

## EE 3325: Applied Quantum Mechanics for Electrical Engineers

CRN: 12945

Course Syllabus: Fall 2021

Instructor: Dr. Aryzbe Najera, [adiaz6@utep.edu](mailto:adiaz6@utep.edu)

Lecture: CRBL C205 (F2F Format) T/TH 12:00 pm – 1:20 pm

Office: E327

Office Hours: T/TH 10:30 am – 12:00 pm

### COURSE DESCRIPTION

An introductory course designed to provide students with a fundamental understanding of (1) electron energy, electron/photon interaction, and electron energy transitions; (2) electromagnetic wave theory and quantization of photon energy; (3) laser theory and operation; and (4) advanced applications such as quantum dots, zener diodes and resonant tunneling diodes. This includes applying boundary conditions to solve the time-independent Schrödinger's equation, normalization of the wave function, and applying fundamental solutions such as the infinite potential well (particle-in-a-box) and finite potential well to laser, quantum dot and tunneling applications.

### COURSE PREREQUISITES

PHYS 2421, EE 2350, MATH 2326 and MATH 1312, with grade of "C" or better.

### COURSE TOPICS

- I. Electrons and Semiconductors
- II. Electromagnetic Waves
- III. Schrödinger Equations and Quantum Applications  
Advanced Applications of Schrödinger Equations: Quantum Dots, Tunneling, Zener Diodes, Resonant Tunneling Diodes.

### EXPECTED LEARNING OUTCOMES

- A. Understand basic fundamental concepts associated with quantum mechanics such as:
  - a. Wave-particle duality
  - b. Quantization of electromagnetic spectrum

- c. Blackbody radiation
  - d. Planck's constant
  - e. Photoelectric effect
  - f. de Broglie's Relations
  - g. Compton Effect
  - h. 2-slit Experiment
  - i. Wave Packets
  - j. Heisenberg's Uncertainty Principle
  - k. Discrete Energy Values
  - l. Eigenfunctions and Eigenvalues
  - m. Electron orbitals
- B. Understand the wave nature of quantum mechanics as it applies to electromagnetic waves and electrons by being able to:
- a. calculate the energy, momentum, frequency and wavelength of electromagnetic waves.
  - b. understand constructive and destructive interference.
  - c. recall the wave equation.
  - d. derive the 2<sup>nd</sup> order differential harmonic equation from the wave equation.
  - e. use solutions from the 2-slit experiment to model the interference pattern.
- C. Understand the probabilistic nature of electrons and be able to:
- a. analyze the 2-slit experiment.
  - b. solve for eigenfunctions from the time-dependent Schrödinger equation
- D. Be able to solve quantum mechanical problems associated with photon-electron interactions such as:
- a. Electron Energy Transitions
  - b. Compton Effect
  - c. X-Ray Production
  - d. Uncertainty Principle
- E. Be able to use boundary conditions and the time-independent Schrödinger equation to solve quantum mechanical problems such as:
- a. Infinite Potential Well (Particle-in-a-box)
  - b. Finite Potential Well
  - c. Tunneling Probability
  - d. Particle Confinement
- F. Be able to design and simulate electronic devices using simulation tools located on the nanoHUB.org website such as:
- a. PN Junctions
  - b. Quantum Dots
  - c. Resonant Tunneling Diodes

## REQUIRED MATERIALS

- Class notes, equation sheets, homework problems and corresponding power point presentations for each lecture were specifically designed for this course.
- You will also need regular access to a computer, stable, consistent internet, Blackboard, and your UTEP email account.

## COURSE ASSIGNMENTS AND GRADING POLICIES

### Grade Distribution:

Quizzes	20%
Homework/Workshops	20%
Midterm Exam	30%
Final Exam	30%

### Grading Scale:

A: 90% - 100% B: 80% - <90% C: 70% - <80% D: 60% - <70% F: 0 - <60%

### Note:

- Each student must complete all assessments.
- Each assessment must be taken the designated date unless arrangements are made in advance with a proof of medical emergency.
- There will be NO EXTRA CREDIT

## CLASS MEETINGS

This course will be taught using active student learning activities to include student-student discussions, group problem solving, blackboard and feedback from the instructor. Students are asked to come to class prepared by completing the designated reading assignment for that day. The reading assignments will be correlated with a short lecture which will be used to introduce problem solving methods and reinforce critical concepts. Short lectures (10-15 min) will be linked to team problem solving sessions, and team assignments will be picked up on a daily basis. The lecture is designed to include at least one team activity per lecture. Occasionally, quizzes will be based on the reading assignment and are listed in the course schedule. Visual teaching tools will be used to reinforce and clarify critical concepts. Several visual tools will come from the [nanoHUB.org website](http://nanoHUB.org) and students are encouraged to register and explore this website during the first week of class. This educational website is supported by the National Science Foundation and is free to all users.

## TECHNOLOGY REQUIREMENTS

Course content is delivered via the Internet through the Blackboard learning management system (LMS). Ensure your UTEP e-mail account is working and that you have access to the Web and a stable web browser. Mozilla Firefox and Google Chrome are the most supported browsers for Blackboard; other browsers may cause complications with the LMS. When having technical difficulties, update your browser, clear your cache, or try switching to another browser.

You will need to have or have access to a computer/laptop, scanner, a webcam, and a microphone. You will need to download or update the following software: Microsoft Office, Adobe, Flashplayer, Windows Media Player, QuickTime, and Java. Check that your computer hardware and software are up-to-date

and able to access all parts of the course. If you encounter technical difficulties beyond your scope of troubleshooting, please contact the [Help Desk](#) as they are trained specifically in assisting with technological needs of students.

## ATTENDANCE POLICY

Attendance is mandatory. When absent, the student is responsible for obtaining notes, handouts, and assignments and for meeting the same deadlines as the rest of the class. Excused absences are limited to documented medical emergencies, religious holidays and UTEP sponsored and/or required activities.

## NETIQUETTE

- Always consider audience. Remember that members of the class and the instructor will be reading any postings.
- Respect and courtesy must be provided to classmates and to instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a F2F situation.
- Blackboard is not a public internet venue; all postings to it should be considered private and confidential. Whatever is posted on in these online spaces is intended for classmates and professor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space. If students wish to do so, they have the ethical obligation to first request the permission of the writer(s).

## QUIZZES

All quizzes will be taken via Blackboard (BB) and will be due at the end of the day (11:59 pm). **Students will have to obtain a scan copy of their complete analysis for each problem and upload a PDF file ALL their solutions to blackboard.**

Note: All quizzes will be worth 20% of the final grade.

## HOMEWORK/WORKSHOP ASSIGNMENTS

Homework activity: Homework will be assigned and will be used to design a learning activity during the following lecture. During the first five minutes of the class period, each group will be assigned roles similar to those listed below and will be given 5 minutes to prepare for their activity. Some examples of group homework activities are listed below.

Activity A: Group work (all members turn in work for a grade)

Activity B: One homework problem (all students have a role)

Activity C: Similar homework problem or concept (all students have a role)

Activity D: Students design a problem (all students have a role)

All homework should follow the standard engineering homework format. Homework that does not follow this format will not be accepted. Students should use the front side of the paper only and include no more than 2 problems per page except when indicated otherwise by the instructor.

Homework Format:

1. Include EE3325, Name, Date
2. Statement of the problem with each solution
3. Neat solutions with legible handwriting

Note: All problem solving activities are considered homework assignments and will be worth 20% of the final grade.

## EXAMS

The midterm exam is worth 30% of the course grade. The final exam is comprehensive and is worth 30% of the final grade. The final exam will count as a make-up exam for a missed midterm exam, for documented and approved absences only. An equation sheet will be provided for each exam. Both exams will be taken via Blackboard (BB). **Students will have to obtain a scan copy of their complete analysis for each problem and upload a PDF file ALL their solutions to blackboard.**

## DROP POLICY

To drop this class, please contact the [Registrar's Office](#) to initiate the drop process. If you cannot complete this course for whatever reason, please contact me. If you do not, you are at risk of receiving an "F" for the course. The deadline to drop this course with an automatic W is **October 29<sup>th</sup>**.

## ACCOMMODATIONS POLICY

The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship on the University. Students requesting an accommodation based on a disability must register with the [UTEP Center for Accommodations and Support Services](#).

## SCHOLASTIC INTEGRITY

Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as

ones' own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the [Office of Student Conduct and Conflict Resolution \(OSCCR\)](#) for possible disciplinary action. To learn more [HOOP: Student Conduct and Discipline](#).

## COVID-19 PRECUTIONS

Please stay home if you (1) have been diagnosed with COVID-19, or (2) are experiencing COVID-19 symptoms. If you are feeling unwell, please let me know as soon as possible, and alternative instruction will be provided. The Student Health Center is equipped to provide COVID 19 testing.

The Center for Disease Control and Prevention recommends that people in areas of substantial or high COVID-19 transmission wear face masks when indoors in groups of people. The best way that Miners can take care of Miners is to get the vaccine. If you still need the vaccine, it is widely available in the El Paso area, and will be available at no charge on campus during the first week of classes. For more information about the current rates, testing, and vaccinations, please visit [epstrong.org](#)

## STUDENT RESOURCES

UTEP provides a variety of student services and support:

- [UTEP Library](#): Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.
- [Help Desk](#): Students experiencing technological challenges (email, Blackboard, software, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.
- [University Writing Center \(UWC\)](#): Submit papers here for assistance with writing style and formatting, ask a tutor for help and explore other writing resources.
- [Math Tutoring Center \(MaRCS\)](#): Ask a tutor for help and explore other available math resources.
- [History Tutoring Center \(HTC\)](#): Receive assistance with writing history papers, get help from a tutor and explore other history resources.
- [Military Student Success Center](#): UTEP welcomes military-affiliated students to its degree programs, and the Military Student Success Center and its dedicated staff (many of whom are veterans and students themselves) are here to help personnel in any branch of service to reach their educational goals.
- [RefWorks](#): A bibliographic citation tool; check out the RefWorks tutorial and Fact Sheet and Quick-Start Guide.