

## PHY 436 Condensed Matter

Instructor: Dr. Romulo Ochoa  
Science Complex - P132  
Phone: 771-3162 e-mail: [ochoa@tcnj.edu](mailto:ochoa@tcnj.edu)

Days and times of scheduled office/student hours:

**Tuesdays 11:00 a.m. - 1:00 p.m., Wednesdays 10:30 a.m. - 11:30 a.m.**

All communication outside of class should be handled by email: [ochoa@tcnj.edu](mailto:ochoa@tcnj.edu)

Expectations for response times: 24 hours on weekdays, 48 hours on weekends.

Expectations for virtual office hours:

- Office hours will be held in zoom.
- It is recommended that you select a time and place to come to office hours where you can have your camera on for better clarity in questions and answers.
- Have your course materials (books, notes, etc.) available when you attend office hours.
- Here is a quick tutorial for screen sharing to aid in showing documents during the call:
  - <https://www.youtube.com/watch?v=YA6SGQIVmcA>

Procedure for attending office hours:

- Select an appointment from the available time slots in Google Calendar.

<https://calendar.google.com/calendar/u/0/selfsched?sstoken=UUhzM11OT0R3X0ZZfGRIZmF1bHR8NTA1M2JiYWFiNmU4YmRjOGNhMWY2ZmQ0NjNjNmI0ZTA>

Open the zoom call that is provided here:

Tuesday office hours:

<https://tcnj.zoom.us/j/96950745936?pwd=Z0dsMFFrMUFmOHl6RnRxeHUvTjBYUT09>

Passcode: 126556

Wednesday office hours:

<https://tcnj.zoom.us/j/98139501076?pwd=eEVbnlVUINDdlV5bHFRR2RyOE1XZz09>

Passcode: 627393

- The waiting room will be activated so that other students do not arrive in office hours in the middle of your questions. Please wait until the professor “admits” you into the office.

### Course Description

Fundamental concepts of condensed matter and applications to problems in current theoretical and applied physics are presented. Topics covered include crystal structure, lattice vibrations, phonons, thermal properties of matter, free electron theory of metals, band theory, semiconductors, superconductors, optical properties of solids and magnetism. Problem solving and computer projects are integral parts of the course.

### Course Materials

Additional topics from “Physics for Scientists and Engineers,” Serway and Jewett.

### Course Requirements

Class attendance, completion of homework associated with each chapter, active class participation, a YouTube video or computer program, two tests, and a final presentation on a relevant topic.

## Course Outline

1. Basic Quantum Mechanics Concepts/Review  
Photoelectric and Compton effects. Uncertainty principle. Bohr's model. Pauli's exclusion principle. Energy states and spectra of molecules. Rotational and vibrational energies.
2. Crystal Structures  
Elementary crystallography. Typical crystal structures. X-ray crystallography. Interatomic forces.
3. Crystal Dynamics  
Sound waves. One dimensional lattice vibrations. Phonons. Heat capacity from lattice vibrations. Anharmonic effects.
4. Free Electrons in Metals Free electron model. Transport properties of the conduction electrons.
5. Energy Bands  
Nearly free electron theory. Metals, insulators and semiconductors. The tight binding approximation. Band structure effective masses.
6. Semiconductors  
Electrons and holes. Impurities. Absorption of electromagnetic radiation. Transport properties. Non-equilibrium carrier densities.

## Grading

1. tests (40 points)
2. final presentation (20 points)
3. homework problems (10 points)  
Late homework will not be accepted. Homework should be presented in an ordered and neat presentation; points will be deducted for lack of these.
4. Computer project or YouTube video (15 points)
5. Class participation/polls (3 points)
6. Additional Projects (12 points): Complete two of the following: Atomic force microscope, scanning electron microscope, 3D printer, X-ray diffraction.

Grading Scale	
Final Score	Letter Grade
92.5 - 100	A
89.5 - 92.4	A-
86.5 - 89.4	B+
82.5 - 86.4	B
79.5 - 82.4	B-
76.5 - 79.4	C+
72.5 - 76.4	C
69.5 - 72.4	C-
66.5 - 69.4	D+
59.5 - 66.4	D

### Exam or Test Absences Policy

- I. Final Exam:** The final exam schedule is known well in advance. Serious personal illness and death in immediate family will be the only acceptable excuses. All students must follow the general guidelines stated below. All excused students must take their make-up final exam before 2:00 PM on the last day of the final exams, or they will receive an incomplete (I) or an F. It is the student's responsibility to request the make-up and provide a timely and acceptable proof.
- II. Tests:** You should make every effort to take the test at its scheduled date. If you cannot: You must **inform** the instructor about the nature of your absence before the missed test (for non-emergency absences) or within 24 hours after the missed test (for emergency absences); By the following class period you must show the instructor (or arrange to be shown) a **proof** that the absence is excusable; it is the student's responsibility to contact the instructor in a timely manner and provide an acceptable excuse.
- III. Excuses:**  
**Non-acceptable:** Travel plans, weddings, lack of preparation, busy schedules; too many other obligations, assignments, or tests; job interviews, doctor's appointments or any other engagements or appointments that can be scheduled at different times, and alike, **will not be accepted** and the student will receive zero points for the test - **no exceptions**. The test dates are known ahead of time, so please plan accordingly.  
**Acceptable:** Personal illness, death in one's family, and alike.
- IV. Taking the Make-Up:**  
A student will be allowed to take a make-up only for an excused absence;  
Unless otherwise stated in writing by her/his physician, s/he must take the make-up **within seven days** of the missed examination.  
If the student fails to inform the instructor, does not provide an acceptable proof, or does not take the make-up in a timely manner, s/he will be given zero.  
The make-ups will be **different** from regular examination, so **timely notification** of the instructor is essential.

### Fourth Hour:

In this class, the deep learning outcomes associated with TCNJ's 4th hour are accomplished by a series of rigorous educational assignments that extend beyond the typical scheduled class time. These include activities such as oral presentations, out-of-class problem sets, and out-of-class online learning activities such as video lectures and reading assignments.

### Additional Resources

- Ashcroft, N. W. and Mermin, N. D., "Solid State Physics," Rinehart and Winston (1976).  
Harrison, W. A., "Solid State Theory," Dover (1979).  
Hofmann, "Solid State Physics," 2nd ed. Wiley-VCH (2015).  
Kittel, C., "Introduction to Solid State Physics," 6th ed. Wiley (1986).  
Myers, H. P., "Introductory Solid State Physics," Taylor and Francis (1990).  
Turton, R., "The Physics of Solids," Oxford (2000)

## **Seminar Project Topics**

Fullerenes  
Giant magnetoresistive effect  
Graphene  
Micro electromechanical devices (MEMS)  
Photonic Crystals  
Photovoltaics and solar cells  
Quantum dots  
Scanning and Transmission electron microscopy  
Semiconductor lasers and LEDs  
Superconductivity  
X-ray diffraction methods  
OLEDs  
Spectroscopy: Raman, Brillouin, Auger, etc.  
Other suggested by students that are considered relevant by instructor

## **SELECTED TCNJ POLICIES**

### **Final Examinations**

The final exam is not scheduled until the middle of the semester. Therefore do not plan on any travel until after the last day of the exam period. TCNJ's final examination policy is available on the web:

<http://policies.tcnj.edu/policies/digest.php?docId=9396>

### **Attendance**

Every student is expected to participate in each of his/her courses through regular attendance at all class sessions. It is further expected that every student will be present, on time, and prepared to participate when scheduled class sessions begin. While attendance itself is not used as a criterion for academic evaluations, grading in this course is based on participation in quizzes to be given at the beginning of several classes. No make-ups or extensions will be given unless a student has a genuine emergency. If a student misses an exam or assignment deadline they must contact the instructor within 36 hours to explain the situation; otherwise the student will earn a zero for that exam or assignment.

Students who must miss classes due to participation in a field trip, athletic event, or other official college function or for a religious holiday should arrange with their instructors for such class absences well in advance. In every instance, however, the student has the responsibility to initiate arrangements for make-up work.

TCNJ's full attendance policy is available at:

<http://policies.tcnj.edu/policies/digest.php?docId=9134>

### **Academic Integrity Policy**

Academic dishonesty is any attempt by the student to gain academic advantage through dishonest means, to submit, as his or her own, work which has not been done by him/her or to give improper aid to another student in the completion of an assignment. Such dishonesty would include, but is not limited to: submitting as his/her own a project, paper, problem set, report, test, or speech copied from, partially copied, or paraphrased from the work of another (whether the source is printed, under copyright, or in manuscript form). Credit must be given for words quoted or paraphrased. The rules apply to any academic dishonesty, whether the work is graded or ungraded, group or individual, written or oral.

TCNJ's academic integrity policy is available at:

<http://policies.tcnj.edu/policies/digest.php?docId=9394>

**Americans with Disabilities Act (ADA) Policy**

Any student who has a documented disability and is in need of academic accommodations should notify the professor of this course and contact the Office of Differing Abilities Services (609-771-2571).

Accommodations are individualized and in accordance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1992. TCNJ's Americans with Disabilities Act (ADA) policy is available at: <http://affirm.pages.tcnj.edu/files/2011/08/Americans-with-Disabilities-Act-4.7.10.docx>

**Academic Integrity Pledge:**

“I pledge to maintain the integrity of this quiz/exam. I pledge to abide by the quiz/exam instructions and to withhold communication through any means with anyone about the content of the quiz/exam or proposed solutions to the questions until the entire class and I have completed it. I understand that there may be students who have formal accommodations to receive extended time on the quiz/exam. I will not communicate anything about this quiz/exam until after I have received my quiz/exam grade. The work that I submit is my own. Final exams are the property of the College. I understand that breaking this pledge constitutes a violation of the TCNJ Academic Integrity Policy that will be reported to the College's Academic Integrity Administrator and result in the application of the Academic Integrity Procedural Standards; this can result in a grade of 0 on the exam, receiving a failing grade for the course, and in severe instances expulsion from the College. Additionally, I agree that I will not post or share the content of the exam at any time.”