Chapter 2: Outline of Physics

Physics is a natural science that involves the study of matter and its motion through spacetime, along with related concepts such as energy and force. More broadly, it is the general analysis of nature, conducted in order to understand how the universe behaves.

Physics can be described as all of the following:

> An academic discipline, one with academic departments, curricula and degrees; national and international societies; and specialized journals.
>
> A branch of science, widely recognized category of specialized expertise within science, and typically embodies its own terminology and nomenclature. Such a field will usually be represented by one or more scientific journals, where peer-reviewed research is published.
>
> A natural science, one that seeks to elucidate the rules that govern the natural world using empirical and scientific method.
>
> > A physical science, one that studies non-living systems.
> >
> > A biological science, one that studies the role of physical processes in living organisms.

Branches of Physics

Acoustics – study of mechanical waves in solids, liquids, and gases (such as vibration and sound)

Agrophysics – study of physics applied to agroecosystems

Astrophysics – study of the physical aspects of celestial objects

Astronomy – studies the universe beyond Earth, including its formation and development, and the evolution, physics, chemistry, meteorology, and motion of celestial objects (such as galaxies, planets, etc.) and phenomena that originate outside the atmosphere of Earth (such as the cosmic background radiation).

Astrodynamics – application of ballistics and celestial mechanics to the practical problems concerning the motion of rockets and other spacecraft.

Astrometry – branch of astronomy that involves precise measurements of the positions and movements of stars and other celestial bodies.

Cosmology – discipline that deals with the nature of the Universe as a whole.

Atmospheric physics – study of the application of physics to the atmosphere

Atomic, molecular, and optical physics – study of how matter and light interact

Biophysics – study of physical processes relating to biology

Chemical physics – branch of physics that studies chemical processes from the point of view of physics.

Classical physics - physics that predates the advent of quantum mechanics.

Computational physics – study and implementation of numerical algorithms to solve problems in physics for which a quantitative theory already exists.

Condensed matter physics – study of the physical properties of condensed phases of matter.

Cryogenics – cryogenics is the study of the production of very low temperature (below −150 °C, −238 °F or 123K) and the behavior of materials at those temperatures.

Dynamics – study of the causes of motion and changes in motion

Thermodynamics - the study of the relationships between heat and mechanical energy

Electromagnetism – branch of science concerned with the forces that occur between electrically charged particles.

Geophysics – the physics of the Earth and its environment in space; also the study of the Earth using quantitative physical methods

Materials physics – use of physics to describe materials in many different ways such as force, heat, light and mechanics.

Mathematical physics – application of mathematics to problems in physics and the development of mathematical methods for such applications and for the formulation of physical theories.

Mechanics – branch of physics concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment.

Nuclear physics – field of physics that studies the building blocks and interactions of atomic nuclei.

Optics – branch of physics which involves the behavior and properties of light, including its interactions with matter and the construction of instruments that use or detect it.

Particle physics – branch of physics that studies the properties and interactions of the fundamental constituents of matter and energy.

Plasma physics – the study of plasma, a state of matter similar to gas in which a certain portion of the particles are ionized.

Quantum physics – branch of physics dealing with physical phenomena where the action is on the order of the Planck constant.

Relativity – theory of physics which describes the relationship between space and time.

Statics – branch of mechanics concerned with the analysis of loads (force, torque/moment) on physical systems in static equilibrium, that is, in a state where the relative positions of

subsystems do not vary over time, or where components and structures are at a constant velocity.

Solid state physics – study of rigid matter, or solids, through methods such as quantum mechanics, crystallography, electromagnetism, and metallurgy.

Theoretical physics – the pursuit of describing physical phenomena with rigorous mathematical models and physical abstractions in order to analyze, explain, and predict natural processes.

Basic Principles of Physics

Physics is one of the "fundamental sciences" because the other natural sciences (*like biology, geology etc.*) deal with systems that seem to obey the laws of physics. According to physics, the physical laws of matter, energy and the fundamental forces of nature govern the interactions between particles and physical entities (*such as planets, molecules, atoms or the subatomic particles*). Some of the basic pursuits of physics, which include some of the most prominent developments in modern science in the last millennium, include:

Describing the *nature, measuring and quantifying of bodies and their motion, dynamics* etc.

- Newton's laws of motion
- Mass, force and weight
- Momentum and conservation of energy
- Gravity, theories of gravity
- Energy, work, and their relationship
- Motion, position, and energy
- Different forms of Energy, their interconversion and the inevitable loss of energy in the form of heat (Thermodynamics)
- Energy conservation, conversion, and transfer.
- Energy source the transfer of energy from one source to work in another.

- Phases of matter and phase transitions
- Temperature and thermometers
- Energy and heat
- Heat flow: conduction, convection, and radiation
- The three laws of thermodynamics
- The principles of waves and sound
- The principles of electricity, magnetism, and electromagnetism
- The principles, sources, and properties of light

Basic quantities

- Acceleration
- Electric charge
- Energy
- Entropy
- Force
- Length
- Mass
- Matter
- Momentum
- Potential energy
- Space
- Temperature
- Time
- Velocity
- Gravity, light, physical system, physical observation, physical quantity, physical state, physical unit, physical theory, physical experiment

Theoretical concepts

- Mass–energy equivalence, particle, physical field, physical interaction, physical law, fundamental force, physical constant, wave

Fields

Theory	Major subtopics	Concepts
Classical mechanics	Newton's laws of motion,Lagrangian mechanics,Hamiltonian mechanics,kinematics, statics, dynamics,chaos theory, acoustics, fluid dynamics, continuum mechanics	Density, dimension, gravity, space, time, motion, length, position, velocity, acceleration, mass, momentum, force,energy, angular momentum, torque, conservation law, harmonic oscillator, wave, work, power
Electromagnetism	Electrostatics, electrodynamics,electricity, magnetism, Maxwell's equations, optics	Capacitance, electric charge, electric current, electrical conductivity, electric field, electric permittivity, electrical resistance, electromagnetic field, electromagnetic induction, electromagnetic radiation, Gaussian surface,magnetic field, magnetic flux, magnetic monopole, magnetic permeability
Theory of relativity	Special relativity, general relativity, Einstein field equations	Covariance, Einstein manifold, equivalence principle, four-momentum, four-vector, general principle of relativity,geodesic motion, gravity,

		gravitoelectromagnetism, inertial frame of reference, invariance, length contraction,Lorentzian manifold, Lorentz transformation, metric, Minkowski diagram, Minkowski space, principle of relativity,proper length, proper time, reference frame, rest energy, rest mass, relativity of simultaneity, spacetime, special principle of relativity, speed of light, stress–energy tensor, time dilation, twin paradox, world line
Thermodynamics and statistical mechanics	Heat engine, kinetic theory	Boltzmann's constant, conjugate variables, enthalpy, entropy, equation of state, equipartition theorem, first law of thermodynamics, free energy, heat, ideal gas law, internal energy, irreversible process, partition function,pressure, reversible process, second law of thermodynamics, spontaneous process, state function, statistical ensemble, temperature, thermodynamic equilibrium, thermodynamic potential, thermodynamic

		processes,thermodynamic state, thermodynamic system, third law of thermodynamics, viscosity, zeroth law of thermodynamics
Quantum mechanics	Path integral formulation,scattering theory, Schrödinger equation, quantum field theory,quantum statistical mechanics	Adiabatic approximation, correspondence principle, free particle, Hamiltonian, Hilbert space, identical particles,matrix mechanics, Planck's constant, operators, quanta, quantization, quantum entanglement, quantum harmonic oscillator, quantum number, quantum tunneling, Schrödinger's cat, Dirac equation, spin, wavefunction, wave mechanics, wave–particle duality, zero-point energy, Pauli exclusion principle, Heisenberg uncertainty principle

Concepts by Field

Field	Subfields	Major theories	Concepts
Particle physics	Accelerator physics, nuclear physics, nuclear astrophysics,par	Standard Model, quantum field theory, quantum chromodynamics,	Fundamental force (gravitational, electromagnetic,weak, strong), elementary particle, spin, antimatter,spontaneous symmetry

	ticle astrophysics, particle physics phenomenology	electroweak theory, effective field theory,lattice field theory, lattice gauge theory, gauge theory,supersymmetry, Grand Unified Theory, superstring theory,M-theory	breaking, brane, string,quantum gravity, theory of everything, vacuum energy
Atomic, molecular, and optical physics	Atomic physics, molecular physics,atomic and molecular astrophysics, chemical physics,optics, photonics	Quantum optics, quantum chemistry, quantum information science	Atom, molecule, diffraction, electromagnetic radiation,laser, polarization, spectral line, Casimir effect
Condensed matter physics	Solid state physics, high pressure physics, low-temperature physics,nanosc	BCS theory, Bloch wave, Fermi gas, Fermi liquid, many-body theory	Phases (gas, liquid, solid, Bose–Einstein condensate,superconductor, superfluid), electrical conduction,magnetism, self-organization, spin, spontaneous symmetry breaking

	ale and mesoscopic physics, polymer physics		
Astrophysics	Cosmology, gravitation physics,high-energy astrophysics,planetary astrophysics, plasma physics, space physics, stellar astrophysics	Big Bang, Lambda-CDM model, cosmic inflation, general relativity, law of universal gravitation	Black hole, cosmic background radiation, cosmic string, cosmos, dark energy, dark matter, galaxy,gravity, gravitational radiation, gravitational singularity,planet, Solar System, star, supernova, universe