PHYS 1101: University Physics II (winter)

Calendar description: This calculus-based physics course is a continuation of PHYS 1100.1(.2), and covers the topics of oscillations and waves, thermodynamics, and electricity and magnetism.

Classes 3 hrs. and lab/tutorial 3 hrs. per week; 1 semester.

Note: Credit cannot be given to students who have already taken PHY 205.0 or 221.0

Contents

Overview

This course is a continuation of University Physics I, carrying on with three weeks on waves and oscillations, three weeks on thermodynamics (the first two laws and an introduction to the kinetic theory of gases), and six weeks of electricity and magnetism. The E&M unit will probably be the first time in both PHYS 1100 and this course where students encounter ideas they have never seen before, such as the Lorentz Force, Gauss' law, and Maxwell's Equations in integral form.

The lab portion of this course is described separately at PHYS 1101L. The instructors of the lab portion enjoy some autonomy in how the lab is conducted, but it is the instructor of the lecture portion of the course, hereafter the "lecturer", who is responsible for the overall course, assigns final grades to the students, and is judged by student evaluations. Therefore, the lab instructor(s) need to consult with the lecturer in how the lab is conducted, and where there is disagreement the view of the lecturer shall prevail.

Prerequisites

PHYS 1100 University Physics I

PHYS 1101 depends on this course weakly, as the topics in 1101 (oscillations, waves, thermodynamics, and E&M) can all, in principle, be taught independently of a course in mechanics. However, the terms and nomenclature, problem solving skills, and level of sophistication students gain from PHYS 1100 are what make it possible for the instructor to cover all the material of this course in one term.

MATH 1210 Introductory Calculus I

Students completing MATH 1210 can do any kind of differentiation this course requires. Students should also be taking MATH 1211 at the same time as this course, and by week 4 when the unit on thermodynamics is begun, students have had a good introduction to integration. However, the E&M unit starting in week 7 requires the use of closed and open path and surface integrals which are not covered in MATH 1211, and the instructor should be prepared to explain these kinds of integrals in class (see Note 2 in the section *Notes to the Instructor*).

Students who failed MATH 1210 in the first semester or who took MATH 1090 instead of MATH 1210 because they failed the placement exam, are now just taking MATH 1210 and integration will be completely foreign to them. Those students who seek help because of this have a good chance to get through this course; those who don't invariably drop it.

Dependent courses

ASTR 2100 Foundations of Astrophysics

ASTR 2100 requires the general physics background and problem-solving skills that PHYS 1100 and PHYS 1101 provide.

PHYS 2300 Vibrations, Waves, and Optics

PHYS 2300 builds directly on the unit on oscillations and waves covered in the first three weeks of PHYS 1101. In addition, PHYS 2300 benefits from the general background in physics and the problem-solving skills provided by both PHYS 1100 and PHYS 1101.

PHYS 2400 Electricity and Magnetism

PHYS 2500 provides the student with a full-course overview of the E&M unit covered in this course in its last six weeks. While the ideas introduced in PHYS 2500 are largely the same as those seen here, the level of sophistication of the problems is significantly higher. To be suitably prepared for PHYS 2500, this course should expose students to all Maxwell's equations in integral form, including a discussion of the displacement current and the magnetisation of matter.

PHYS 3350 Thermal Physics (indirectly)

Since PHYS 3350 is cycled with PHYS 3400 (Electrodynamics), it is possible students won't take PHYS 3400 until the last semester of their fourth year. Yet, PHYS 3400 is the first time they see thermodynamics formally since the three-week unit given in this course. Thus, a solid foundation in the first and second laws are critical, as are the ideas of phase-space (P-V, T-S) diagrams, state variables, and the kinetic theory of gases. All of these ideas will be revisited and developed further in the first half of PHYS 3400, with the second half devoted to Statistical Mechanics.

Student Outcomes

The development of sound, systematic problem-solving skills is paramount, and will serve both our students and freshmen engineers (the vast majority of the class) well in any future physics classes they take.

Students completing PHYS 1101 should begin to develop the following skills:

1. gain a competency in units and unit conversions
2. accept different notation conventions
3. develop a systematic and consistent approach to problem solving (*e.g.*, p-V diagrams, Gaussian surfaces), and learn to translate word problems into mathematical equations. Many students will cling to their "rules of thumb" and simplistic approaches learned in high school that don't work for the more complex problems encountered in this course, particularly in the E&M unit.
4. be able to visualise a problem and use diagrams effectively
5. apply differential calculus to physics problems
6. learn to conceptualise physics and recalibrate their intuition

Typical problems students completing PHYS 1101 should be able to solve:

1. From the sinusoidal representation of a wave or oscillation, determine the period, frequency, wavelength, amplitude, velocity, etc.
2. Find the amount of useful work that can be extracted from a gas in a system executing a clockwise rectangular loop on a T-S diagram.
3. What is the capacitance of an isolated charged sphere?
4. What is the force on a dielectric slab that is only partially between two charged plates?
5. How is a "mag-lev train" propelled?

Curriculum

In parentheses is an approximate number of lectures to spend on each topic.

In square brackets are the names of various demonstrations as they are listed in the department's demonstration catalogue that could be used for each major topic.

1. Oscillations and waves (6) [Oscillator sampler; Wave machine; Slinky; Beating; Doppler ball]
   - SHM, pendulum
   - transverse and longitudinal waves
   - describing a wave as a sine function
   - sound waves
2. Temperature and Heat (2)
   - thermal expansion
   - heat absorption and conduction
   - First Law of Thermodynamics
3. Kinetic Theory of gases (2)
   - ideal gas law
   - pressure, mean free path
   - degrees of freedom, specific heats (C_V, C_p)
   - p-V diagrams
4. Entropy (2) [Entropy be-damned!—the biggest wow of the year]
   - state variables, and entropy
   - Second Law of Thermodynamics
   - p-T, T-S, S-V diagrams
   - Carnot cycles (engines and refrigerators)
   - state variables along isobars, isotherms, isochors, and isentrops
5. Electric fields (1) [Pith ball; Wimshurst machine (someone will stick their tongue in it for the class); Tesla coil with discharge tubes (no tongues here!)]
   - Coulomb's law
   - the concept of a field
   - fields due to line and disc charges
6. Gauss' law (2)

  - electric flux through closed and open surfaces (integrals)
  - point, line, and sheet charges

7. Potential (2)
  - electric potential of point, line, and sheet charges
  - dipole, charged isolated conductor
  - dielectrics and capacitance

8. Circuits (1) [Circuits in parallel and series]
  - current, resistance, and resistivity
  - Ohm's Law
  - Kirchhoff's Rules as a restatement of conservation of energy and charge
  - resistors in parallel and series
  - simple circuits (and "monster" circuits; *e.g.*, question 6, p 653, HRW Ed. 6)

9. Magnetic fields (3) [Lorentz force: CRT; Lorentz force: Current; Induced $\vec{B}$ in a solenoid]
  - Lorentz forces (another example of the cross product)
  - Hall effect
  - Biot and Savart (an apparent "violation" of Newton's 3rd Law)
  - magnetic force on a current-carrying wire
  - magnetic dipole
  - Ampere's law
  - solenoids and toroids

10. Induction (2) [Induction: Solenoid; Induction: Eddy currents]
  - Lenz' and Faraday's law
  - induced and non-conservative electric fields, eddy currents

11. Maxwell's equations (1)
  - no magnetic charges
  - induced magnetic fields
  - displacement current
  - summary of Gauss' Laws, Faraday's Law, and Ampere-Maxwell Law, all in integral form

Suggested texts

The text used for this course should be the same as the text used for PHYS 1100.

Notes to the instructor

1. PHYS 1100 and PHYS 1101 serve two primary purposes:

    - foundation courses for (astro)physics majors;
    - service courses for chemistry and the engineering programme.

    These two purposes are often at loggerheads—the level needed by our potential majors is often higher than that needed by the engineers.

    Historically, these courses have been taught at a level neither higher nor lower than necessary to provide a thorough treatment of Halliday, Resnick and Walker, where any and all problems in that text are fair game for assignments and, to a lesser extent, exams. In practise, this has meant teaching to the B/B+ students.

2. Integration seen in MATH 1211 is strictly 1-D. The integration in the thermodynamics unit is really path integration but is well-disguised as ordinary 1-D integrals (and students need not be the wiser). On the other hand, the integrals in the E&M unit are bona fide open and closed surface and path integrals, and it is difficult to disguise them as anything else. The instructor should be prepared to spend the equivalent of half a lecture in aggregate over the course of two or three classes explaining what these kinds of integrals actually mean, and how they differ from ordinary 1-D integrals.

3. Demonstrations in this class are even more important than in the preceding course PHYS 1100, particularly in the E&M unit where students are exposed to what may be the first new ideas to them since the beginning of PHYS 1100. Some of the phenomena in E&M are quite unbelievable until seen (*e.g.*, the Lorentz force, Eddy currents, the generation of current in a solenoid by inserting a permanent magnet), and students will have almost no intuition upon which to rely.

4. Instructors for the three first-year courses [PHYS 1100 (University Physics I), this, and PHYS 1500 (Introduction to Modern Physics)] are strongly urged to discuss and agree upon a mutually suitable text in time for ordering texts for the fall.

5. The portion of course grade assigned to the laboratory portion (PHYS 1101L) should be between 20% and 30%.

6. It has been this department's policy that students repeating this course may be exempt from repeating the laboratory portion *if*:

    - the grade attained in the lab portion in the previous attempt of the course was a C− or better;

- the grade attained in the lab from the previous attempt of the course is used as the lab grade for the current attempt

Students exempted from repeating the lab portion should not, however, be exempted from repeating the tutorial portion of the course, should tutorials be part of the course.