Solid State Physics

CEFNS, PHY581, Lecture Course 7990 (3-hrs.)
Department of Physics and Astronomy
Northern Arizona University, Mountain Campus
Fall 2018: August 27 – December 14, 2018
Pre- or co-req. PHY 471; Co-convened with PHY481

NAU NORTHERN ARIZONA UNIVERSITY
College of the Environment, Forestry, and Natural Sciences

Class Meeting Times & Location

- In-person meeting: Room 218, Physical Sciences Bldg. 19, MWF: 10:20am – 11:10am

Instructor Contact Information & Office Hours

- John Gibbs, Office: 307 Bldg. 19, Phone: 523-1916, Email: john.gibbs@nau.edu
- Office Hours: 9:00am – 10:00am

Class Website

- http://www.physics.nau.edu/~gibbs/18_fall_PHY481&581.html (link)

Course Purpose

- This course is required for graduation from the MS in Applied Physics, and is an essential part of the curriculum. We will learn how the microscopic structure gives rise to the macrostates of crystalline solids. These macrostates dictate a solid's physical properties including thermal, electrical, magnetic, and optical.

Student Learning Outcomes

- By the end of the class, students will be able to explain how the microscopic structure of rigid materials (the behavior and interactions of the atomic and molecular underpinnings) leads to macroscopic behavior. Further, students will be able to solve basic problems about solids analytically and interpret experimental data, and will learn to communicate these concepts to both lay- and expert audiences.

Assignments & Grading System (see second page for details of assignments)

- We will have homework and quizzes over the topics listed below. I encourage you to work with your classmates on the homework. No midterm exams but a comprehensive final exam will be given. You will also have a final project that will entail a paper and a presentation.
- Grades: **A** (90-100%), **B** (80-89%), **C** (65-79%), **D** (50-64%), & **F** (<50%)
- Breakdown: 30% Homework; 30% Quizzes, 20% Final project, 20% Final Exam
- Final Exam: Monday, December 10 @ 10:00am – 12:00pm

Reading Material

- The structure of the class will approximately follow the book: *The Oxford Solid State Basics* (2013) – a free version (available on our webpage): Oxford University Professor Steven H. Simon's, *Lecture Notes for Solid State Physics*. I will also borrow heavily from the books *Elementary Solid State Physics* by M. Ali Omar & *Introduction to Solid State Physics*, by Charles Kittel.

Tentative Schedule of Topics

- Time permitting, I aim to cover the listed topics below (15 weeks, 42 lectures):

TOPICS	WEEKS
SPECIFIC HEAT IN SOLIDS	1
ELECTRONS IN METALS	2-3
STRUCTURE OF SOLIDS	4
VIBRATIONS (PHONONS)	5-6
CRYSTALS & RECIPROCAL SPACE	7-9
BAND STRUCTURE	10-12
MAGNETISM IN SOLIDS	13-14
SUPERCONDUCTIVITY	15

*** University closures:**

Mon. Sept. 3 – Labor Day
Mon. Nov. 12 – Veterans Day (observed)
Fri. Nov. 23 – Thanksgiving Break

Details of Assignments and Alignment with Learning Outcomes

- Homework: In order to achieve the stated learning outcomes, the homework assignments are the most important of all three categories of assessment. Each of the topics in the table in the previous section will have at a minimum of one assignment that will consist of 2-5 problems that will challenge the student to think critically about how the microstates lead to the macrostates of solid materials. In order to obtain the most from these assignments, students should attempt the problems alone. Only after attempting to solve the problems should the student consult the instructor or classmates to arrive at the correct answers.

- Quizzes: The quizzes will test the working knowledge and understanding of how microstates lead to macrostates in solids. The quizzes will cover the topics on the previous page and will consist of 2-5 problems that will be solved in class. These quizzes are mostly a control to assure the students are learning the material themselves and not relying completely upon external help as may be the case for the homework assignments.

- Final Project: Students will be given a choice of topics from which they will choose a final project. The students will work in teams of two, and will be required to write a high-quality, publication-worthy paper on that topic. Furthermore, the teams will be required to present their topics near the end of the semester, which will last for ~20 minutes. More details will be supplied during the semester.

- Final Exam: A comprehensive final exam will assess the student's overall knowledge of the topics. The questions will likely not be as detailed as the homework and quiz problems, but will be designed to assess the working analytical skills of the student regarding the fundamentals of solid state physics.

Course Policies

- There is no attendance policy & assignments may be turned in late with a penalty at the professor's discretion.
- Quizzes cannot be made up; however, one quiz will be dropped from the final grade.

University Policies & Other Resources

ACADEMIC INTEGRITY

- NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full academic integrity policy available at https://policy.nau.edu/policy/policy.aspx?num=100601.

COURSE TIME COMMITMENT

- Pursuant to Arizona Board of Regents guidance (Academic Credit Policy 2-224), for every unit of credit, a student should expect, on average, to do a minimum of three hours of work per week, including but not limited to class time, preparation, homework, and studying.

DISRUPTIVE BEHAVIOR

- Membership in NAU's academic community entails a special obligation to maintain class environments that are conductive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not breach the peace, interfere with normal class activities, or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which

can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's disruptive behavior policy at https://nau.edu/university-policy-library/disruptive-behavior.

NONDISCRIMINATION AND ANTI-HARASSMENT

- NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, or veteran status. Due to potentially unethical consequences, certain consensual amorous or sexual relationships between faculty and students are also prohibited. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's Safe Working and Learning Environment (SWALE) policy. EAO also assists with religious accommodations. For additional information about SWALE or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or via the EAO website at https://nau.edu/equity-and-access.

TITLE IX

- Title IX is the primary federal law that prohibits discrimination on the basis of sex or gender in educational programs or activities. Sex discrimination for this purpose includes sexual harassment, sexual assault or relationship violence, and stalking (including cyber-stalking). Title IX requires that universities appoint a "Title IX Coordinator" to monitor the institution's compliance with this important civil rights law. NAU's Title IX Coordinator is Pamela Heinonen, Director of the Equity and Access Office located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011. The Title IX Coordinator is available to meet with any student to discuss any Title IX issue or concern. You may contact the Title IX Coordinator by phone at 928-523-3312 (TTY: 928-523-1006), by fax at 928-523-9977, or by email at pamela.heinonen@nau.edu. In furtherance of its Title IX obligations, NAU will promptly investigate and equitably resolve all reports of sex or gender-based discrimination, harassment, or

  sexual misconduct and will eliminate any hostile environment as defined by law. Additional important information about Title IX and related student resources, including how to request immediate help or confidential support following an act of sexual violence, is available at http://nau.edu/equity-and-access/title-ix.

ACCESSIBILITY

- Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), 928-523-6906 (TTY), 928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at https://nau.edu/disability-resources/student-eligibility-process or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU's Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

RESPONSIBLE CONDUCT OF RESEARCH

- Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at https://nau.edu/research/compliance/research-integrity.

SENSITIVE COURSE MATERIALS

- University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.