.
4. Enhance the critical thinking, analytical reasoning, and problem solving skills for graduate level.
5. Expand an awareness of a scientific basis for advancements in contemporary scientific and technological issues.

- **Intended learning objectives / outcomes:**

In the learning objectives / outcomes, we answer a question: "What will the graduate students know and be able to do as a result of taking the class of Phys-625 and passing the final examination." The learning outcomes for graduate students are as follow:

1. Understand the basic principles of Solid State Physics.
2. Be aware and in depth understand the most important results in Physics of Solids that were discovered and developed mainly in 2nd half of 20th century *including following:*

   Crystal structure, Crystal lattice, Binding in solids, Phonons and Thermal properties, Properties of the electrons in solids, Band theory of solids, Semiconducting properties of solids, Fermi surfaces.

3. Understand the physical basis of numerous contemporary applications of Solid State Physics.
4. Graduates will develop a comprehension of the current basis of broad knowledge in Solid State and Condensed Matter physics.
6. Learners will build on a critical thinking, analytical reasoning, and problem solving skills at a level of MS and Ph. D. candidates.
7. They will know about the problems in Solid State applications, and practical problems confronting Solid State physics in 21st century.

8. MS and Ph. D. candidates will know about main Nobel Prize awards in the field of Solids and Condensed matter.

- **Fostering independent learning:**

A. To foster knowledge of the literature of a discipline:

1. Discuss the problems confronting physics of solids in the 21-st century based on the results developed mainly in 2^{nd} half of 20th century.

2. Learners will be recommended additional reading including texts, monographs, and particular Journal publications.

B. To ensure ongoing graduate student engagement in research:

3. Since in this course we introduce the graduates to the latest results in "Solid State Physics," they will have enough knowledge to understand contemporary needs in new high-technology applications and practical solutions.

4. Graduate students of my class will be given a particular homework consisting a presentation of a research topic of their choice, or to present in extended format a particular section from the text.

5. Alternatively, the learners may choose to give a talk on latest results in the field, for example, "Nobel Prize in Physics", applications of Nano-Sciences & Engineering, etc.

C. To ensure appropriate professional practice and training experience:

6. When teach the physical basis of major contemporary applications of Solid State Physics, to prompt learners to search for the publications in the scientific Journals for a particular physics phenomenon or effect.

7. Graduate students will know how to use interactive methods and Internet for their independent learning on "Solid State Physics I" especially those parts that describe the latest results in Solid State and its contemporary applications.

8. Learners will make the appropriate scientific presentations.

- **Grading Scale:** A -------------------- 90 – 100,
  B -------------------- 80 – 89,
  C -------------------- 70 – 79, etc.

Grades will be based on the home works, chapter tests, and final examination:

Home works and Presentation ----- 20%
Two tests ---------------------- 40% (#1=20%, #2=20%)
Final examination ------------------- 40%
TOTAL --------------------- 100.

➢ **Chapter Tests and Final examination schedule:**

- **Test 1 (**Chapters 1, 2, 3, 4**): Thursday, February 26.**
  [Crystal structure, Binding, and Phonons in Solids]

- **Test 2 (**Chapters 5, 6, 7**): Tuesday, April 9.**
  [Electrons and Energy bands**]**

❖ **FINAL EXAMINATION ------------ Monday, May 4, Noon.**

- **HOMEWORK RULES:**

1. **Homework** is assigned after some sections are covered and **is due in a week**.
2. Homework paper should be 8.5 x 11 inches with no torn or tattered edges. Homework papers should be stapled.
3. Show all your work; the answer alone is not worth anything. Homework problems must include enough English to be understandable.
4. **Important: Circle the finale answers that you want to be graded**.

- **COURSE CONTENTS:**

1. Ch. 1: **CRYSTAL STRUCTURE.** [2.5 Classes]
Fundamental types of crystal lattices. Simple crystal structures.

2. Ch.2: **WAVE DIFFRACTION AND THE RECIPROCAL LATTICE**. [2.5 Classes]
Diffraction of X-rays and matter waves by crystals. Brillouin Zones.

3. Ch. 3: **CRYSTAL BINDING**. [2.5 Classes]
Binding in the crystals of inert gases, ionic crystals, covalent crystals, metals. Hydrogen bonds.

4. Ch.4: **PHONONS I: CRYSTAL VIBRATIONS**. [2.5 Classes]
Vibrations of crystals with monatomic basis. Two atoms per primitive basis.
Quantization of elastic waves. Phonon momentum. Inelastic scattering by phonons.

- **TEST #1 (Class #11) → Thursday, February 26**

5. Ch.5: **PHONONS II: THERMAL PROPERTIES.** [2.5 Classes]
Phonon heat capacity. Anharmonic crystal interactions. Thermal conductivity.

6. Ch.6: **FREE ELECTRON FERMI GAS.** [4 Classes]
Energy levels in one dimension. Effect of temperature on the Fermi-Dirac distribution.
Free electron gas in three dimensions. Heat capacity of the electron gas. Electrical conductivity and Ohm's law. Hall Effect. Thermal conductivity of metals.

7. Ch. 7: **ENERGY BANDS.** [2.5 Classes]
Nearly free electron model. Bloch functions. Kronig-Penney Model. Wave equation of electron in a periodic potential. Number of orbitals in a band.

- **TEST #2 (Class 21) → Thursday, April 9**

8. Ch. 8: **SEMICONDUCTOR CRYSTALS.** [3 Classes]
Band gap. Equations of motion. Intrinsic carrier concentration. Impurity conductivity.
Thermoelectric Effects. Semimetals. Superlattices.

9. Ch. 9: **FERMI SURFACES AND METALS.** [2 Classes]
Reduced and periodic zone schemes. Construction of Fermi surfaces.
Electron and hole orbits. Calculation of energy bands.
PRESENTATIONS.

10. REVIEW [Last class #27]

- **FINAL EXAMINATION → Monday, May 4, Noon.**

- - The dates of chapter tests are tentative, and may be changed;

  BUT NOT the FINAL EXAMINATION.