

Physics 142 Syllabus

This is the second of a two semester sequence in introductory physics, covering electrostatics, magnetostatics, the electromagnetic wave equation, light, and optics, *with calculus*. Its intended targets are math/science majors other than physics or mathematics (who are better advised to take Physics 162, the course for majors and more advanced and mathematically inclined students).

List of Topics

The following topics are covered at the rate of approximately one per week during the regular semester, three per week in summer school:

- **Discrete Charge and the Electric Field:** Charge, Coulomb's law, electrostatic field, superposition principle, electric dipoles.
- **Continuous Charge and Gauss's Law:** Continuous charge distributions, field of loop, line, disk, sphere of charge, Gauss's law for electrostatic field, Gauss's law used to find fields of point/sphere, line/cylinder, plane/slab distributions of charge, properties of conductors, Gauss's law and conductors.
- **Electrostatic Potential Energy:** Potential energy of two interacting charges, potential, superposition principle, computing potential from fields, computing potential using superposition, conductors in electrostatic equilibrium, charge sharing, dielectric breakdown.
- **Capacitance and Resistance:** Capacitance, plane capacitors, cylindrical capacitors, spherical capacitors, capacitance in series and parallel, dielectrics, dielectrics and capacitance. Resistance, resistivity/conductivity, Ohm's law, resistors in series and in parallel. RC circuits (charging and discharging).
- **Magnetic Force:** Force on point charge in given $\vec{B}$ field, force on current carrying segment of wire, motion of point charge in uniform field, cyclotron frequency, velocity selector, cyclotron, Thomson's apparatus for measuring e/m , mass spectrometer, Hall effect, magnetic dipole (moment), force and torque on magnetic dipole, potential energy of magnetic dipole.
- **Magnetic Field:** No isolated monopoles, Gauss's law for magnetism, field of a moving point charge, Biot-Savart law, field of long straight wire carrying current, a ring carrying current, a rotating disk of charge, Ampere's law, using Ampere's law to find the field of wire/cylinder, solenoid, toroidal solenoid, infinite sheet of current.

- **Faradaw's Law and Induction:** Motional potential differences, motional currents in loops, Faraday's law, Lenz's law, Lenz's law and energy conservation, magnetic flux and inductance, mutual inductance, self inductance, self inductance of solenoid, toroidal solenoid, solenoid as generic inductor L , voltage across an inductor, mutual inductance and transformers,
- **Alternating Current Circuits:** AC generator, household voltage, current, wiring true facts and dangers, transformers and power transmission (Tesla vs Edison feud), LC circuit, LRC circuit, harmonically driven series LRC circuit (reprise of simple harmonic oscillator, damped harmonic oscillator, damped driven harmonic oscillator, resonance and power curves, V_{rms} and I_{rms} , Q , high pass and low pass filters, impedance, parallel LRC circuit.
- **Maxwell's Equations and Light:** Non-invariance of Ampere's law, charge conservation and invariant current, Maxwell Displacement Current, Maxwell's Equations (as a complete set), derivation of (homogeneous) wave equation for $\vec{E}$ and $\vec{B}$ fields in free space, speed of light, solutions to wave equation, especially harmonic solutions, energy density in electromagnetic field, intensity of light and the Poynting vector, power as flux of Poynting vector, momentum in electromagnetic waves, radiation pressure, dipole antenna, accelerating charges and failure of classical physics.
- **Properties of Light:** Speed of light in a medium, index of refraction, dispersion, law of reflection, Fermat principle, law of refraction (derivation of Snell's law from wave geometry), polarization of light (definition), polarization by absorption (Malus's law), scattering, reflection, how/why polarized sunglasses work, scattering and why sky is blue (Rayleigh's law), non-relativistic doppler shift, Cerenkov radiation in a medium, Huygens principle.
- **Mirrors and Lenses:** Ray approximation and how rays are emitted in all directions from all points on object, plane mirror, definition of object, image, object distance, image distance, magnification, real image, virtual image, erect image, inverted image, ray diagram, spherical mirrors in paraxial approximation (including derivation of equation linking s, s', f), ray diagrams with parallel, focal, central rays, spherical lenses, thin lenses, lensmakers formula, thin lens equation, ray diagrams for lenses.
- **The Eye and Optical Instruments:** The eye, especially lens, pupil, and retina, normal vision, nearsighted vision, farsighted vision (and corrections), simple magnifier, telescope, "Galilean" (non-inverting) telescope, compound microscope, "Galilean" (non-inverting microscope, aberrations.
- **Physical (Wave) Optics:** Huygens principle revisited, thin film interference, two slit interference (and phasors revisited), three slit, four slit...

N slit interference (via phasors), diffraction through single slit, combined two slit interference and diffraction, diffraction grating, Rayleigh criterion for resolution, radio telescope arrays.