## Introductory Physics II

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### News

» Welcome! This page provides information for students starting this course. All live course information will be posted on the Brightspace platform. Please follow the Brightspace page for announcements and updates.

Please review news and the course outline carefully. All the relevant information is posted here, and most of your administrative questions are already answered.

» The course uses a free online textbook from OpenStax (see the link on the left).

» For students working on their math skills, do not forget to take a look at topic-specific short tutorials, on the right-hand side of the Math section of PPLATO. Topics such as Brackets, Fractions, Simple equations, Inequalities, Simultaneous equations, Quadratic equations, etc. are well covered.

The formula sheet will be revised and expanded with all the relevant information before the final exams. Be sure to download and print out an updated version of the formula sheet before the exam.

Times and Locations: Lectures: M 1200-1400hrs, W 1300-1500hrs TH242 - Thistle Complex. Weekly Quiz: W 1200-1300hrs, TH242 - Thistle Complex.

### Older news

### Course Outline

**What Brock calendar entry says**:

Statics and dynamics of fluids; heat and thermodynamics; geometrical and wave optics; electric and magnetic forces; DC circuits; special relativity and quantum physics.

**What do I need to bring into the course?**

This course is suitable for students with a high school science background. High school calculus or Physics are *not* required, but strong skills in elementary algebra, geometry, and trigonometry are necessary: the course is *quantitative* in nature. A good scientific calculator is required. PHYS 1P21/1P91 is prerequisite to this course.

**Textbook**

Our textbook is *College Physics*, second edition, by Urone, Hinrichs, Dirks, and Sharma, published by OpenStax (Rice University). The book, a solution manual, and other student resources are available at https://openstax.org/details/college-physics.

**PPLATO**

PPLATO a set of online resources organized as a full-scale Physics and Mathematics textbook. There are two types of resources: in the left column there are FLAP (Flexible Learning Approach to Physics), while on the right are supplementary self-assessment modules. Think of the left-hand column as of the chapters of a complete textbook, and of the right-hand column as of tutorials on a selection of topics.

**Supplementary (paper) texts**

Some people like to have secondary sources to read in case they have difficulty understanding the primary textbook in some places. This is *not* required, but if you would like a secondary source, borrow one from a library, or buy an inexpensive used algebra-based textbook from your favourite used bookstore or internet source. Look for titles such as *Physics* or *College Physics*. If your major subject is Physics or a related field, and you would like a more advanced (say, calculus-based) textbook for reference, look for titles that include "for Scientists and Engineers."

**Topics to be covered**

As time permits, some topics not listed below may be added, while some other topics may not be covered during lectures and tutorial sessions. The outline below is only an approximation.

» Fluid Statics: Sections 11.1-11.7.

» Fluid Dynamics: Sections 12.1-12.3.

» Temperature & Gas Laws: Sections 13.1-13.5.

» Heat: Sections 14.1-14.4.

» Thermodynamics: Sections 15.1-15.4, 15.6-15.7.

» Electric Charge & Electric Field: Sections 18.1-18.5, 18.7.

» Electric Potential & Electric Energy: Sections 19.1-19.7.

» Electric Current & Resistance: Sections 20.1-20.5.

» Circuits & DC Instruments: Section 21.1.

» Magnetism: Sections 22.1-22.5, 22.9.

» Electromagnetic Waves: Sections 24.1-24.4.

» Geometric Optics: Sections 25.1-25.7.

» Wave Optics: Sections 27.1-27.5, 27.8.

» Special Relativity: Sections 28.1-28.6.

» Quantum Physics: Sections 29.1-29.8.

Textbook Chapters 1-10 were covered in PHYS 1P21/91, and are required as mandatory background material for PHYS 1P22/92. Please make sure to review them if needed.

## Lecture materials

### Solids and fluids

- Mechanical and bulk properties of matter; stress and strain
  - stretching/compression
  - shear (=sideways)
  - volume deformation
- Bulk properties are determined by averages
  - **Ex:** density
  - **Ex:** pressure
  - *Aside:* How does an altimeter work?
- Hydrostatics
  - **Ex:** gauge pressure (water tower)
  - **Ex:** buoyant force (iceberg)
  - **Ex:** floating without water
  - **Ex:** density determination for a coin ("Eureka!")
- Hydrodynamics
  - **Ex:** blood flow in aorta
  - Bernoulli's equation
  - **Ex:** a straw atomizer (see this hint)
  - Torricelli's theorem
  - **Ex:** Disaster at Sayano-Shushensk Hydro Power Station, 18.08.2009
  - viscous flow, *e.g.* velocity distribution in a pipe
  - **Ex:** an injection
  - **Ex:** running on water, a hoax or the real thing?
  - Low Reynolds number and onset of turbulence
  - **Ex:** blood flow through aorta
  - A white blood cell chasing a bacterium
  - *Life at low Reynolds number*, by E.M.Purcell

### Heat and Thermodynamics

- Heat and temperature
  - 0th law of thermodynamics: thermal equilibrium
  - temperature scales: absolute, Celsius, Fahrenheit
  - thermal expansion: length, area, volume
  - volume and linear thermal expansion coefficients are related
  - **Ex:** density of water, why does ice float?
  - **Ex:** SR-71 Blackbird
  - **Ex:** trains run on "long strips of metal"
  - heat capacity and specific heat
  - **Ex:** calorie is not "Calorie"

- **Ex:** calorimetry: keeping the labels straight
- **Ex:** the phase diagram of water
- phase equilibrium and latent heat
- **Ex:** the critical point of benzene
- heat transport: conduction, convection, radiation

- The ideal gas and the gas laws
  - the equation of state, $pV = Nk_BT$
  - Boltzmann constant, $k_B=1.38x10^{-23}$J/K
  - particular cases: $p=const$ (isobaric), $T=const$ (isothermal), $V=const$ (isometric)
  - isotherms and isobars
  - Avogadro's number, $N_A=6.022x10^{23}$ molecules/mol
  - universal gas constant $R=8.31$ J/(mol.K)=$0.0821$ (l.atm)/(mol.K)
  - **Ex:** volume of 1 mole of gas
  - kinetics of ideal gas molecules: elastic collisions with the walls
  - Maxwell's speed distribution
  - statistical characteristics of distributions: $v_{most\ probable}$ or $v_{rms}$ or $v_{average}$ ?
- Heat engines
  - 1st law of thermodynamics: heat is a form of energy, $U=+Q-W$
  - work $W=pV$ for $p=const$
  - **Ex:** isothermal expansion
  - **Ex:** $Q=0$ (no heat flow, adiabatic)
  - combining isothermal with adiabatic processes allows thermal cycles
  - heat engines and Carnot cycle
  - **Ex:** Otto internal combustion cycle
  - 2nd law of thermodynamics: perfect heat-to-work conversion is not possible
  - **Ex:** the Stirling engine
  - **Ex:** refrigeration
  - **Ex:** violating laws of TD
- Entropy
  - entropy and the 2nd law
  - time's arrow and the fate of the Universe
  - 3rd law of thermodynamics: absolute $T=0$ is not attainable

### Electrostatics

- Electrostatic or Coulomb's force
  - charge, electrons, protons, neutrons, and matter
  - periodic table
  - sticky tape experiment
  - direction of Coulomb force
  - **Ex:** Newton vs. Coulomb in a hydrogen atom
  - **Ex:** charging exercise 1
  - **Ex:** charging exercise 2
  - **Ex:** coulomb force
- Electric field
  - **Ex:** field of two charges
  - **Ex:** superposition of fields I
  - **Ex:** superposition of fields II
  - electric field of extended sources
  - **Ex:** a ring of charge
  - electric field lines ($+q$, $-q$, parallel plates, dipole)
  - **Ex:** Interpreting field line diagrams
  - electric field inside conductors is zero
  - **Ex:** atmospheric electrical field
  - **Ex:** motion in constant field I
  - **Ex:** motion in constant field II
- electric potential energy and potential
  - **Ex:** electric potential energy and force
  - **Ex:** energy vs. potential
  - electrostatic potential (cf. gravitational potential)
  - potential produced by a system of point charges
  - **Ex:** work-energy theorem for electrostatics
  - **Ex:** two protons
  - equipotential surfaces for: a point charge; a dipole

- Ex: reading equipotential diagrams I
  - **Ex:** reading equipotential diagrams II
  - **Ex:** reading equipotential diagrams III
  - capacitors and dielectrics
  - **Ex:** stored electric energy in a capacitor

**Electric Circuits, Current and Resistance**

- Current is a movement of charge
- Voltage and Electric Field
  - capacitor and wire
  - Electric Field is contained within wires
  - A mechanical battery
  - A real battery
  - **Ex:** Electric Field inside D-cell
- Resistance
  - defined phenomenologically: $R = V/I$, Ohm's Law
  - defined phenomenologically: $J = \sigma E$, Ohm's Law
  - **Ex:** electric socks
  - defined through material's properties: $R = \rho L/A$
  - **Ex:** reshaping a wire
  - **Ex:** current and wire diameter
- a water analogy
- Simple electric circuits
  - in series; Kirchhoff's voltage rule (KVR)
  - in parallel; Kirchhoff's current rule (KCR)
  - equivalent resistance
- Energy/power in electric circuits
  - defined: $P = VI = I^2R = V^2/R,$

- **Magnetism, induction, electromagnetic fields**
- **Light & Optics**
- **Quantum Physics**

**Magnetism**

- Magnetic forces and magnetic fields
  - field of a bar magnet
  - magnetic field lines start at "N", end at "S"
    there are **no** magnetic monopoles
  - **Ex:** uniform magnetic field
  - **Ex:** Earth's magnetic field; North *vs.* "N"
- Magnetic materials, ferromagnetism
- Magnetic force on a moving charge
  - magnitude: $F = qvB\sin\phi$
  - direction: the right-hand rule
  - **Ex:** magnetic force 1
  - **Ex:** magnetic force 2
  - **Ex:** magnetic force 3
  - **Ex:** magnetic force 4
- Motion of charged particles in constant magnetic fields
  - Bubble Chambers
  - **Ex:** uniform circular motion
  - aurora borealis
  - **Ex:** the solar wind
  - engineering applications
  - television
  - **Ex:** mass-spectrometer
  - **Ex:** alpha particles in B field
- Magnetic force on an electric current
  - **Ex:** magnetic force on a current
  - **Ex:** magnetohydrodynamic drive
  - **Ex:** loudspeaker
  - **Ex:** electric train using the Earth's magnetic field
- Force on a loop of current
  - magnetic moment of a coil

    - DC electric motor
- Magnetic fields produced by electric currents
    - a long straight wire
    - **Ex:** health effects of the em radiation from transmission lines, etc.
    - magnetic field of a loop; a solenoid
    - two wires exert forces on each other
    - **Ex:** solenoid
    - **Ex:** a flexible loop
    - **Ex:** a hairpin current
    - **Ex:** magnetic field at the center of a loop
    - **Ex:** forces on loop
- Electromagnetic induction
    - magnetic flux $\Phi = BA\cos\phi$
    - **Ex:** calculating flux
    - current induced by a changing magnetic flux
        - changing the area: a moving rod, a shape distortion
        - **Ex:** a shrinking loop
        - changing the angle
        - changing magnetic field
    - **Ex:** ground-fault detection
    - **Ex:** a moving-coil microphone
    - **Ex:** an electric guitar pick-up coil
    - **Ex:** magnetic tape playback
    - **Ex:** magnetic flux
    - **Ex:** change in flux
    - **Ex:** faraday's law
    - Lenz's law: induced emf opposes changes in flux
        - **Ex:** Lenz's Law 1
        - **Ex:** Lenz's Law 2
        - **Ex:** Lenz's Law 3
        - **Ex:** non-conductors/broken circuits
    - motional emf
        - **Ex:** tethered satellite experiment
    - generators
        - **Ex:** back-emf of an electric motor
    - transformers
        - two coils share the same flux
        - iron core "concentrates" the field lines
        - **Ex:** reducing power losses in transmission lines
    - self-inductance
    - Maxwell's equations: electricity & magnetism unified; electromagnetic wave

## Light and Optics

- Light is an e.m. wave
    - oscillating transverse em **fields**
    - **Ex:** measurement of the speed of light by Fizeau, Michelson [1, 2]
    - radiation pressure: a comet's tail
    - mathematics of waves
    - wave fronts and rays
    - EM spectrum
- Polarization is a wave property
    - polarization of waves on a string
    - intensity of unpolarized and polarized light
    - Malus' law: crossing two polarizers
    - applications of crossed polarizers in optics
        - **Ex:** polarizing sunglasses at a lakeside
        - **Ex:** LCD
        - **Ex:** strain detection in polymers
- Interference and diffraction are wave phenomena
    - constructive and destructive interference
    - Young's double-slit experiment
        - bright and dark fringes: path difference
    - Newton's rings: setup, fringe pattern, detecting defects

- diffraction depends on wavelength/dimension ratio
    - X-ray diffraction from crystals
    - holography
- Ray optics
    - R.Feynman explaining the nature of photons in a lecture for a general audience
    - Huygen's principle
    - law of reflection
        - specular vs. diffuse reflection
        - virtual image formed by a plane mirror
        - **Ex:** angles unchanged by reflection
    - refraction of light
        - speed of light in a medium; optical index (density)
        - marching band analogy
        - refraction illustrated using the Huygen's principle
        - derivation of Snell's law
        - **Ex:** apparent depth
        - **Ex:** looking out of water
        - total internal reflection
        - **Ex:** prism binoculars
        - **Ex:** critical angle
        - polarization by reflection, Brewster's angle
        - dispersion: *n* depends on wavelength
        - **Ex:** rainbow dispersion - by many droplets; physics of rainbows: the details
        - *further reading:* a brief interactive summary of refraction
    - spherical mirrors
        - concave and convex mirrors
        - image formation and ray tracing;
        - real & virtual images
        - magnification and mirror equation
    - thin lenses
        - converging and diverging lenses
        - image formation and ray tracing;
        - real & virtual images
        - a virtual object: lenses in combination
        - **Ex:** macro lens on a camera
        - **Ex:** a magnifying glass
        - lens-making; optical power in diopters
        - **Ex:** a human eye; near-sightedness and far-sightedness

### Quantum Physics

- Light is an EM wave
    - polarization is a wave phenomena
    - interference: constructive and destructive
    - Young's double-slit experiment
        - bright and dark fringes: path difference;
        - **Ex:** two slit (conceptual)
- Light is a stream of "particles"
    - photoelectric effect
    - **Ex:** intensity and photons
    - **Ex:** cut-off frequency
- de Broglie's matter waves
    - wave-particle duality
    - two slit electron diffraction
    - Davisson & Germer experiment
    - **Ex:** wavelength of a baseball
    - **Ex:** deBroglie wavelength
    - **Ex:** deBroglie wavelength change

### Tests and the grading scheme

| Component | PHYS 1P22 | PHYS 1P92 | Comments |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Weekly Quizzes | 60% | 40% | 9 50-minute weekly tests (Tests will conducted in-person every Wednesday 12-1 pm). One lowest grade (excluding zeros from the tests missed without a medical/compassionate excuse) are dropped from the average. Review questions (not for credit) will be posted at the end of each chapter. As the problems are randomly selected and modified. A mixture of qualitative and numerical problems. |
| Final Exam | 40% | 40% | Details will be provided prior to the final exam. You must pass the final exam (50% or more) in order to pass the course*. |
| Laboratories | - | 20% | Completing all labs, and submitting written lab reports are required to complete the lab component of the course. Students receiving a lab grade that is lower than 60% overall average will be required to withdraw from PHYS 1P92, and will only be able to receive a grade in PHYS 1P22. |
| | | | The late work policy for lab grades is: Lateness less than 24 hours, maximum possible grade = 70% ; Lateness less than 48 hours, maximum possible grade = 30% ; Lateness less than 72 hours, maximum possible grade = 10%. The late penalty will be waived for special cases only (i.e. medical or compassionate considerations). Documentation will be required. |

If you fail to obtain at least 50% on the final exam, you do not obtain a credit in the course (regardless of your calculated final grade). The Registrar's Office will enter your final grade as the lower of your calculated final grade or 45F. In this case, to attain a credit for the course, you would need to repeat the course.

### Expectations and responsibilities

Here is a summary of our expectations of you, which are your responsibilities. You are expected to:

- attend each scheduled lecture and laboratory session;
- do your work honestly and maintain academic integrity
- complete each test, using only the materials that have been authorized for use, such as a non-graphics calculator and writing instruments.
- attend labs (PHYS 1P92) having **prepared in advance** by reading relevant parts of the lab manual, and having completed the prelab problems.

And most important of all, you must take responsibility for your own learning. The lectures are there to guide you and assist you, but only you can actually do the hard work of learning the course material. To get the most out of the course, work on it a little bit every day. Daily work is key for placing your learning in long-term memory, where it will be readily available to help you to advance your knowledge in second year and beyond - and acing the final exam, of course. Cramming on the night before may place the material in your short-term memory and you might even do fine on a weekly test, where the amount of new material is relatively small, but this approach will fail miserably on the final exam.

Your instructor will provide weekly textbook chapter references; read through those sections. The best way is to read them twice: once before the lectures, just to orient yourself in the material, to identify those parts that seem like they might need extra time and attention. Make a note of the questions that arise in your mind. The lecture should answer some of them, and if it does not, raise your hand and ask! It is likely that many others have the same question. After the lecture, read the textbook again, with a pen and paper in hand, repeating all derivations on your own, trying every solved example before looking at the solution, then solving every follow-up questions at the end of the section. Only one half of them have answers; you must learn to have enough confidence in your skills to solve even those problems where the answer is not known in advance. The odd-numbered problems will allow your to make sure, and the even-numbered ones will allow you to test yourself. Both are integral to the learning process.

Use your time effectively. Study smart, instead of hard. Ask questions in class. Your instructor will be available on Mondays, Thursdays and Fridays in the hours before and after lecture in MC E220, sending an email first is a good way to check availability. Do not wait until you have a "worthy" pageful of questions - that's too long to let them fester unanswered. There is also a Physics Help Desk, with TAs available to help out. Find out where and when it is held, and come often. It is better to come three times with one or two questions than once with a list accumulated over the past several weeks, when things get too desperate. Asking questions is a sign of active learning, not a sign of weakness!