# PHYS 225
# Applications of Modern Physics: from the atom to the diode

**Lecture:** MWF 2:55pm - 4:00pm OWS 250
**Lab:** Tuesday 8:00am – 11:30am or 1:35pm – 5:05pm OWS166

**Instructor:** Dr. Marie Lopez del Puerto
OWS 160B
651 962-5213
mlpuerto@stthomas.edu

**Office hours:** Send me an email to set up an appointment, or just stop by my office.

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**Course objectives:**

1. **Gaining factual knowledge.** Learn elementary materials science concepts, elementary quantum mechanics concepts, and the modern theory of solids.
   (readings, lectures, on-line simulations, laboratories, and exams).
2. **Learning fundamental principles, generalizations or theories.** Understand elementary quantum mechanics, the microscopic origin of the behavior of materials, and the basic operation of semiconductor devices.
   (readings, on-line simulations, laboratories, lectures and exams).
3. **Learning to apply course material to improve problem solving skills.** Learn how to apply elementary quantum mechanics to the basic operation of semiconductor devices. Learn how to model physics problems in the computer.
   (HW problems, groups problems, laboratories, and exams)

**ABET course outcomes:**

**a.** an ability to apply knowledge of mathematics, science, and engineering
(HW problems, group problems, exam problems, lab exercises)

**b.** an ability to analyze and interpret data
(HW problems, lab exercises, exam problems)

**g.** an ability to communicate effectively
(in writing through lab summaries)

**k.** an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
(Matlab)

**Writing-to-Learn:** The laboratory portion of this course is designated as *Writing-to-Learn* in the University of St. Thomas' Writing-Across-the-Curriculum initiative. *Writing-to-Learn* courses are designed to help you learn about the content of the course through frequent (but informal) writing assignments.

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**Text:** S. O. Kasap, Principles of Electronic Materials and Devices, 3rd ed. McGraw Hill (2006).

**Website:** http://ida.phys.stthomas.edu/PHYS225
Homework assignments and solutions, reading assignments, and course announcements will be posted online. Please check the website often.

**Tests (72%):** There will be four midterm exams and one cumulative final. Each midterm exam will cover one or two chapters, will be closed book, and will count 12% towards your final grade. The final exam will be cumulative and will count 24% towards your final grade. **Exams must be taken at the scheduled time**, however, if you have a conflict or excused absence (certifiable illness or family emergency), please contact me as soon as possible.

## Electronic Device use During Tests

Beginning Spring 2011, the only calculator that you may have during an exam is Texas Instruments TI-30X IIS or similar non-graphing scientific calculator previously approved by the instructor.

For the computational part of the exam, you may only use departmental laptops running Matlab. Running any other application (email client, internet browser, etc) will be considered a breach of the honor code with a minimum sanction of failure for the work involved.

**Lab (20%):** The lab will consist of computational and experimental laboratories, and group problems. For the computational problems we will use *Matlab* and online simulations. There will be three lab summaries due (**5% each**, see calendar for dates due). On days in which we do group problems or tutorials (**5% total**), they will be due at the end of the lab period.

**Homework (8%):** A few homework problems will be **posted online** after every class period and will be due the following class period. I encourage you to work in groups and come to office hours, but you should only submit your own work. Homework will be graded on effort, three points per problem set. Please make a reasonable effort, keeping in mind that doing the homework is crucial to learning the material. Homework solutions will be posted online after the homework is due. **No late assignments will be accepted** unless due to a certifiable illness or family emergency**,** but your (one) lowest homework grade will be dropped.

***Approximate* Grading Guidelines:** (may be adjusted down 1-2%)

| | | | |
|---|---|---|---|
| A: 95-100% | B: 82-85% | C: 70-73% | D: 58-61% |
| A-: 90-94% | B-: 78-81% | C-: 66-69% | D-: 55-57% |
| B+: 86-89% | C+: 74-77% | D+: 62-65% | F: 0-54% |

**Honor Code:** The UST Physics department believes that academic integrity is an essential characteristic of a healthy academic community. We have an Honor Code in the Physics Department. This means that we trust you. We take this very seriously – and so a breach of this trust has very severe consequences. Cheating – in any form – will be dealt with according to the University's Academic Integrity Policy, which stipulates a minimum sanction of failure for the work involved.

**Attendance:** Attending class and laboratory sessions is strongly encouraged. If you have to miss a class, you should get class notes and assignments from a classmate. There are no make-up group problems. Make-up labs and exams will be given at the discretion of the instructor only due to certifiable illness or emergency circumstances. Leaving early or coming back late from Easter or Midterm break is NOT an emergency circumstance. In case of emergency or other special circumstance that necessitates missing class for an extended period of time, please let me know as soon as possible.

**Electronic Devices:** Use of cell phones, pagers, messaging PDAs, or other wireless communication devices (including personal laptops for e-mail) is not permitted at anytime during lecture, laboratory sessions or exams. In-class use of departmental laptops should be restricted to the use of software related to the course. Please be considerate of your fellow students and conduct your e-business outside of the classroom.

**Disabilities:** Classroom accommodations will be provided for qualified students with documented disabilities. Students are invited to contact the Enhancement Program – Disability Services about accommodations for this course within the first two weeks of the term. Telephone appointments are available to students as needed. Appointments can be made by calling 651-962-6315 or 800-328-6819, extension 6315. You may also make an appointment in person in O'Shaughnessy Educational Center, room 119. For further information, you can locate the Enhancement Program on the web at http://www.stthomas.edu/enhancementprog/.

## Consent Form - University of St. Thomas

Course Assessment in the Physics Department
IRB proposal #A10-131-01

We are conducting a study about student misconceptions and outcomes in Physics courses, which will help us improve this course. We invite you to participate in this research. You were selected as a possible participant because you are enrolled in a Physics course. Please read this form and ask any questions you may have before agreeing to be in the study. This study is being conducted by faculty in the Physics Department.

The purpose of this study is to identify common misconceptions students have coming into the different Physics courses, and to measure the outcomes of the courses in students' problem solving skills and conceptual understanding of the material.

There is no benefit for participating in this study.

You may ask any questions you have now. If you have questions later, you may contact the Physics department chair, at 651 962-5214. You may also contact the University of St. Thomas Institutional Review Board at 651 962-5341 with any questions or concerns.

Your consent to participate in this study is implied when you complete any assessment, survey or exam in this course, unless you notify the Physics department chair of your desire to be excluded from this research study.

| Course Schedule | | | | | |
|---|---|---|---|---|---|
| **Date** | | **Lecture** | **Lab** | | **Date** |
| Jan | 31 | Introduction, pre-test | Pre-test<br>Intro to Matlab | 1 | Feb |
| Feb | 2 | Ch. 1: Elementary Materials Science | | | |
| | 4 | 1.1 Atomic structure and number | | | |
| | 7 | 1.2 Atomic mass and mole | Classical<br>Statistics Lab | 8 | |
| | 9 | 1.3 Bonding and types of solids | | | |
| | 11 | 1.4 Kinetic molecular theory | | | |
| | 14 | 1.5 Molecular velocity and energy distribution | **Lab summary #1 due in lecture Friday 2/25** | | |
| | 16 | | | 15 | |
| | 18 | 1.8 The crystalline state<br>1.9 Crystalline defects | | | |
| | 21 | Review | **EXAM 1** | 22 | |
| | 23 | Ch. 3: Quantum physics | | | |
| | 25 | 3.1.1 Light as a wave | | | |
| | 28 | 3.1.2 The photoelectric effect | Photoelectric effect tutorial | 1 | Mar |
| Mar | 2 | 3.2 The electron as a wave | | | |
| | 4 | 3.3 Infinite potential well | | | |
| | 7 | 3.4 Heisenberg uncertainty principle | Wave equation tutorial | 8 | |
| | 9 | 3.5 Tunneling (QM tutorial) | | | |
| | 11 | | | | |
| | 14 | Review | **EXAM 2** | 15 | |
| | 16 | 3.6 Potential box | | | |
| | 18 | 3.7 Hydrogenic atom | | | |
| | 21-25 | **MIDTERM BREAK** | **MIDTERM BREAK** | 22 | |
| | 28 | Ch. 4: Modern theory of solids | 3.9 Stimulated emission and Lasers<br>Lasers tutorial | 29 | |
| | 30 | 4.1 Hydrogen molecule | | | |
| Apr | 1 | 4.2 Band theory of solids | | | |
| | 4 | 4.3 Semiconductors | | 5 | Apr |
| | 6 | 4.4 Electron effective mass | Quantum Dot Lab<br>**Lab summary #2 due in lab 4/26** | | |
| | 8 | 4.5 Density of states | | | |
| | 11 | 4.6 Statistics | | 12 | |
| | 13 | 4.7 Quantum theory of metals | | | |
| | 15 | | | | |
| | 18 | Review | **EXAM 3** | 19 | |
| | 20 | 4.8 Fermi energy significance | | | |
| | 22-25 | **EASTER BREAK** | Thermocouples and Superconductors<br>**Lab summary #3 due in lecture on Friday 5/13** | 26 | |
| | 27 | Ch. 5: Semiconductors | | | |
| | 29 | 5.1 Intrinsic semiconductors | | | |
| | 2 | 5.2 Extrinsic semiconductors | | 3 | May |
| May | 4 | 5.7 Optical absorption | | | |
| | 6 | Ch. 6: Semiconductor devices | | | |
| | 9 | 6.1 PN junction<br>6.2 PN junction band diagram<br>6.7 Junction field-effect transistor<br>6.9 Light emitting diodes | **EXAM 4** | 10 | |
| | 11 | Review | | | |
| | 13 | Review, Post-test | | | |
| | 18 | **FINAL EXAM 1:30pm – 3:30pm** | | | |