Review of Physics
PHYS 6700X / Summer 2019

Organization

PHYS 67001 — Review of Physics A: Mechanics & Thermodynamics (June 3 – June 21)

Prof. Boldizsar Janko
TA: Luca Boccioli / Zhou Zhou

PHYS 67002 — Review of Physics B: Electromagnetism (June 24 – July 12)

Prof. Anthony Hyder
TA: Luca Boccioli / Zhou Zhou

PHYS 67003 — Review of Physics C: Quantum Mechanics (July 15 – August 2)

Prof. Morten Eskildsen / Boldizsar Janko
TA: Luca Bocciolli

Class

Monday – Friday, 9:00 AM – 11:30 AM, 184 NSH

Note: There will be no class meeting on July 4.

Office hours

The instructor will be available for office hours, and the teaching assistant will hold regularly scheduled afternoon help sessions, according to schedules communicated to you by the instructor.

Description

Overview

The Review of Physics summer course sequence is intended for incoming graduate students before their first semester at Notre Dame:

PHYS 67001 Review of Physics A: Mechanics & Thermodynamics
PHYS 67002 Review of Physics B: Electromagnetism
PHYS 67003 Review of Physics C: Quantum Mechanics

Participation is optional, but highly recommended. This "physics boot camp" for incoming graduate students is an opportunity for you to review the essential components of your upper-level undergraduate physics courses, including classical mechanics (with some thermodynamics), electromagnetism, and quantum mechanics. The goal is to ensure that you and your colleagues have a

common conceptual core, mathematical foundation, and problem-solving proficiency as you embark on graduate studies.

It is important to realize that this is a "forward looking" review, designed to ease you into the mindset of your core graduate courses and allow you to hit the ground running in the fall. For instance, electromagnetism will focus on the application of Maxwell's equations and wave dynamics, while quantum mechanics will focus on properly understanding quantum mechanics in terms of state vectors and operators living in Hilbert spaces. We have chosen textbooks at an appropriate level to help you bridge this gap, and then, hopefully, to later serve you as resources in understanding the classic but notoriously dense graduate texts.

A significant emphasis will be placed on ensuring you are fully at ease with the necessary (but, as experience has shown, often spotty) mathematical background, such as vector analysis and linear algebra. There will also be an emphasis on critical problem solving approaches, or how to decide which approach to use and when to switch approaches, in order to help you with the transition from the simpler undergraduate-level problems you may be familiar with to the more challenging, open-ended problems you will find in your graduate courses.

The Preliminary Examination consists of three parts, split over three days, on Mechanics & Thermodynamics, Electromagnetism, and Quantum Mechanics. Each review course attempts to at least touch on the major topics from the corresponding part of the Preliminary Examination (see Section 4 of the *Guide for Graduate Students*). If you have mastered the basic concepts and proficiencies of undergraduate mechanics, thermodynamics, electromagnetism, and quantum mechanics, at the level reviewed in the summer course, the general expectation is that you should be able to pass the Preliminary Examination on your first attempt.

However, it is important to realize that it is *your responsibility* ensure that you have mastered the materials specified in the description of the Preliminary Examination (see Section 4 of the *Guide for Graduate Students*), regardless of which specific topics might be selected for emphasis by the instructor when you take the review course. In the short time available, the review course can only *attempt* to review some substantial portion of undergraduate-level physics. It is up to you to study any materials which the review course might not have touched upon as deeply as you find you need (the specific areas in need of deeper review may be expected to differ from student to student depending on background). A variety of relevant textbooks, including the reference textbooks cited in the Preliminary Examination description, will be available on reserve in the Chemistry Physics Library (see *Textbooks* below).

Topics

Each segment of the Review of Physics will focus on the topics identified for the corresponding portion of the Preliminary Exam (see Section 4 of the *Guide for Graduate Students*), as well as relevant prerequisite mathematical concepts:

Review of Physics A: Mechanics & Thermodynamics.

Statics (vector decomposition), central forces, rigid body motion, oscillatory motion and normal modes

Basics of Lagrangian/Hamiltonian formulation of classical mechanics

Laws of thermodynamics, ideal gas, state equation

Mathematical concepts reviewed include: Vector techniques and curvilinear coordinate systems; derivatives, chain rule, integration by parts; total differentials, directional derivatives, partial derivatives; basic ODE techniques (including exponential ansatz); Maxwell relations; *approaches for critically deciding among problem solving techniques and when to switch among them*

Review of Physics B: Electromagnetism.

Basic electrostatics from the perspective of the Laplace/Poisson equation (*e.g.*, Laplace/Poisson equation in simple geometries, image charges), multipole expansion, magnetostatics

Maxwell's equations, electromagnetic waves, physical optics

Mathematical concepts reviewed include: Vector calculus for electromagnetism (gradient, curl, Laplacian, vector derivative identities, vector integrals); basic linear PDEs (separation of variables, exponential ansatz $e^{i\mathbf{k}\cdot\mathbf{r}}$ & $e^{i\omega t}$)

Review of Physics C: Quantum Mechanics.

General formalism of quantum mechanics in terms of linear operators and Hilbert spaces, matrix representation of quantum problems, coordinate/momentum representations

Quantum harmonic oscillator (Dirac formulation), basic properties of angular momentum operators, central force problem, identical particles

Mathematical concepts reviewed include: Linear algebra (matrices, vector spaces, eigenproblems); eigenbases (including Fourier transform & series); linear operators (their representations in various bases, commutator relations)

Textbooks

For each of the exam topics listed above, the Preliminary Examination decription identifies the corresponding sections in certain representative reference textbooks, indicated by an asterisk (*) below, in order to indicate the expected scope and coverage of these topics on the exam (see Section 4 of the *Guide for Graduate Students*). You should keep the reference textbooks and section listings in mind in preparation for the exam, as these provides a clear definition of the exam's coverage, independent of any choices of emphasis in this particular year's Review of Physics course.

However, a variety of other textbooks may also be suitable for use in reviewing the relevant undergraduate-level physics. One or more principal texts, indicated by a hash (#) below, has been identified by this summer's course instructor for each course segment.

The department has purchased sufficient copies of both the reference textbooks and any other principal textbooks, and placed them on reserve with the Chemstry/Physics Library, so that you can check out your own copy for the entire summer. To allow you to obtain multiple perspectives on these topics, a limited number of copies of various complementary recommended textbooks, also listed below, are also being placed on reserve.

Review of Physics A: Mechanics & Thermodynamics.

*# John R. Taylor, *Classical Mechanics* (Univ. Science Books, 2005). ISBN 189138922X.

*# Daniel V. Schroeder, *An Introduction to Thermal Physics* (Addison Wesley Longman, 2000). ISBN 0201380277.

Ralph Baierlein, *Thermal Physics* (Cambridge, 1999). ISBN 0521658381.

Herbert B. Callen, *Thermodynamics and an Introduction to Thermostatistics*, 2ed. (Wiley, 1985). ISBN 0471862568.

Enrico Fermi, *Thermodynamics*, new ed. (Dover, 1956). ISBN 048660361X. *[An e-book version is also available through the Notre Dame library.]*

Review of Physics B: Electromagnetism.

*# J. R. Reitz, F. J. Milford, and R. W. Christy, *Foundations of Electromagnetic Theory*, 4ed (Addison Wesley Longman, 1993). ISBN 0201526247.

David J. Griffiths, *Introduction to Electrodynamics*, 4ed (Pearson, 2013). ISBN 0321856562.

Roald K. Wangsness, *Electromagnetic Fields*, 2ed (Wiley, 1986). ISBN 0471811866.

Review of Physics C: Quantum Mechanics.

David J. Griffiths, *Introduction to Quantum Mechanics*, 2nd ed. (Pearson Prentice Hall, 2005). ISBN 1107179866.

* John S. Townsend, *A Modern Approach to Quantum Mechanics*, 2ed (Univ. Science Books, 2012). ISBN 1891389785.

Ramamurti Shankar, *Principles of Quantum Mechanics*, 2ed (Plenum, 1980). ISBN 0306447908.

Claude Cohen-Tannoudji, Bernard Diu, and Franck Laloë, *Quantum Mechanics*, Volume I (Wiley, 1977). ISBN 0471164321.

For all segments…

Riley, Hobson, and Bence will be your textbook for PHYS 70003 Mathematical Methods in Physics in the fall semester. You are expected to *obtain your copy early*, to use during the summer course, so that you can use it as a mathematical resource in the summer course. (Copies are available at the Notre Dame bookstore.) Your instructors will refer you to it for background and exercises on mathematical topics as needed.

K. F. Riley, M. P. Hobson, and S. J. Bence, *Mathematical Methods for Physics and Engineering: A Comprehensive Guide*, 3ed (Cambridge University Press, 2006). ISBN 0521679710.

If you do not already have your own copy of the *Mathematical Handbook*, you should obtain one for use this summer *and on the Preliminary Exam itself*. Several copies are on reserve with the Chemstry/Physics Library, but you will likely wish to purchase your own copy to have for future reference. (Copies are available at the Notre Dame bookstore.)

Murray R. Spiegel, Seymour Lipschutz, and John Liu, *Mathematical Handbook of Formulas and Tables*, 5th ed. (McGraw-Hill, New York, 2017). ISBN 9781260010534.

Practicalities

Grading & attendance

This course is graded satisfactory/unsatisfactory (S/U). If you come prepared and on time to the class meetings and actively participate in the problem solving activities, you will get an S. Otherwise, you will get a U.

If you are enrolled in the course, attendance is mandatory, and at most 3 absences are allowed from any of these course segments. If, for any reason, you expect that you will need to be away for more than 3 of the 14 class meetings of any of these segments, you are not eligible to enroll or receive a stipend for that segment. In the event of unexpected medical or other emergencies resulting in absences beyond this limit, be sure to notify the instructor immediately, and provide proper documentation. A course of action will be determined in consultation with the DGS.

Remote participation

Even if you will not be here in time to formally enroll in the course, you are still invited to follow along with the materials remotely to the extent your schedule permits. The instructor will post all assignments online and may post additional resources as available. We will be setting up a teleconferencing connection (via Zoom) so that you can observe the course on a live audio/video feed and hopefully participate to a limited extent. If and when you do arrive on campus, you are also welcome to join in person for the remaining class meetings.

May 27, 2019