

Physics II: Course Overview and Roadmap

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Physics II at a glance



Course profile

Programme	Computer Science
Study level	First-cycle (engineer)
Semester	3
Language	English
Status	Obligatory
Course code	ECSCS.li4.07046.26

Workload and verification

- **5 ECTS**
- **30 h** lectures + **30 h** auditorium classes
- Didactic cycle: **2026/2027**
- Learning outcomes verified by a **written final examination** together with the auditorium-class component

Course perspective

Physics II connects field concepts, circuit models, waves and optics with selected foundations of quantum and nuclear physics. The emphasis is on **physical reasoning**, **quantitative problem solving**, and applications relevant to science, engineering and computing.

Course goals, prerequisites, and learning approach

What the course is designed to develop

- A coherent understanding of electricity and magnetism, induction, electromagnetic waves, optics, and selected quantum/nuclear physics.
- Quantitative problem solving using physical laws, units, mathematical relations and justified approximations, connected to modern scientific and technological applications.
- Correct use of specialised English terminology, standard notation and mathematical expressions when presenting physical reasoning and solutions.

Expected background

Elementary algebra, vectors, basic differential and integral calculus, plus the mechanics and waves of Physics I.

Mathematics used when needed

Simple differential equations, partial derivatives, and elementary surface/volume integrals will be introduced or reviewed. **Advanced vector calculus is not assumed.**

Concepts → model → problem solving → applications

Examination, auditorium classes, and final grade

Final percentage score

$$S = 0.60 E + 0.40 A + B$$

- E : percentage score from the **written final examination**.
- A : auditorium-class score from the midterm test/colloquium, assigned exercises and homework.
- B : active/substantive participation bonus, **maximum 10 percentage points**.

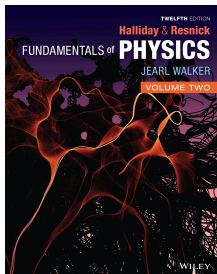
Conditions to complete the course

- Final score capped at **100%**.
- A positive result in **both** the final exam and auditorium-class component is required.
- Successful completion of auditorium classes is required for admission to the final exam.
- Lecture attendance: not compulsory, but strongly recommended.
- Auditorium-class attendance: compulsory.

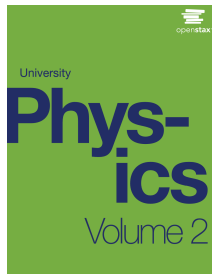
Practical note

Detailed dates and criteria are announced at the beginning of the course; retakes follow the applicable AGH Study Regulations.

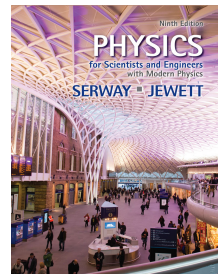
Main references



D. Halliday, R. Resnick, J. Walker
Fundamentals of Physics, Volume 2
12th ed., John Wiley & Sons, 2022.



S. J. Ling, J. Sanny, W. Moebis
University Physics, Volume 2
OpenStax, Rice University, Houston; original publication 2016.

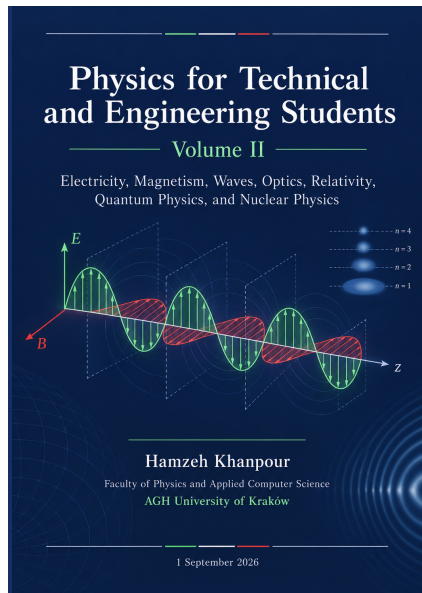


R. A. Serway, J. W. Jewett, Jr.
Physics for Scientists and Engineers with Modern Physics
9th ed., Brooks/Cole-Cengage, 2014.

Use them comparatively:

consult alternative explanations, derivations, worked examples and problem-solving strategies alongside the lectures.

Our Physics II course book



Physics for Technical and Engineering Students - Volume II

Hamzeh Khanpour

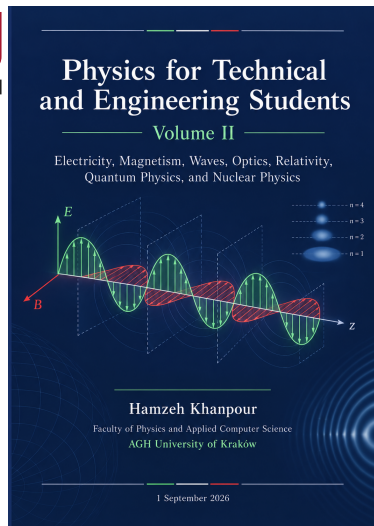
Electricity, Magnetism, Waves, Optics, Relativity, Quantum Physics, and Nuclear Physics

Faculty of Physics and Applied Computer Science, AGH University of Kraków

Role in this course

- Written for technical and engineering students and aligned with the Physics II progression.
- Connects physical motivation to equations, modelling assumptions, worked reasoning and applications.
- Supports lectures, auditorium-class problem solving, and independent study between classes.

What is distinctive about our book?



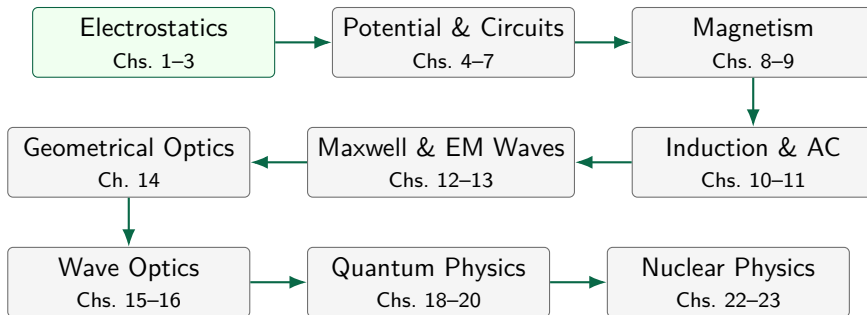
Core learning architecture

- Numerous worked examples and substantial practice/problem material, with explicit attention to assumptions and sign conventions.
- Formula-summary material and chapter-level synthesis for revision and self-study.
- Recurrent engineering, measurement/laboratory and computational connections across the manuscript.
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Beyond the minimum syllabus

Every chapter includes an **Advanced Topics for Technical and Engineering Students**. Broader topics include **Special Relativity** (Ch. 17) and **Particles, Fundamental Interactions, and the Big Bang** (Ch. 24). These deepen context but are **not automatically examinable** in the official 2026/2027 Physics II syllabus.

Physics II roadmap: the full journey



Book enrichment around the official course

Ch. 17 develops **Special Relativity**; Ch. 21 deepens **electrical conduction in solids and semiconductor devices**; Ch. 24 broadens the modern-physics perspective to **particles and cosmology**. These chapters support context and continuity beyond the 11 official syllabus blocks.

Electrostatic fields and Gauss's law

Physical question

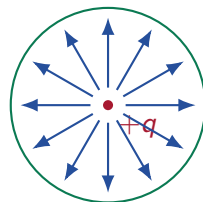
How do charges create forces and fields, and when can symmetry turn a difficult field calculation into a simple flux argument?

We will cover: charge and conservation; Coulomb's law and superposition; electric fields and field lines; discrete/continuous charge distributions; electric flux; Gauss's law; planar, cylindrical and spherical symmetry; conductors in electrostatic equilibrium; charged-particle motion in uniform $\mathbf{E}$.

Two anchor relations

$$\mathbf{F}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}, \quad \oint_S \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\text{enc}}}{\epsilon_0}.$$

Gaussian surface



$\mathbf{E}$ radial by symmetry

Why it matters

Electrostatic shielding, sensors and capacitive devices, charged-particle control, and the field/flux language used throughout electromagnetism.

Textbook: Chs. 1–3.

Electric potential, capacitance and dielectrics

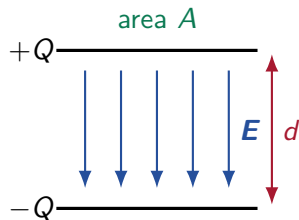
Physical question

How do we replace a vector field description by an energy-per-charge description, and how can electric-field energy be stored and controlled in capacitors?

We will cover: potential and potential difference; potential energy; point and continuous charge distributions; equipotentials and dipoles; capacitance; parallel-plate, cylindrical and spherical capacitors; series/parallel combinations; stored energy; dielectrics and polarisation.

Anchor relations

$$\Delta V = - \int_a^b \mathbf{E} \cdot d\mathbf{\ell}, \quad C = \frac{Q}{\Delta V}.$$



Why it matters

Energy storage, capacitive sensing, insulation and dielectric design, field control, and the voltage language used in circuits.

Textbook: Chs. 4–5.

Electric current and DC circuits

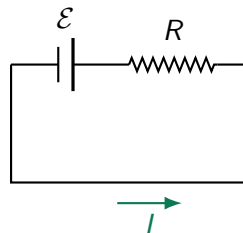
Physical question

How does microscopic charge transport become a measurable current, and how do conservation laws determine voltages and currents in real circuit models?

We will cover: current and current density; drift velocity; resistivity and resistance; Ohm's law; emf, internal resistance and terminal voltage; series/parallel networks; Kirchhoff rules; electrical power; ammeters/voltmeters; RC charging/discharging; basic conductor and semiconductor behaviour.

Anchor relations

$$I = \frac{dQ}{dt}, \quad V = IR, \quad \sum_{\text{loop}} \Delta V = 0.$$



Why it matters

Circuit analysis, measurement loading, power dissipation, time constants, sensor interfaces, and the bridge toward semiconductor electronics.

Textbook: Chs. 6–7; Ch. 21 enrichment.

Magnetic fields and forces



Physical question

How do moving charges and currents respond to magnetic fields, and how do currents themselves generate magnetic fields?

We will cover: Lorentz force; cyclotron motion, mass spectrometry and Hall effect; forces on wires and between currents; torque and magnetic dipole moment; Biot–Savart law; Ampère’s law; solenoids and toroids; magnetic flux and Gauss’s law for magnetism.

Anchor relations

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B}), \quad \oint \mathbf{B} \cdot d\mathbf{\ell} = \mu_0 I_{\text{enc}}.$$

Why it matters

Particle spectrometers, Hall sensors, motors, magnetic confinement, current standards, solenoids and toroidal devices.

Textbook: Chs. 8–9.

Electromagnetic induction



Physical question

How can a changing magnetic environment generate an emf and a circulating electric field, even without a battery?

We will cover: magnetic flux and flux linkage; Faraday's law and Lenz's law; motional emf; induced electric fields; eddy currents; and the operating principle of electric generators.

Anchor relation

$$\mathcal{E} = -\frac{d\Phi_B}{dt}, \quad \Phi_B = \int_S \mathbf{B} \cdot d\mathbf{A}.$$

Why it matters

Generators, induction heating, magnetic braking, transformers, pickup coils and contactless sensing all use the same flux-change principle.

Textbook: Ch. 10.

Inductance and AC circuits



Physical question

How do circuits store magnetic energy, oscillate, respond to sinusoidal driving, and select frequencies through resonance?

We will cover: self- and mutual inductance; self-induced emf; magnetic energy; RL transients; LC oscillations and RLC circuits; sinusoidal AC; reactance, impedance and phase; phasors; resonance and quality factor; transformers.

Anchor relations

$$\mathcal{E}_L = -L \frac{dI}{dt}, \quad \omega_0 = \frac{1}{\sqrt{LC}},$$
$$Z = \sqrt{R^2 + (X_L - X_C)^2}.$$

Why it matters

Power systems, resonant filters, transformers, impedance matching and frequency-selective measurement all require amplitude *and* phase.

Textbook: Chs. 10–11.

Maxwell's equations and electromagnetic waves

Physical question

How do the electric and magnetic laws fit together, and why does their synthesis predict waves that propagate at the speed of light?

We will cover: displacement current and the Ampère–Maxwell law; the four Maxwell equations; plane electromagnetic waves; the $\mathbf{E}$ – $\mathbf{B}$ relation; spectrum; energy density, intensity and Poynting vector; momentum/radiation pressure; standing waves and resonant cavities; antennas and microwaves.

Two consequences of Maxwell's theory

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}, \quad \mathbf{S} = \frac{1}{\mu_0} \mathbf{E} \times \mathbf{B}.$$

Why it matters

Radio, Wi-Fi, optical communication, antennas, microwave systems and photonics are applications of one coupled electromagnetic field theory.

Textbook: Chs. 12–13.

Geometrical optics and optical systems



Physical question

When is light well described by rays, and how do reflection, refraction and lenses determine where images form?

We will cover: wavefronts and rays; Fermat's principle; reflection and refraction; refractive index and Snell's law; total internal reflection and dispersion; plane/spherical mirrors; refracting surfaces; thin lenses and ray diagrams; lens combinations; optical fibres; the eye; microscopes and telescopes.

Anchor relations

$$n_1 \sin \theta_1 = n_2 \sin \theta_2, \quad \frac{1}{f} = \frac{1}{s} + \frac{1}{s'}.$$

Why it matters

Cameras, machine vision, fibre optics, corrective lenses, microscopes and telescopes are governed by the same imaging relations.

Textbook: Ch. 14.

Physical question

Which observations cannot be explained by rays alone, and how do phase and coherence create interference, diffraction and polarization effects?

We will cover: Huygens' principle; coherence and interference; Young's double slit; optical path and phase; thin films, Newton's rings and anti-reflection coatings; Michelson interferometer; single-slit and circular-aperture diffraction; gratings and resolution; X-ray diffraction; polarization, Malus's law and Brewster's law.

Anchor relations

$$d \sin \theta = m\lambda, \quad I = I_0 \cos^2 \theta.$$

Why it matters

Interferometry, optical coatings, resolution, spectroscopy, crystallography and polarization control rely on the wave nature of light.

Textbook: Chs. 15–16.

Foundations of quantum physics



Physical question

Why does classical physics fail at microscopic scales, and what new rules describe photons, matter waves and quantized states?

We will cover: blackbody radiation and Planck's hypothesis; photons and the photoelectric effect; Compton scattering; emission/absorption and atomic spectra; the Bohr model; wave-particle duality and de Broglie waves; electron diffraction and particle double-slit experiments; the uncertainty principle.

Anchor relations

$$E = h\nu, \quad \lambda = \frac{h}{p}, \quad \Delta x \Delta p_x \geq \frac{\hbar}{2}.$$

Why it matters

Photodetectors, electron microscopy, lasers, semiconductors and quantum technologies build on these principles.

Textbook: Chs. 18–20; Ch. 17 enrichment.

Physical question

How are nuclei bound and why are some unstable?
How do radioactive decay, fission and fusion convert mass-energy into observable phenomena and useful energy?

We will cover: nuclear composition and isotopes; nuclear radius/density; atomic and nuclear masses; mass defect and binding energy; stability; decay law, activity and half-life; α , β and γ decay; reactions and Q -values; radiometric dating; fission, fusion and solar energy; technological applications.

Anchor relations

$$N(t) = N_0 e^{-\lambda t}, \quad T_{1/2} = \frac{\ln 2}{\lambda},$$
$$Q = (m_i - m_f) c^2.$$

Next

We now begin with **Chapter 1: Electric Charge and Coulomb's Law**, the first step toward electrostatic fields and Gauss's law.

Textbook: Chs. 22–23 cover this block; Ch. 24 is broader enrichment.

