Solid State Physics
PHY 524/EE 524
Fall, 2026

I. INSTRUCTOR

Professor Lance De Long
Office: CP101 (257-6876)
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II. COURSE DESCRIPTION/MOTIVATION

PHY524 is a three-hour, ***intermediate-level***, lecture and problem course that introduces students to the concepts and formalism of solid state or condensed matter physics for physicists or other science/engineering majors. The Course is the single-most-important introductory course for specialists in solid state physics, chemistry, materials science and electrical engineering, and is prerequisite for most advanced or graduate courses in these areas of research.

The ***UK Bulletin*** describes PHY524 as a course on "introductory solid state physics with emphasis on the properties of electrons in crystals, crystal structure, crystal diffraction, reciprocal lattice, lattice vibrations and phonons, free electron theory, energy bands in solids, semiconductors."

Primary emphasis will be placed on the effects of crystal symmetry on electronic band structure and electrical conductivity, and the effects of quantum mechanics on selected thermodynamic and electromagnetic properties such as heat capacity and magnetic susceptibility. Additional material on surfaces/interfaces, nanomaterials and low-dimensional systems will be added to the traditional treatments of infinite crystalline solids wherever possible. These additions reflect the recent upsurge in the use of thin film devices and nanostructures in information technologies and sensor applications.

The Course will use simple theoretical models that introduce more general theoretical principles used in graduate courses on statistical mechanics and condensed matter physics. The presentations of both classical and quantum statistical models of basic properties of solids will emphasize so-called "single-particle" models, since interacting systems of particles are extremely difficult to analyze quantitatively. Additionally, classical macroscopic thermodynamic and electromagnetic treatments will be introduced to provide approximate, but intuitive formalisms for obtaining a basic understanding of interacting systems.

III. COURSE DELIVERY AND VENUE

PHY 524 is currently listed as an **IN-CLASS COURSE.** The classroom assigned to PHY524 is **The 90, Rm 211**, which will be the site for weekly lectures and the IN-CLASS Midterm and the Final Examinations, as scheduled below and in the *UK Bulletin*. The traditional method of hand-delivery of in-class exams will be used throughout the Semester. Deadlines for homework submissions are discussed below.

We will make use of the ***UK CANVAS*** shell to expedite the assigning and grading of homework during the Semester. Note that the *UK CANVAS* platform offers students convenient and secure access to their scores on homeworks and exams, as well as answer keys, lecture notes and supplemental materials. Students are required to submit homework solutions via **scanned pdf files**. In an emergency, assignments may be submitted to the Instructor via email attachment or cell phone camera images, depending on their availability to particular students.

Should a pandemic occur during the Fall Semester, the Instructor will likely switch to **REMOTE LEARNING**. This would require students to use a PC and some type of scanner to turn in homework and exams. In a REMOTE LEARING scenario, lectures would meet **SYNCHRONOUSLY ONLINE**, TR, 9:30 – 10:45, using the UK ***ZOOM*** platform.

IV. REQUIRED MATERIALS AND PREREQUISITES

The required textbook is C. Kittel, *Introduction to Solid State Physics* (John Wiley and Sons, New York, 2005, 8th Ed.). A useful reference for macroscopic thermodynamics is the book by C. J. Adkins, *Equilibrium Thermodynamics* (Cambridge, 3rd Ed., Cambridge, UK, 1983). The Instructor will put a few other texts or references on reserve in the Science and Engineering Library, including most of the sources listed in the Course Schedule, below.

Familiarity with multivariate calculus and partial derivatives will be essential. It is assumed students are familiar with the elementary principles of electricity and magnetism, thermodynamics, elementary statistical mechanics, and basic quantum mechanics, at least at the levels of PHY 231, 232 and 361; nevertheless, background at the levels of PHY 522, 416, 417 and 520 will be very useful. Students enrolled in the cross-listed EE 524 course can expect more difficulty in understanding and using some of the mathematical models introduced in Upper Division background courses (especially PHY522 and PHY520); however, the Instructor will assume that Engineering students have no prior experience with this material when discussing relevant models in Lecture.

As stated above, students will need to use ***CANVAS and possibly ZOOM*** **software** throughout the Course. *CANVAS* can be accessed from the UK *CANVAS* Shell via *MyUK*. It is assumed that students will have access to UK email and the internet services throughout the Fall Semester. Issues involving hardware and software problems should be directed to the College of Arts and Sciences IT personnel for assistance. Students are also encouraged to consult one another to solve these kinds of problems and minimize downtime from online course activities.

V. STUDENT RESPONSIBILITIES

PHY 524 will resemble a traditional graduate seminar course supervised by a "reader". Lectures will present example problems and discussions of particularly difficult aspects of condensed matter phenomena or related mathematical methods. Active ***involvement in class discussions*** and use of logic and integrative thinking on the part of students will be emphasized. ***Prior preparation***, including careful reading of pre-posted Lectures will introduce students to important skills and subject matter, and prepare them to ask productive questions during class time. Students should also read pre-assigned sections of the textbook or other references (on Reserve in the *S and E Library*, or posted on *CANVAS*) before they are covered in Lecture. All of the preparatory material assigned for each online Lecture is listed in the Course Schedule attached to this Syllabus.

Homework problems will be assigned from Lecture and the Textbook on a weekly basis. Homework assignments will develop the student's ability to independently apply the information and skills gained in the Text, Lecture and previously assigned Homework, to new situations. The student can expect around four or five problems assigned per week, for around 4-5 points of credit for each problem assigned. ***Past experience has shown that poor homework performance is highly correlated with a low course grade.***

Students should expect to attend all Lectures, and to spend at least 8 to 10 hours per week on assigned homework and background reading.

VI. GRADING

The "500-level" of this Course implies that it be taught at a level that both Upper Division undergraduates and beginning graduate students can digest. Undergraduate students will be assessed by the usual grade scale ranging from "A" to "E", as outlined in the criteria for assigning course grades contained in the ***University of Kentucky Bulletin***. Note that Graduate Students must maintain a minimum grade point average of 3.0, which differs from the Undergraduate rules; in particular, a "C" grade is considered a "poor" performance for Graduate Students. Consult the ***UK Graduate School Bulletin*** for details. The final course grade will be based on:

A. Homework (total of scores), 40%
B. One Midterm Hour Exam, 20%
C. Final Exam, 40% (IN CLASS, Tuesday, December 13, 2022, 10:30 to 12:30 EST)

VII. ATTENDANCE AND MAKE-UPS

PLEASE NOTE THAT STUDENTS WHO DO NOT ATTEND EITHER OF THE FIRST TWO LECTURES OF THE COURSE MAY BE DROPPED FROM THE CLASS ROLE.

If you must miss an examination or cannot turn in a homework set, a make-up can be arranged. Acceptable excuses include serious illness, official University activity (e.g., away game, field trip, conference), etc. Foreseeable absences, such as University activities, must be cleared with your instructor at least one week in advance. Unforeseen absences must be excused by your Instructor no later than one week after the fact in for a make-up to be allowed. You may not double-schedule classes or agree to out-of-class exams in conflict with PHY 524 exams -- these are not acceptable excuses. The Instructor has the right to request some form of documentation justifying student absences and has authority to judge the acceptability of the excuse, consistent with University rules.

In extraordinary circumstances in which the student has a valid excuse for missing a large number of assignments or the Final Exam, an "Incomplete" grade may be given, consistent with University regulations.

VIII. Course Evaluations

Course evaluations are an important (and mandatory!) component of our Department's instructional program. An on-line course evaluation system was developed to allow each student

ample time to evaluate each component of the course and instructor, thus providing the Department with meaningful numerical scores and detailed commentary while minimizing the loss of instructional time in the classroom. The evaluation window for Fall, 2022, will open sometime just before the last week of classes in early December. To access the system during this time, simply go the Department of Physics Web page at www.pa.uky.edu and click on the link for Course Evaluations; then follow the instructions. You will need to use your student ID\# to log into the system, and this will also allow us to monitor who has filled out evaluations. However, when you log-in you will be assigned a random number that will keep all your comments and scores anonymous.

IX. Class Recording Notification

The University of Kentucky Student Code of Conduct defines Invasion of Privacy as using electronic or other devices to make a photographic, audio, or video record of any person without their prior knowledge or consent when such a recording is likely to cause injury or distress.

Meetings of this course may be recorded. All video and audio recordings of lecturers and class meetings, provided by the instructors, are for educational use by students in this class only. They are available only through the Canvas shell for this course and are not to be copied, shared, or redistributed.

As addressed in the Student Code of Conduct, students are expected to follow appropriate university policies and maintain the security of linkblue accounts used to access recorded class materials. Recordings may not be reproduced, shared with those not enrolled in the class, or uploaded to other online environments.

If the instructor or a University of Kentucky office plans any other uses for the recordings, beyond this class, students identifiable in the recordings will be notified to request consent prior to such use. In anticipation of such cases, students may be asked to complete an "authorization of use" form by a faculty member.

Video and audio recordings by students are not permitted during the class unless the student has received prior permission from the instructor. Any sharing, distribution, and or uploading of these recordings outside of the parameters of the class is prohibited. Students with specific recording accommodations approved by the Disability Resource Center should present their official documentation to the instructor.

All content for this course, including handouts, assignments, and lectures are the intellectual property of the instructors and cannot be reproduced or sold without prior permission from the instructors. A student may use the material for reasonable educational and professional purposes extending beyond this class, such as studying for a comprehensive or qualifying examination in a degree program, preparing for a professional or certification examination, or to assist in fulfilling responsibilities at a job or internship.

XI. COURSE SCHEDULE (07/13/26 VERSION)

DATE	ACTIVITY	TOPIC	READINGS/HW
PART ONE: THE STRUCTURE AND SYMMETRIES OF SOLIDS			
T Aug 25	L1	Intro to Condensed Matter	W2.5-2.8, 3.1-3.5; C 1
R Aug 27	L2	Basics of Crystal Structure and Symmetry	K 1; C 2; AM 4, 7; M Chapts. 1-7
T Sept 1	L3	Crystal Planes and Miller Indices	K 1; C 2.1-2.4; **HW#1 Due**
R Sept 3	L4	Elastic Scattering of Waves by Crystals	K 2; C 4.1-4.2
M Sept 7	**---**	**LABOR DAY HOLIDAY**	
T Sept 8	L5	Lattice with Basis; Structure and Form Factors	K 2; C 4.1-4.2; **HW#2 Due**
R Sept 10	L6	Diffraction Conditions (Bragg, Laue)	K 2; AM 6
F Sept 11	**---**	**LAST DAY TO DROP COURSE**	
T Sept 15	L7	Properties of the Reciprocal Lattice; Brillouin Zones	K 2; AM 5; **HW#3 Due**
R Sept 17	L8	Structure of Surfaces and Interfaces	K 17
PART TWO: STABILITY AND EXCITATIONS OF CRYSTAL LATTICES			
T Sept 22	L9	Bonding in Solids; One-D van der Waals Model	K 1,3; C5.1, 5.6; AM 19-20; W 2.7; **HW#4 Due**
R Sept 24	L10	Covalent Bonding; Hydrogen Molecular Ion	C 5.1-5.2; K 3; L 9; S 1; W 2.7; AM 19-20
T Sept 29	L11	General Covalent Bonding; Hard Core Repulsion	C 5.3; AM 20; K3; W 2; S 1
R Oct 1	L12	Ionic Bonding	K 3; C5.4; AM 20; A 1, 8.1; W 2.7

DATE	ACTIVITY	TOPIC	READINGS/HW
T Oct 6	L13	Elastic Waves in 1-D, Monatomic Lattice (I); Equation of Motion and Born-von Karman BC's Anharmonicity, Thermal Expansion, Conductivity	K 4; C 6.1-6.2; AM 22; **HW#6 Due**
R Oct 8	**MTE**	**MID-TERM EXAM (In-Class)**	**K Chapts. 1-3**
T Oct 13	L14	Elastic Waves in 1-D, Monatomic Lattice (II)	K 4; C 6.1-6.2; AM 22
R Oct 15	L15	Elastic Waves in1-D Lattice with Basis	K 4; C 6.3; **HW#7 Due**
M Oct 19	**---**	**MIDTERM GRADES POSTED**	
T Oct 20	L16	Normal Modes, Dispersion Relations, Density of States	K 4, 5; C 6.4-6.5; **HW#8 Due**
R Oct 22	L17	Quantized Lattice Vibrations (Phonons)	K 5, App. C
Oct 26-27	**---**	**FALL BREAK—NO CLASS**	**HW#9 Due**
R Oct 29	L18	Debye and Einstein Models of 3-D Lattice	K 5; AM 23
T Nov 3	L19	Free Electron Model, Bohr-Sommerfeld Method	K 6, AM 1-3; C 7.4 **HW#10 Due**
R Nov 5	L20	Applications/Successes of Free Electron Model	K 6, AM 1-3; C 7.4
PART THREE: ELECTRONIC STRUCTURE OF CRYSTALLINE SOLIDS			
T Nov 10	L21	Electrons in Periodic Potentials: Classification Of Orbitals, Bloch's Theorem, BvK BC	K 7; AM 8; **HW#11 Due**
R Nov 12	L22	Bloch's Theorem and Formal Symmetries	K 7; C 7.2; AM 8; D10.1-2
S Nov 14	**---**	**LAST DAY TO WITHDRAW FROM COURSE**	
T Nov 17	L23	Kronig-Penny Model	K 7; D10.1-3; **HW#12 Due**
R Nov 19	L24	Nearly Free Electron (NFE) Model I	K 7, AM 9; C 7.4

DATE	ACTIVITY	TOPIC	READINGS/HW
T Nov 24	L25	Nearly Free Electron (NFE) Model II	K 7, AM 9; C 7.4; **HW#13 Due**
Nov 25-27	**---**	**THANKSGIVING HOLIDAY; NO CLASS**	
T Dec 1	L26	Tight Binding Model I	K 7, AM 10; C 7.4; **HW#14 Due**
R Dec 3	L27	Tight Binding Model II	K 7, AM 10; C 7.4
Dec 7-11	**---**	**PREP, READING DAYS**	
T Dec 8	L28	Semiclassical Electron Motion; Fermi Surface; Classification of Solids	K 7, 9; D10.4-10.5; AM 12,19
W Dec 9	**---**	**LAST DAY OF CLASS (no L29 on 12/10)**	
Dec 14-18	**---**	**FINAL EXAMS**	
T Dec 15	**FE**	**PHY524 FINAL EXAM, IN CLASS, 8:00 to 10:00 am** Comprehensive Coverage of whole Semester.	
F Dec 18	**---**	**END OF FALL SEMESTER; GRADES DUE TO REGISTRAR 12:30 EST**	

KEY TO PRIMARY COURSE REFERENCES:

A: C. J. Adkins, "Equilibrium Thermodynamics", 3rd Edition (Cambridge U. Press, Cambridge, 1983)

AM: N. W. Ashcroft and N. D. Mermin, "Solid State Physics", 1st Edition (Saunders College, Philadelphia, 1976)

B: J. S. Blakemore, "Solid State Physics" (Cambridge University Press, 2nd Ed., Cambridge, 1985)

C: J. R. Christman, "Fundamentals of Solid State Physics" (John Wiley and Sons, New York, 1988)

D: A. J. Dekker, "Solid State Physics" (Prentice-Hall, Englewood Cliffs, New Jersey, 1959)

E: R. M. Eisberg, "Fundamentals of Modern Physics" (John Wiley and Sons, New York, 1961)

K: C. Kittel, "Introduction to Solid State Physics", 8th Edition (John Wiley and Sons, New York, 2005)

L: R. B. Leighton, "Principles of Modern Physics" (McGraw-Hill, New York, 1959)

LL: L. D. Landau and E. M. Lifshitz, "Electrodynamics of Continuous Media" (Addison-Wesley, Reading, MA, 1960)

M: H. D. Megaw, "Crystal Structures: A Working Approach", 1st Edition (W. B. Saunders, Philadelphia, 1973)

MK: J. P. Mc Kelvey, "Solid State and Semiconductor Physics" (Krieger, 1982)

RM: J. R. Reitz and F. J. Milford, "Foundations of Electromagnetic Theory" (Addison-Wesley Publishing, Reading, MA, 1967).

S: J. C. Slater, "Quantum Theory of Molecules and Solids", 1st Edition (McGraw-Hill, New York, 1965)

VV: J. H. Van Vleck, "Electric and Magnetic Susceptibilities" (Oxford University Press, London, 1966)

W: A. J. Walton, "Three Phases of Matter", 2nd Edition (Clarendon Press, Oxford, 1983)