

Introduction to Physics

Introduction to Physics – Study Notes

1. What Is Physics?

- **Definition:** The scientific discipline that studies matter, energy, and the fundamental forces that govern their interactions.
 - **Goal:** To describe how the universe works through concise, testable models and laws.
 - **Scope:** From subatomic particles to galaxies; from static objects to dynamic processes.
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2. Core Concepts & Terminology

Concept	Meaning	Everyday Example
Matter	Anything that has mass and occupies space.	A rock, a cup of water.
Energy	The capacity to do work or cause change.	Heat from a stove, kinetic energy of a moving car.
Force	Interaction that changes an object's motion (Newton's 2nd law).	Pulling a rope, gravity pulling an apple down.
Field	A region where a force can be felt without direct contact.	Magnetic field around a magnet.
Wave	A disturbance that transfers energy without transporting matter.	Sound traveling through air.
Particle	Small, localized object with defined properties (mass, charge).	Electron, proton.

3. The Scientific Method in Physics

1. **Observation** – Gather data from experiments or nature.
2. **Question** – Identify a specific problem or phenomenon.
3. **Hypothesis** – Propose a testable explanation.
4. **Prediction** – Derive consequences that follow from the hypothesis.
5. **Experiment** – Design controlled tests; collect quantitative results.
6. **Analysis** – Compare predictions with data; use statistics to assess agreement.

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7. **Conclusion** – Accept, modify, or reject the hypothesis; publish findings.

4. Fundamental Branches

Branch	Focus	Key Topics
Classical Mechanics	Motion of macroscopic objects	Newton's laws, conservation of momentum, oscillations.
Thermodynamics	Heat, work, and energy transformations	Laws of thermodynamics, entropy, engines.
Electromagnetism	Electric and magnetic fields	Coulomb's law, Maxwell's equations, circuits.
Optics	Light behavior	Reflection, refraction, diffraction, lasers.
Quantum Mechanics	Physics at atomic & subatomic scales	Wave-particle duality, Schrödinger equation, spin.
Relativity	Space-time structure at high speeds & strong gravity	Special relativity ($E=mc^2$), general relativity (gravity as curvature).
Statistical Mechanics	Collective behavior of many particles	Boltzmann distribution, phase transitions.
Astrophysics & Cosmology	Universe-scale phenomena	Stellar evolution, Big Bang, dark matter/energy.

5. Fundamental Laws (Selected)

1. Newton's Three Laws of Motion

- *First:* Inertia – a body remains at rest or in uniform motion unless acted upon by a net force.
- *Second:* ($\mathbf{F} = m\mathbf{a}$) – force equals mass times acceleration.
- *Third:* Action–reaction – forces occur in equal and opposite pairs.

2. Law of Universal Gravitation

$$[F = G\frac{m_1 m_2}{r^2}]$$

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- G = gravitational constant, r = distance between centers.

3. Conservation Principles

- **Energy** –