

- **Instructor:** Dr. Igor Ostrovskii
- **Lecture:** T, Th 11:00 – 12:15, Room 109 Lewis Hall
- **Office:** Room 207 Lewis Hall, Email: iostrov@phy.olemiss.edu
- **Office Hours:** Th 3:30 – 4:30 p.m. (207 Lewis Hall), and by appointment.

COVID-19 policy: Faculty members and students must wear facemask or face covering while in the class room, hallways, etc. Students and faculty should stay 6 feet apart while entering and exiting any classroom.

- **TEXT:**

- **Main reading:**

1) “Introduction To Solid State Physics” by Charles Kittel, 8-th edition.

ISBN-10: 047141526X | ISBN-13: 978-0471415268. We cover chapters 1 through 8 and 20.

- **Additional reading:**

2) “Condensed Matter in Nutshell” by Gerald D. Mahan. Princeton University Press, 2011.

ISBN-10: 0691140162 | ISBN-13: 978-0691140162

- **Course objectives:**

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

- **GRADING SCALE:**
A's ----- 89 – 100
B's ----- 79 – 88
C's ----- 69 – 78
D's ----- 59 – 68

EVALUATION:

❖ **Grades are based on: The home works, tests, class activity, presentation, and final examination:**

Home works ---17%; Two tests --- 38% (2x19%); Class activity ---10 % for no absences,

Presentation --- 10%; Final exam ---25 %; TOTAL = 100 points

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

- **Test 1** (Chapters 1, 2, 3, 4): **Tuesday, February 23** (class 11)
[Crystal structure, Binding, and Phonons in Solids]
- **Test 2** (Chapters 5, 6, 7): **Thursday, April 1** (class 22)
[Electrons and Energy bands in Solids]

❖ **FINAL EXAMINATION ----- Tuesday, April 27, Noon – 3 p.m.**

- **EXAMS AND HOME WORKS RULES:**

1. ***EXAMS may not be “worked out,” EXAM at its day/time will be the only one.***
2. **Homework** is assigned after some sections are covered and **is due in a week.**
3. Homework paper should be 8.5 x 11 inches with no torn or tattered edges. Homework papers should be stapled.
4. Show all your work; the answer alone is not worth anything. Homework must include main principles, diagrams, explanations, enough English to be understandable.
5. **Important: Circle the finale answers that you want to be graded.**

IN CLASS: Turn off your phones before class! • You are expected to be civil to others in the class.

▪ **COURSE CONTENTS:**

1. **Ch. 1: CRYSTAL STRUCTURE.** [3 Classes]
Fundamental types of crystal lattices. Simple crystal structures. *Superlattices*.
2. **Ch.2: WAVE DIFFRACTION AND THE RECIPROCAL LATTICE.** [2 Classes]
Diffraction of X-rays and matter waves by crystals. Brillouin Zones.
3. **Ch. 3A: 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.
Phonons in superlattices.
 - **TEST #1 (Class #11) → Tuesday, February 23 (class 11)**
5. **Ch.5: PHONONS II: THERMAL PROPERTIES.** [3 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.** [3 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 22) → Thursday, April 1 (class 22)**
8. **Ch. 8: SEMICONDUCTOR CRYSTALS.** [3 Classes]
Band gap. Equations of motion. Intrinsic carrier concentration. Impurity conductivity.
Thermoelectric Effects. Semimetals. Superlattices.
9. **Review session for Final Examination** [1 Class]
10. **STUDENT PRESENTATIONS:** Overview of two chapters. [2 Classes]

❖ **FINAL EXAMINATION → Tuesday, April 27, Noon – 3 p.m.**

- The dates of chapter tests are tentative, and may be changed, **BUT NOT the FINAL EXAMINATION.**

- **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, Point defects in solids.
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 21st-st century based on the results developed mainly in 2nd 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.
9. *The Faculty Senate produced in November 2015 the document, which encourages faculty members to include the following text in their syllabi: "All materials distributed electronically and in hard copy in this class are protected under intellectual copyright. Any attempt to upload these documents onto the Internet (or to distribute them by some other means) or to profit from the distribution (by Internet or other means) of these documents constitutes theft and will be in violation of intellectual property law and the UM Academic Conduct Code unless expressly permitted for by the instructor. Accessing such materials for your own use is also in violation of the UM Academic Conduct Code. Additionally, the distribution of your own class notes via the Internet or other means, or access of such materials, encourages absence from class and is highly discouraged."*
10. **UM Attendance guidelines:** If a **student informs** an instructor in advance about an anticipated absence and the instructor decides not to provide an accommodation for a major exam or assessment, the student may appeal to the department chair or program director (or dean, when the instructor is chair or program director) who oversees the course. An appeal must be based on (a) failure of the instructor to articulate a policy, (b) failure of the instructor to follow the articulated policy, or (c) failure by the instructor to offer a reasonable accommodation for a documented absence that caused a student to miss an assessment that is **worth 20% or more of the course grade.** [Based on UM "Class Attendance Guidelines,"- **No accommodations for missed chapter tests will be made.**]