PHYSICS 151 — COLLEGE PHYSICS I

UH MANOA — Fall 2022 Semester

Course Information & Policies

updated: 31 Aug 2022

Due to the ongoing pandemic, PORTIONS OF THIS SYLLABUS MAY CHANGE during the semester. Any substantive changes will be widely publicized. Thank you in advance for your patience and flexibility.

Instructor	Mr. Michael Nassir, nassir@hawaii.edu Watanabe Hall Rm. 426, (808) 956-2922
Office Hours	Tue & Thu 3:00–5:00 p.m. in Watanabe Hall Rm. 426 (*likely to change in the future!*) *Please check door of Wat 426 for a note directing you to a neighboring classroom.* Meetings at other times by appointment, or call office phone anytime
Lecture	Sec. 1: MWF 9:30–10:20 a.m. Sec. 7: MWF 10:30–11:20 a.m. Physical Science Building (PSB or PHYSCI), Rm. 217 *You may attend either lecture hour, EXCEPT on exam days (assigned lecture only).*

Class Materials — Laulima "Resources"

Most class materials will be added gradually throughout the semester in Laulima's Resources tab/tool:
- **Lecture slides** will be posted online shortly before or after each lecture.
- **Lecture videos** will be posted online 1–5 days after each class session.
- **Tutorials** (sample problems) and other handouts will be distributed on paper in lecture AND posted online as PDFs.
- **Tutorial Solutions** will only be posted as PDFs.

Textbook & Online Homework

Young & Adams, *College Physics*, 11th ed. (2020), Chaps. 1–16 (vol. 1)
Mastering Physics — online homework system linked to eBook (Young & Adams) & additional study resources
- eBook & Mastering Physics — $66.20 automatic "IDAP" charge to your student account around Tue. Sept. 13, unless you "opt-out" beforehand. *See separate handout for access instructions and additional details.*
- Looseleaf version (unbound, 3-hole-punched): Discounted price of approx. $45? through Mastering Physics (anytime) or approx. $20? through UH Bookstore — special-order at Textbook Counter.
- Paperback (vol. 1 & vol. 2 sold separately) or Hardcover (full text): No discounted prices offered. Not stocked in UH Bookstore, so purchase through outside sellers, or directly from Pearson (full price): https://www.pearson.com/store/p/college-physics/P100002458383

Scientific Calculator

- Should include scientific notation (power-of-10) notation, trigonometric functions, exponents & logarithms.
- Graphing or programmable calculators are allowed, but NOT necessary.
- Necessary and expected for homework, problem sets & exams.
- ***Smart phones, tablets, computers, or similar devices are NOT permitted during exams.***

PHYS 151 Course Description

This course is the first half of a two-semester introduction to the fundamental concepts, laws, and formulas of physics. PHYS 151 covers mechanics (kinematics, dynamics, gravitation, energy, momentum, rotation), waves, and thermodynamics. Lectures and problem-solving will regularly use the mathematical tools of algebra, geometry, trigonometry, and vectors, but *not* calculus.

Prerequisites

Grade of "C" or better in **MATH 140 (trigonometry & pre-calculus) or MATH 215 or higher**; or instead, a passing score on the Mathematics Department's Math Placement Exam (≥14 on Part I & ≥10 on Part II).

We expect students to enter PHYS 151 lecture equipped with good facility in geometry, advanced algebra (including exponents & logarithms), and trigonometry. We use these mathematical tools extensively right from the start of PHYS 151 without reviewing them, so if you are not confident about your math skills in those areas, please review them before attempting this course. Please see Chap. 0 of our textbook for a summary of math topics you should be familiar with.

PHYS 151L Lab

If you plan to take PHYS 151L lab, we recommend that you do so concurrently with the lecture — the lab provides a hands-on way of reinforcing and complementing many of the topics presented in lecture. However, we do *not* require concurrent enrollment in PHYS 151L lab with PHYS 151 lecture; you can instead take PHYS 151L lab in a future term, or not at all.

Our PHYS 151 lecture and PHYS 151L lab courses are run and graded completely separately. None of the points or assignments for lecture count toward the lab, or vice versa.

The supervising professor for our lab classes is Dr. Philip von Doetinchem, Please see his PHYS Lab webpage for much more information, including syllabi and contact information for individual lab sections & TAs:

https://www.phys.hawaii.edu/~philipvd/22_fall_intro_labs_uhm.html

PHYS 151 Learning Outcomes — General

Upon successful completion of this course, students should be able to:

- Define and use the terminology of mechanics, waves, fluids, and simple thermodynamics.
- Apply the equations and principles of non-calculus-based physics to solve a wide range of problems in mechanics, waves, fluids, and simple thermodynamics.
- Recognize where and how these physical principles apply to natural phenomena, problems and professional settings within other scientific fields, and technology and situations encountered in daily life.

PHYS 151 Learning Outcomes — Detailed

Upon successful completion of this course, students should be able to:

- Describe the instantaneous and average relationships among position, velocity, and acceleration; construct and interpret graphs of all three; and calculate all three for the special case of constant acceleration.
- Identify vector vs. scalar quantities; convert two-dimensional vectors between magnitude & direction and Cartesian components; perform scalar multiplication and addition of vectors.
- Describe the nature of force and the meaning and implications of Newton's Three Laws of Motion.
- Apply Newton's 2nd Law to calculate the dynamics of systems for the special case of constant net force (including static equilibrium), including systems with ideal springs, contact friction, inclined planes, cables/pulleys, and uniform circular motion.
- Apply Newton's Law of Universal Gravitation to calculate the dynamics of simple systems of masses.
- Apply Kepler's Laws of Planetary Motion to describe and calculate the properties of simple orbits.
- Describe and calculate various forms of energy, including mechanical work, kinetic energy, and potential energies.
- Explain the Law of Conservation of Energy and its relationship to conservative vs. non-conservative forces.
- Apply Conservation of Energy to calculate kinematic quantities of a system, and identify where it is appropriate to do so.
- Describe the relationship between force and impulse/momentum, and apply it to calculate kinematic quantities of appropriate situations.
- Explain the Law of Conservation of Linear Momentum and its relationship to elastic vs. inelastic collisions.
- Apply Conservation of Momentum to calculate kinematic quantities of a system, and identify where it is appropriate to do so.

- Describe the analogy between rotational and translational kinematic & dynamic quantities, formulas, and conservation laws; apply them separately and in concert to calculate kinematic & dynamic quantities of rotating systems.
- Define density and pressure; apply them and related formulas to calculate physical properties of a variety of fluid-mechanical situations, including hydrostatics, buoyancy, and systems of confined fluid flow (Bernoulli's Equation and Continuity Equation).
- Describe the kinematics and energy conservation of simple harmonic motion, give examples of relevant physical systems, and calculate their kinematic/dynamic properties.
- Explain the nature of waves and the phenomena of wave motion, superposition & interference, reflection, and formation of one-dimensional standing-wave modes.
- State the mathematical relationships that govern wave propagation, superposition, standing-wave modes, beats, and the Doppler Effect, and apply them to calculate related physical quantities.
- Describe the phases/states of matter; explain the kinetic basis of temperature, forms of internal energy, and the primary modes of heat/energy transport.
- Employ mathematical definitions of specific heat capacity and latent heat to quantitatively relate heat to changes in temperature.
- Describe broadly the kinetic theory of gases; apply the Ideal Gas Law (and its related forms) to calculate thermodynamic quantities related to various transformations of a confined gas; find the work performed during isobaric expansion/contraction.
- Describe the broad meaning and implications of the 1st Law of Thermodynamics, and apply it quantitatively to ideal gas transformations.
- Explain the simple model of a heat engine and the quantitative relationship between efficiency, inputs & outputs, and Carnot temperatures.
- Qualitatively and quantitatively define changes in entropy; describe the broad meaning and implications of the 2nd Law of Thermodynamics.

Course Grades

Each student's **overall course percentage** will be computed as follows:

Top 4 of 5 Exam percentages (4 Midterm Exams & Final Exam) — 16% each
Online Homework percentage — 36%

Final letter-grade cutoffs for overall course percentage:

95.0% A+	80.0% B+	65.0% C+	50.0% D+
90.0% A	75.0% B	60.0% C	45.0% D
85.0% A–	70.0% B–	55.0% C–	40.0% D–

At the end of the semester, these cutoffs may be lowered at the instructor's discretion, but they will not be raised.

Students can calculate their course letter grade at any time using the following method:

- Convert all point-scores into percentages:
  - Total Online HW percentage = (total points earned) / (total points possible)
  - Midterm 1 Exam percentage = (points earned) / (points possible)
  - Midterm 2 Exam percentage = (points earned) / (points possible)
  - Midterm 3 Exam percentage = (points earned) / (points possible)
  - Midterm 4 Exam percentage = (points earned) / (points possible)
  - Final Exam percentage = (points earned) / (points possible)
- Discard one lowest Exam percentage.
- Calculate overall course percentage (OCP):
  - OCP = (best exam percentage)×(0.16) + (second-best exam percentage) ×(0.16)
    + (third-best exam percentage)×(0.16) + (fourth-best exam percentage)×(0.16)
    + (Total Online HW percentage)×(0.36)
- Convert OCP to corresponding letter grade according to above table.

Exams

• **Four Midterm Exams** will test you on material from every few weeks of the course.
• A **Final Exam** will cumulatively test all of the previous midterm material, although it will emphasize new material from the last few weeks of the course.
• Each Exam (including Final Exam) will be worth the **same weight** toward your overall course percentage and final letter grade.
• **ONE lowest Exam score (percentage) will be automatically dropped** for each student. The Final Exam is included in this calculation and is eligible to be dropped.
• **NO MAKE-UP EXAMS ARE AVAILABLE.** If you miss an exam, that score of zero is eligible to become your one dropped exam score.

Exam Dates

Midterm #1	**Mon. Sept. 19**	Chaps. 1–2, portions of Chap. 3
Midterm #2	**Mon. Oct. 10**	Chaps. 3–5
Midterm #3	**Mon. Oct. 31**	Chaps. 6–8
Midterm #4	**Mon. Nov. 21**	Chaps. 9–10, 13
Final Exam	**Mon. Dec. 12 (Sec. 1) or Fri. Dec. 16 (Sec. 7), 9:45–11:45am**	Chaps. 11–12, 14–16 & cumulative review of all previous topics

Exam Note-Sheets

– You are allowed to bring **1 sheet of handwritten notes** (no computer printouts or photocopies) to Midterms #1 & #2.
– You are allowed to bring **2 sheets of handwritten notes** to Midterms #3 & #4 and the Final Exam.
– Your sheets of paper can be no larger than 8.5×11 inches.
– You can use BOTH sides of each sheet.
– You can retain your note-sheets after each exam to build upon for later exams.
– Do NOT let these note-sheets become a substitute for learning formulas and practicing problems! (Graduate-school exams like the MCAT do NOT allow open notes — you must memorize your formulas.)

Online Homework

• **Online Homework** assignments in **Mastering Physics** (MP) will be **due most Mondays, Wednesdays, and Fridays at 11:55 pm**. **Due dates will begin with Week #2 of the semester.** Each assignment will usually be posted roughly a week before it is due. Please check Mastering Physics regularly for new assignments and due dates.

• Points

– Point values for each problem are based on its difficulty, number of parts, time required, and importance. For multi-part problems, Mastering Physics divides the problem's points evenly between the parts.

– Homework points (and time required) vary widely from assignment to assignment, typically in the range of 20–60 points.

– Online HW points will be simply added up to form a grand total for the entire semester, in the range of 1000–1500 points. Therefore, individual HW points weigh equally in your Online HW Total, and percentage-scores for individual HW assignments do not matter.

• Penalties

This should match the Grading Policy that can be viewed in MP for our assignments:

Lateness: Minus 20% per day past the due date/time, decreasing to zero credit at 5 days. This penalty is applied ONLY to individual late problems, not to the entire assignment score. Also, the penalty is prorated for fractions of day (i.e., 2 hours late ⇒ –1.7% penalty).

Wrong Answers – Multiple-Choice Questions: Fractional penalty for every wrong answer, decreasing to zero credit when only one choice remains.

Wrong Answers – Free-Response Questions (numerical entry, etc.): No penalty for first 10 wrong attempts, then question is forfeit (no credit).

• Bonuses

Some assignments contain one or two problems worth a small amount of **extra credit**, and those problems are labeled as such in Mastering Physics. Those assignments will therefore have a maximum possible score >100%.

• Optional Non-Credit Assignments

Any Mastering Physics assignments that are labeled "NOT FOR CREDIT" are for optional practice. They are NOT worth any points toward your Online HW point-total.

Textbook Reading & Additional Problems

• **Reading assignments** (textbook section numbers) are listed in the attached course calendar, and are also repeated near the start of each tutorial sheet. These are the sections of our text that will be covered in lecture, and which you will be responsible to know for exams. For each topic, lecture will highlight most of the important formulas, concepts, and vocabulary, and show a few examples of their applications. Our textbook is valuable because it contains additional worked example problems beyond those of our lectures and tutorials.

• Use our textbook more like a reference manual or cookbook, instead of reading it through start-to-finish like a novel:

– Skim the relevant textbook sections in advance of their related lecture, then go back and read more carefully after lecture.

– When first skimming a section to orient yourself to a topic, skip long text passages or mathematical derivations. Instead, pay most attention to headers, **highlighted or boxed formulas**, important-looking diagrams & tables, and the gist of any worked examples.

– **End-of-chapter summaries** are extremely useful one-page distillations of the essential formulas and topics — often, those are all you need to use when working on homework problems.

• **eBook:** There are several ways to access the eBook through Mastering Physics:

– Follow the "Pearson eText" tab along the left-hand side of our course page

– Follow the "Study Area" tab along the left-hand side of our course page

– Hyperlinks that open relevant portions of the eBook are located throughout MP homework problems and study resources.

• **Study Area in Mastering Physics:** Click on the "Study Area" tab along the left-hand side of our course page. After it launches, you will see links to the eBook, Videos, Chapter quizzes, online Physics simulations, and more. I encourage you to explore this and use it to enhance each of our topics.

• **End-of-Chapter Problems:** Solving physics problems is a skill learned through repeated practice, similar to a sport or musical instrument. To truly gain proficiency, I recommend that you attempt as many additional end-of-chapter problems as your time permits. **Short answers to all odd-numbered end-of-chapter problems are located in the textbook Appendix.**

Getting Help with Physics

The following resources are available free-of-charge to current UH Manoa students:

• **Physics Lab TAs** (mostly graduate students in Physics) hold ~30 hours/week of drop-in office hours in Watanabe Hall Rm. 421 (our Physics Library & Study Center). Although lab TAs *must give first priority to students with lab-related questions*, they can also assist with lecture homework problems or other physics questions as time permits. Scroll halfway down this page for a master schedule of all TA names/days/hours:
https://www.phys.hawaii.edu/~philipvd/22_fall_intro_labs_uhm.html

• The **Natural Sciences Learning Emporium** in Bilger Addition 209 is open daily for all students to seek free, drop-in assistance with lower-division math or science classes. Schedules of tutors for physics (coming soon) and other STEM subjects are posted online here:
http://uhnatsci.org/emporium/tutorschedules.php

• The **Learning Assistance Center** offers free one-on-one tutoring by appointment for physics and many other introductory math & science courses. Make an appointment online at least 24 hours in advance:
https://manoa.hawaii.edu/undergrad/Learning/tutoring-by-appt/

• The **Housing Success Center** is open Sunday–Thursday, 6:00–9:00pm, for free walk-in assistance for physics and other introductory math & science courses. Check their online schedule of tutors & subjects:
https://manoa.hawaii.edu/undergrad/Learning/walk-in-tutoring/

Solving Physics Problems & "Showing Your Work"

In Fall 2022, you will NOT be asked to submit detailed work for Online HW or Exams. However, the following is general good practice for solving physics problems, so please follow it whenever possible:

It is a central notion in science to show your method along with your results, so that others can follow your reasoning and can question any steps or assumptions. Also, clear and complete work will only help you later when you review your own work and study for exams. It is never possible to "show too much work," but it is easy not to show enough!

- Write out all **major mathematical steps** from your **initial formula(s)** to **your final answer.** (Minor algebraic steps and arithmetic calculations can be omitted.) Your lines of mathematical work should read **sequentially and logically**.
- Accompany your math with **sketches**, **diagrams**, and **short written phrases or comments,** where appropriate. Whenever you introduce a new quantity, like an angle or length, create a simple, neat diagram that clearly shows what the variable represents!
- All numerical values should include **units**.
- Very large and very small values should be written in **scientific (power-of-10) notation**.
- Final numerical answers should be **fully calculated and simplified**, then expressed as a decimal value rounded to an appropriate number of **significant figures**. It is rarely appropriate to leave your final answer to a physics problem as a fraction, square-root, or other un-rounded mathematical value, or in an un-simplified algebraic form.

In summary, "showing your work" should include:

1. **Initial Formula**, followed by major algebraic rearrangement steps (if necessary)
2. **Substitution**: "plugging in" known values, followed by major calculation steps (if necessary)
3. **Final Answer**: underlined or boxed, with proper **units**, **sci. notation** (if needed), & **significant figures**
4. Additional **diagrams** or **comments**, as needed to define quantities. (A picture is worth 10^3 words!)

• **Organization** and **neatness** matter! Both should result naturally if you follow the above format. Disorganized or illegible work can lead to both mathematical and conceptual errors.

PHYS 151 Fall 2022 Calendar of Topics & Textbook Sections *Version: 22 Aug 2022*

• This is an intended schedule of topics, but actual subject matter covered by each date may lag behind. In that case, exams will only cover material actually discussed in lecture before each exam date. Relevant chapters and sections will be confirmed before each exam.

• For each section/topic listed below in regular type, you will be expected to know and understand the major formulas, concepts, and terminology, and how to apply them correctly to basic and intermediate-level problems.

• For sections/topics listed in *[[brackets]]*, you only need to familiarize yourself *qualitatively* with their concepts and terminology. For these sections, you do NOT need to learn any specific formulas, nor will you be asked to solve any numerical problems for those topics.

DATE	EVENT	READ: Young & Adams, *College Physics*, 11th ed.
M Aug 22	Lect #1	Intro to PHYS 151 *[[§1.1–1.2: Intro to Physical Laws & Models]]* Chap. 0: Math Review *(self-review, not in lecture)* §0.1–0.2: Powers-of-10 & Scientific Notation
W Aug 24	Lect #2	§1.3–1.4: SI/Metric Units & Prefixes; Unit Conversions §1.5: Uncertainty & Significant Figures *[[§1.6: Estimates & Orders of Magnitude]]*
F Aug 26	Lect #3	§2.1–2.2: Position & Displacement, Speed & Velocity
M Aug 29	Lect #4	§2.1–2.2: Graphing Position & Velocity
W Aug 31	Lect #5	§2.3: Acceleration; Graphing Acceleration
F Sept 2	Lect #6	§2.4–2.5: Kinematics with Constant Acceleration
(M Sept 5)	HOLIDAY	*Labor Day*
W Sept 7	Lect #7	§2.6: Freefall
F Sept 9	Lect #8	§1.7–1.8: Vectors vs. Scalars, Vector Notation, Vector Components
M Sept 12	Lect #9	§1.7–1.8: Vector Arithmetic: Scalar Multiplication, Addition/Subtraction
W Sept 14	Lect #10	§2.7, 3.5: Relative Velocity, Adding Velocities in 1-D & 2-D §3.1–3.2: 2-D Kinematics
F Sept 16	Lect #11	§3.3: Projectile Motion
M Sept 19	**MIDTERM #1**	**Lectures #1–9** ≈ *assigned sections of Chaps. 1–2*
W Sept 21	Lect #12	§4.1–4.6: Common Forces, Newton's Laws of Motion, Free-body Diagrams
F Sept 23 & M Sept 26	Lect #13	§5.1–5.2: Applying Newton's 2nd Law: 1-D & 2-D Dynamics & Equilibrium
W Sept 28	Lect #14	§5.4 & 11.2: Elastic Force: Ideal Springs & Hooke's Law *[[§11.1: Stress & Strain; Elasticity vs. Plasticity]]* §5.3: Force of Surface Friction (Kinetic & Static) *[[§5.3: Fluid Drag]]*
F Sept 30	Lect #15	§5.2–5.3: Applying Newton's 2nd Law: Inclines *not in textbook*: Simple Machines & Mechanical Advantage §5.5: Four Fundamental Forces of Nature
M Oct 3	Lect #16	§11.2: Period, Frequency & Angular Frequency §3.4, 6.1: Uniform Circular Motion, Centripetal Acceleration & Force *[[§6.2: Motion in a Vertical Circle]]*
W Oct 5	Lect #17	§6.3: Newton's Law of Universal Gravitation §6.4: Weight & Surface Gravity
F Oct 7	Lect #18	§6.5: Orbits *not in textbook:* Kepler's Laws of Planetary Motion
M Oct 10	**MIDTERM #2**	**Lectures #10–15** ≈ *assigned sections of Chaps. 3–5*
W Oct 12	Lect #19	§7.1–7.3: Energy, Work, Work-Energy Theorem §7.8: Power
F Oct 14	Lect #20	§7.5: Gravitational Potential Energy §7.4–7.5: Elastic Potential Energy §7.7: Conservative vs. Non-conservative Forces
M Oct 17	Lect #21	§7.6: Conservation of Energy
W Oct 19	Lect #22	§8.1, 8.5: Momentum & Impulse
F Oct 21	Lect #23	§8.2: Conservation of Momentum §8.3–8.4: Elastic vs. Inelastic 1-D Collisions *[[§8.8: Rocket Propulsion]]*
M Oct 24	Lect #24	§8.6-8.7*:* Center of Mass, Velocity of CM

W Oct 26	Lect #25	§9.1–9.3: Rotational Kinematics §9.4: Moment of Inertia, Rotational Kinetic Energy §9.5: Rolling Objects
F Oct 28	Lect #26	§10.1: Torque §10.2: Rotational Dynamics §10.3: Rotational Work §10.6: Static Equilibrium & Stability, Mechanical Advantage of Levers
M Oct 31	**MIDTERM #3**	**Lectures #16–24** ≈ *assigned sections of Chaps. 6–8*
W Nov 2	Lect #27	§10.4–10.5: Angular Momentum; Conservation of Ang. Mom. §10.7: Vector Nature of Angular Quantities *[[§10.7: Gyroscopes & Precession]]*
F Nov 4	Lect #28	§13.1: Density §13.2: Pressure, Pascal's Principle, Hydrostatic Pressure Increase with Depth
M Nov 7	Lect #29	§13.3: Archimedes' Principle & Buoyancy
W Nov 9	Lect #30	§13.5: Flowing Fluids: Continuity Equation §13.6–13.8: Flowing Fluids: Bernoulli's Equation & Principle
F Nov 11	HOLIDAY	*Veterans' Day*
M Nov 14	Lect #31	§11.2–11.4: Simple Harmonic Motion & Energy Conservation
W Nov 16	Lect #32	§11.5: Simple Pendulums *[[§11.6: Damped Oscillations, Driven Oscillations, Resonance]]*
F Nov 18	Lect #33	§12.1, 12.3: Mechanical Waves & Wave Speeds §12.2: Continuous Waves *[[§12.4: Mathematical Description of Continuous Waves]]* §12.5: Reflection & Transmission *[[§12.9, 12.13–12.14: Sound Waves & Acoustics]]* §12.10: Wave Energy & Intensity, Decibel Scale of Loudness
M Nov 21	**MIDTERM #4**	**Lectures #25–30** ≈ *assigned sections of Chaps. 9–10, 13*
W Nov 23	Lect #34	§12.5: Principle of Superposition §12.8: Constructive & Destructive Interference §12.11: Beats §12.6: Standing Wave Modes (Normal Modes) on a String
(F Nov 25)	NO CLASSES	*Thanksgiving & Non-Instructional Day*
M Nov 28	Lect #35	§12.7: Standing Wave Modes in Air Columns §12.12: Doppler Effect & Shock Fronts
W Nov 30	Lect #36	§14.1–14.2: Temperature *[[§16.8: Absolute Zero]]* §14.3: Thermal Expansion of Solids & Liquids §14.4: Heat; Heat Capacity & Specific Heat
F Dec 2	Lect #37	§14.5–14.6: Latent Heat & Phase Transitions *[[§14.7: Heat Transfer Methods: Conduction, Convection, Radiation]]*
F Dec 2 & M Dec 5	Lect #38	§15.1–15.2: Equations of State, Ideal Gas Law §15.2: *PT* Phase Diagrams §15.3–15.4: Kinetic Theory of Gases, Maxwell-Boltzmann Distributions
M Dec 5	Lect #39	§15.5: 1st Law of Thermodynamics §15.5: Work Done by/on a Gas, *PV* Diagrams §15.6–15.7: Constant-Value & Adiabatic Thermodynamic Processes
W Dec 7	Lect #40	§16.1–16.2: Reversible Processes & Heat Engines *[[§16.3–16.4: Combustion Engines & Refrigerators]]* *[[§16.9: Efficiencies of Real-World Processes]]* §16.5–16.6: 2nd Law of Thermodynamics, Carnot Engines §16.7: Entropy
Mon Dec 12 & Fri Dec 16 9:45-11:45a	**FINAL EXAM**	**Cumulative, with emphasis on Lectures #31–40** ≈ *assigned sections of Chaps. 11–12, 14–16*