Physics 2425 Principles of Physics I

Instructor

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Office Hours: MW 9:00 – 10:30 am, TT 8:00 – 9:00 am, F 8:00 – 11:00 am
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Course Description

Content

Fundamental principles of physics, using calculus, for science, computer science, and engineering majors; the principles and applications of classical mechanics, including harmonic motion, physical systems and thermodynamics; experimental design, data collection and analysis, and preparation of laboratory reports; with emphasis on problem solving.

Prerequisites

Completion of MATH 2413 - Calculus I is required before taking Physics 2425.

Textbook

The textbook is *Matter & Interactions, 4th edition* by R. Chabay and B. Sherwood (John Wiley & Sons, 2015). Textbook Errata are at http://matterandinteractions.org/errata/.

Course Overview

In this course we will be examining the nature of matter and its interactions. The variety of phenomena that we will be able to explain and understand is very wide, ranging from the orbit of a planet to the speed of sound in a solid. The ***main goal*** of the course is to have you engage in a process central to science: ***modeling a broad range of physical phenomena using a small set of powerful fundamental principles***.

Approach

The course will emphasize rigorous problem-solving in physics using a student-centered active learning environment. Class sessions will require students to be responsive, to think, and to perform hands-on tasks. Key concepts of new material will be discussed in short lectures. Lab time will be interspersed with classroom discussion. If you devote a sufficient amount of time each day to studying physics, you will be in a position to attack physics problems efficiently, based on a clear understanding of the fundamental physical principles that underlie all successful analyses.

Collaborative Work

This course encourages collaborative teamwork, a skill that is valued by most employers. As you study together, help your partners to get over confusions, ask each other questions, and critique each other's homework write-ups. Teach each other! You can learn a great deal by teaching. But remember that you are responsible for understanding all details of a problem solution.

Study requirements

In addition to your time in class each week, you are expected to spend about 10 hours studying outside of class. If you typically spend less than 8 hours in outside study, you are unlikely to be able to learn the material. Less well prepared students may find they need to spend even more time than this. If you typically spend more than 12 hours in outside study, it is extremely important that you consult with me about ways to study more efficiently.

It is important to keep up with the class. New concepts introduced in this course build on earlier ones, so mastering key concepts is critical. If you get behind, seek help right away!

Attendance policy

Attendance and effort are vital to success in this course. Class attendance keeps you well connected to the course, so that you know at all times what's going on, what are the most important points, etc., and gives you opportunities to ask questions and clear up confusions. Therefore, students are expected to be in attendance for every class session. However, everybody gets sick, has some emergency, needs to care for a friend or family member or similar stuff now and then. Therefore, all students will be allowed two excused absences, no documentation required. The third and fourth absences will be unexcused and after a fifth absence you will be dropped from the class. Missing only lecture, missing only lab, or missing both will all be considered an absence. Chronic tardiness or leaving lab early will also be considered an absence (arriving late or leaving early three times will be considered one absence). If you stop attending class and wish to avoid an "F" you must obtain an official drop form, have it signed, and take the completed form to the registrar's office before your fifth absence. See the current class schedule for the last day you can drop a class.

Assignments

Readings in Perusall

Perusall is a collaborative reading and annotation tool which turns reading assignments from an isolated solitary activity into an engaging collective social interaction. While reading your text in Perusall you can highlight a selection and ask a question or post a comment which will start a new discussion thread; you can also add a reply or comment to an existing thread. Each thread is like a chat with one or more of your classmates. This collaborative questioning and answering helps you master readings faster, understand the material better, and get more out of your physics class. For more information see the handout "How Perusall Works". As you read the text, you should work each checkpoint question and keep these in your course portfolio – see below.

Homework

Homework will consist of four or five problems each week requiring detailed written solutions. Writing good solutions provides practice in communicating your thinking process in a clear and precise way. Engineers (as well as professionals in other technical areas) actually spend a significant amount of time communicating their ideas in a way that is comprehensible to others. Being able to write clearly is an important skill for an engineer. You will also find that writing good explanations of your thinking process will improve your understanding of the physics concepts you are studying. Communicating your thinking process on paper will require writing sentences and paragraphs in addition to equations and formulas. A well written solution will include verbal explanation stating what physics principles are used, appropriate well-labeled diagrams, symbolic solution before numerical values are substituted, and correct numerical result with correct number of significant figures and correct units. Students whose work is excessively messy or poorly explained will be asked to rewrite the assignment.

Course Portfolio

You will maintain all your course work in a three-ring binder. The binder must have separate sections for your checkpoint solutions, in-class problem solutions, written homework solutions, and lab work. You may also include sections for your reading notes and class notes if you want. These materials may be collected for inspection at any time. Please make certain that you keep your portfolio up-to-date and bring it with you to every class meeting and when seeking help during office hours. Maintaining a well-organized, up-to-date portfolio will provide you an extremely useful tool for reviewing before exams.

Getting help with assignments

You should ask lots of questions in class to clear up any initial confusion you might have about a topic. I also encourage you to avail yourself of my help during office hours. You do not have to wait for my official office hours to get help; anytime I am in my office you are always welcome to come get help. If you fall behind for any reason, please let me know as soon as possible. The sooner I know about these situations, the better I can help you make up work. I will do what I can to help you complete the course satisfactorily.

Laboratory

During lab you will typically work in groups of three students on the following three kinds of activities:

- Experiments, involving measurement and analysis of data according to fundamental principles.
- Computer modeling, involving constructing 3-D models of physical systems and their motion. This will involve the VPython programming language. No previous programming experience is needed – I will teach you the basic concepts needed. Some computer modeling activities may need to be finished outside of class.
- Group problem solving, involving work on large, complex problems. In lab you may begin work on a large problem to be completed outside class or the entire problem may be solved during class.

You must attend class during the day the lab is done in order to receive credit. If you have an excused absence, you will be excused from the lab you missed, and your lab average will be taken from your remaining labs. If you miss a lab, you should work with your classmates to be sure you understand the missed lab activities since these will be covered on tests.

Semester Project

Semester projects will be chosen in consultation with the instructor. Possibilities include numerical simulations that expand beyond what we do in lab, an experimental project carried out and reported by the student, extended analysis of a challenging, more realistic problem to demonstrate application of fundamental physics principles, or some other creative project you get approved as long as it demonstrates mastery of the basic physics principles studied. You must decide on your project and have it approved by the instructor before the midterm exam. A first draft of your project report will be due four weeks after the midterm exam. Final project reports will be due the week before the final exam.

Exams

Midterm exam

A single midterm exam will be given approximately half way through the semester. The date of the exam is shown on the course calendar. The exam will be closed-book, but some relevant formulas and constants will be provided. If you have an excused absence, you will need to contact me to make up the missed exam.

Final exam

A comprehensive final exam will cover all of the course material. The final exam will be closed-book, but some relevant formulas and constants will be provided. It will be given during the scheduled final exam time as shown in the schedule of classes and on the course calendar.

Grade calculation

Your final grade will be assigned based on your overall, weighted class average using the weighting scheme shown below:

Weighting Scheme		
Task	Code	Weight
Reading	R	10%
Homework	H	20%
Lab	L	20%
Semester Project	P	10%
Midterm	M	20%
Final	F	20%

The letter grades will be based on a fixed scale as follows:

A: 89.5 – 100 B: 79.5 – 89.5 C: 69.5 – 79.5 D: 59.5 – 69.5 F: below 59.5

If everyone in the class does well, grades are not curved downward. Everyone can get an A. There usually is a "gray area" between two letter grades for borderline cases (grades within 0.5 points of the break point). Earning the higher grade in these cases depends on your interactions in class and whether your test and homework performance shows improvement during the course of the semester.

Miscellaneous information

In this class, the teacher will establish and support an environment that values and nurtures individual and group differences and encourages engagement and interaction. Understanding and respecting multiple experiences and perspectives will serve to challenge and stimulate all of us to learn about others, about the larger world and about ourselves. By promoting diversity and intellectual exchange, we will not only mirror society as it is, but also model society as it should and can be.

Students with disabilities, including but not limited to physical, psychiatric, or learning disabilities, who wish to request accommodations in this class should notify the Disability Services Office early in the semester so that the appropriate arrangements may be made. In accordance with federal law, a student requesting accommodations must provide acceptable documentation of his/her disability to the Disability Services Office. For more information, call or visit the Disability Services Office at Levelland (Student Health & Wellness Office) 806-716-2577, Reese Center (Building 8) 806-716-4675, or Plainview Center (Main Office) 806-716-4302 or 806-296-9611.

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If you are pregnant, or have given birth within six months, Under Title IX you have a right to reasonable accommodations to help continue your education. To activate accommodations you must submit a Title IX pregnancy accommodations request, along with specific medical documentation, to the Director of Health and Wellness. Once approved, notification will be sent to the student and instructors. It is the student's responsibility to work with the instructor to arrange accommodations. Contact Crystal Gilster, Director of Health and Wellness at 806-716-2362 or email at cgilster@southplainscollege.edu.

Core Objectives Addressed in this course:

As a part of the Texas Core Curriculum established by the Texas Higher Education Coordinating Board (THECB), the following core objectives will be addressed in this class:

> **Communication Skills –** effective development, interpretation and expression of ideas through written, oral, and visual communication
>
> **Critical Thinking Skills -** creative thinking, innovation, inquiry, analysis, evaluation and synthesis of information
>
> **Empirical and Quantitative Skills -** manipulation and analysis of numerical data or observable facts resulting in informed conclusions
>
> **Teamwork -** ability to consider different points of view and to work effectively with others to support a shared purpose or goal

Course Objectives

Learning objectives students should achieve to successfully complete this course:

1. Apply the <u>momentum principle</u> (Newton's second law of motion) to analyze and predict the future motion of a system subject to a net force (constant or varying).
2. Use the <u>momentum principle</u> stated in any of its various forms (update, conservation, and instantaneous form) to model the interactions of both simple and complicated systems with their surroundings.
3. Give examples of each of the fundamental interactions, recognizing which fundamental interaction is responsible for the forces acting between a system and its surroundings. In the case of gravitational and electrical interactions, calculate the forces between interacting particles.
4. Discuss how contact forces (tension, compression, and friction) can be modeled based on the internal atomic structure of solids, including determining appropriate values for the interatomic spacing and interatomic bond stiffness. Relate these microscopic properties to measureable macroscopic properties such as Young's modulus.
5. Apply the <u>energy principle</u> to analyze the transformations of energy within a system (including kinetic energy, potential energy, and rest energy) and the transfers of energy between a system and its surroundings (including work, energy transferred due to a temperature difference, and other energy transfers).
6. Distinguish between the overall mechanical energy of a large multiparticle system and its internal energy. Use specific heat to relate changes in a system's internal thermal energy to changes in its temperature.
7. Apply the <u>energy principle</u> to the quantized electronic, vibrational, and rotational energies of atoms and molecules, including their interactions with their surroundings by emission and absorption of photons and collisions with energetic electrons.
8. Use the <u>momentum and energy principles</u> together to analyze how interactions of an extended system (rigid or deformable) with its surroundings change the energies and motions of the system.
9. Use the <u>momentum and energy principles</u> together to analyze elastic and inelastic collisions (both head-on and scattering collisions) at speeds small compared to the speed of light and at relativistic speeds.
10. Apply the <u>angular momentum principle</u> in both the update and conservation forms to analyze the motions of systems subject to both nonzero and zero net torques.
11. Combine the <u>momentum principle, energy principle, and angular momentum principle</u> to analyze extended systems interacting with their surroundings to find changes in the system's energies and motions.
12. Apply the fundamental assumption of statistical mechanics to the Einstein model of a solid to determine the most likely energy distribution between two interacting systems, relating this to the definition of entropy and the second law of thermodynamics.
13. Calculate a system's temperature in terms of rate of change of entropy with internal energy and discuss why thermal equilibrium of two systems occurs when they have the same temperature.
14. Calculate the dependence of heat capacity on temperature using the Einstein model of a solid.

Calendar

Phys 2425.001 Fall 2019

Week	Monday		Wednesday	
	Readings	Topics	Readings	Topics
1	08/26	Course Introduction; *Perusall* Registration	08/28 **1.1 – 1.5**	Detecting Interactions: Newton's 1st Law; Vectors Lab – VP01: Intro to Computational Modeling
2	09/02	Labor Day – No Class	09/04 **1.6 – 1.11**	Velocity; Position Update Equation; Momentum; Change in Momentum Lab – VP02: Computational Models of Motion 1
3	09/09 **2.1 – 2.4**	The Momentum Principle (Newton's 2nd Law); Iteratively Predicting Motion – Constant Net Force Lab – Momentum Change of a Fan Cart	09/11 **2.5 – 2.7**	Analytical Prediction of Motion – Constant Net Force; Iteratively Predicting Motion – Varying Net Force Lab – VP03: Computational Models of Motion 2
4	09/16 **3.1 – 3.6**	Fundamental Interactions; Gravitational Force; Reciprocity (Newton's 3rd Law); Predicting the Motion of Gravitationally Interacting Objects Lab – VP04: Calculating Gravitational Force	09/18 **3.7 – 3.12**	Electric Force; Strong and Weak Interactions; Momentum Principle for Multiparticle Systems; Momentum Conservation; Collisions Lab – VP05: A Space Voyage Part 1
5	09/23 **4.1 – 4.8**	Atomic Model of Contact Interactions: Tension Forces, Normal Forces, Frictional Forces Lab – VP06: A Space Voyage Part 2	09/25 **4.9 – 4.14**	Speed of Sound in a Solid; Derivative Form of the Momentum Principle; Analytical Solution for a Spring-Mass System; Buoyancy Lab – Measuring Young's Modulus
6	09/30 **5.1 – 5.5**	Determining Unknown Forces Using the Derivative Form of the Momentum Principle Lab – Determining Spring Stiffness	10/02 **5.6 – 5.10**	Applying the Derivative Form of the Momentum Principle to Curving Motion Lab – Mass/Spring Oscillator
7	10/07 **6.1 – 6.5**	The Energy Principle applied to a Single Particle System Lab – VP07: Spring/Mass Model Part 1	10/09 **6.7 – 6.9**	The Energy Principle applied to Multiparticle Systems; Gravitational Potential Energy; Electric Potential Energy Lab – Problem Solving
8	10/14 **6.10 – 6.14**	Energy Graphs; Mass of Multiparticle Systems; Binding Energy; Choosing Initial and Final States Lab – VP08: A Space Voyage Part 3	10/16	**Mid-Term Exam**
9	10/21 **7.1 – 7.4**	Elastic Potential Energy of a Spring; Potential Energy of Interacting Neutral Atoms; Internal Energy; Specific Heat Lab – Problem Solving	10/23 **7.5 – 7.10**	Energy Principle applied to Large Multiparticle Systems; Microscopic Work (Heat Transfer); Energy Accounting; Energy Dissipation Lab – VP09: Spring/Mass Model Part 2
10	10/28 **8.1 – 8.3**	Energy Quantization – Electronic Energy Levels; Emission and Absorption Spectra Lab – Running Up Stairs	10/30 **8.4 – 8.10**	Energy Quantization – Vibrational and Rotational Energy Levels Lab – Atomic and Molecular Spectra
11	11/04 **9.1 – 9.2**	Separation of Kinetic Energy in Multiparticle Systems into Translational, Rotational, and Vibrational Kinetic Energy; Moment of Inertia Lab – Problem Solving	11/06 **9.3 – 9.4**	Modeling a System as a Point Particle and Modeling a System as an Extended Object; Detailed Model of Friction Lab – Jumping upward
12	11/11 **10.1 – 10.6**	Collisions – Applying both Momentum and Energy Principles Together Lab – Problem Solving	11/13 **10.7 – 10.12**	Rutherford's Discovery of the Nucleus; Relativistic Particle Collisions Lab – VP10: Rutherford Scattering Model
13	11/18 **11.1 – 11.6**	Angular Momentum and the Angular Momentum Principle Lab – Problem Solving	11/20 **11.7 – 11.10**	Combining All Three Fundamental Principles in Problem Solving Lab – Torque and Angular Momentum Change
14	11/25 **11.11 – 11.12**	Angular Momentum Quantization; Gyroscopic Motion Lab – Problem Solving	11/27	Thanksgiving – No Class
15	12/02 **12.1 – 12.4, 12.7**	Fundamental Assumption of Statistical Mechanics; Entropy and the Second Law of Thermodynamics Lab – VP11: Statistical Mechanics Part 1	12/04 **12.5 – 12.7**	Definition of Temperature ; Predicting the Specific Heat Capacity of Solids Lab – VP12: Statistical Mechanics Part 2
16	12/09	**Final Exam – 1:00 to 3:00 pm**	12/11	