C XI–UNIT I-PHYSICAL WORLD AND MEASUREMENT-CONCEPT 1- NOTES & FORMULAE

★ What is Science ?

- ✓ The word Science originates from the Latin verb Scientia meaning 'to know'.
- ✓ The Sanskrit word Vijnan and the Arabic word Ilm convey similar meaning, namely 'knowledge'.
- ✓ Science is a systematic attempt to understand natural phenomena in as much detail and depth as possible and use the knowledge so gained to predict, modify and control phenomena.
- ✓ Science is exploring, experimenting and predicting from what we see around us. The curiosity to learn about the world, unraveling the secrets of nature is the first step towards the discovery of science.
- ✓ Systematic observations, controlled experiments, qualitative and quantitative reasoning, mathematical modeling, prediction and verification or falsification of theories, Speculation and Conjecture are the various steps in the exploration of meaning of Science.

★ What is Physics?

- ✓ The word 'Physics' comes from a Greek word 'fusis' meaning 'nature'. Its Sanskrit equivalent Bhautiki is used to refer to the study of the physical world.
- ✓ Physics can be described as a study of all the basic laws of nature and their manifestation in different natural phenomena. Hence, Physics is a branch of science which deals with the study of nature and natural phenomena.

★ **What is the scope of Classical Physics?**

Classical Physics deals mainly with macroscopic phenomena and it includes subjects like Mechanics, Electrodynamics, Optics and Thermodynamics.

★ **What is the scope of Mesoscopic Physics ?**

✓ The domain of the study of phenomenon with particles of size $>10^{-6}$m is called macroscopic whereas the study with particles of size $<10^{-6}$m is called microscopic.

✓ The domain intermediate between the macroscopic and microscopic phenomena dealing with a few tens or hundreds of atoms is mesoscopic Physics.

★ **In defining the scope of physics, what are the ranges of magnitudes of physical quantities like length, mass, time?**

✓ The range of length is 10^{-15}m (radius of nucleus) to 10^{26}m (boundary of observable universe)

✓ The range of mass is 10^{-31}kg (mass of electron) to 10^{55} kg (mass of observable universe)

✓ The range of time is 10^{-24}s (life span of most unstable particle) to 10^{17}s (age of universe)

★ **'The most incomprehensible thing about the world is that it is comprehensible.' Who made these remarks?**

Albert Einstein

★ **What is the contribution of S. Chandrasekhar to physics?**

✓ While studying the constitution of the stars, he has proved that the maximum mass that a white dwarf can have is 1.4 times the solar mass. This mass is known as Chandrasekhar limit (CSL).

✓ If a star crosses this limit, it has to face a catastrophic collapse

★ **What is the discovery of C.V. Raman?**

Inelastic scattering of light by molecules

★ **It has been postulated that there may be some particles moving with speed greater than the speed of light. Such particles have been named as ___**

Tachyons

★ **"Every great physical theory starts as a heresy and ends as a dogma". Give some examples from the history of science for the validity of this incisive remark.**

✓ According to the **geocentric theory** given by Ptolemy, the earth is stationary and all other heavenly bodies such as Sun, Stars and other planets revolve around it.

✓ Later on, an Italian scientist Galileo postulated **heliocentric theory**, according to which the Sun is stationary and earth along with other planets revolve around it. This theory was a heresy at that time but later on, Newton and Kepler supported this theory and it became a dogma.

✓ According to Newton's corpuscular theory, light consists of small corpuscles (particles). It is started as a heresy and ended in Max Planck's quantum theory of light as a dogma.

★ **Fundamental forces in nature - Comparison of relative strengths and ranges of different fundamental forces of nature**

✓ **Fundamental forces in nature are**

- Gravitational force
- Electromagnetic force
- Strong nuclear force
- Weak nuclear force

✓ Comparison of relative strengths of fundamental forces

Name	Relative strength	Range	Operates among	Mediated Particle
Gravitational force	10^{-39}	Infinite	All objects in the universe	Graviton
Weak nuclear force	10^{-13}	Very short, Sub-nuclear size nearly 10^{-16}m	Elementary particles, particularly electron and neutrino	Boson
Electromagnetic force	10^{-2}	Infinite	Charged particles	Photon
Strong nuclear force	1	Short, nuclear size nearly 10^{-15}m	Nucleons, heavier elementary particles	π-meson

✓ **In terms of strengths ,** $F_G < F_W < F_E < F_N$

★ Progress in unification of different forces/domains in nature

Name of the Physicist	Year	Achievement in unification
Isaac Newton	1687	Unified celestial and terrestrial mechanics, showed that the same laws of motion and the law of gravitation apply to both the domains
Hans Christian Oersted	1820	Showed that electric and magnetic phenomena are inseparable aspects of a unified domain , electromagnetism.
Michael Faraday	1830	

James Clerk Maxwell	1873	Unified electricity, magnetism and optics, showed that light is an electromagnetic wave.
Sheldon Glashow, Abdus Salam, Steven Weinberg	1979	Showed that the 'weak' nuclear force and the electromagnetic force could be viewed as different aspects of a single electro-weak force.
Carlo Rubia, Simon Vander Meer	1984	Verified experimentally the predictions of the theory of electro-weak force

★ **Physicists from different countries of the world and their major contributions**

Name	Major contribution/discovery	Country of Origin
Archimedes	Principle of buoyancy , Principle of the lever	Greece
Galileo galilee	Law of inertia	Italy
Christian Huygens	Wave of theory of light	Holland
Isaac Newton	Universal law of gravitation, Laws of motion, Reflecting telescope	U.K.
Michael Faraday	Laws of electromagnetic induction	U.K.
James Clerk Maxwell	Electromagnetic theory, Light-an electromagnetic wave	U.K.
Heinrich Rudolf Hertz	Generation of electromagnetic waves	Germany
J.C Bose	Ultra short radio waves	India
W.K. Roentgen	X-rays	Germany

J.J. Thomson	Electron	U.K.
Marie Sklodowska Curie	Discovery of radium and polonium, Studies on natural radioactivity	Poland
Albert Einstein	Explanation of photoelectric effect, Theory of relativity	Germany
Victor Francis Hess	Cosmic radiation	Austria
R.A. Millikan	Measurement of electronic charge	U.S.A
Ernest Rutherford	Nuclear model of atom	New Zealand
Niels Bohr	Quantum model of hydrogen atom	Denmark
C.V. Raman	Inelastic scattering of light by molecules	India
Louis Victor de Broglie	Wave nature of matter	France
M.N. Saha	Thermal ionization	India
S.N. Bose	Quantum statistics	India
Wolfgang Pauli	Exclusion principle	Austria
Enrico Fermi	Controlled nuclear fission	Italy
Werner Heisenberg	Quantum mechanics, Uncertainty principle	Germany
Paul Dirac	Relativistic theory of electron, Quantum statistics	U.K.
Edwin Hubble	Expanding universe	U.S.A
Ernest Orlando Lawrence	Cyclotron	U.S.A
James Chadwick	Neutron	U.K.
Hideki Yukawa	Theory of nuclear forces	Japan
Homi Jahangir Bhabha	Cascade process of cosmic radiation	India
Lev Davidovich Landau	Theory of condensed matter, Liquid	Russia

	helium	
S. Chandrasekhar	Chandrasekhar limit, structure and evolution of stars	India
John Bardeen	Transistors, Theory of super conductivity	U.S.A
C.H. Townes	Maser, Laser	U.S.A
Abdus Salam	Unification of weak and electromagnetic interactions	Pakistan
Wolfgang Pauli	Neutrino in β - decay	Austria

★ Link between Technology and Law/Phenomenon in Physics

Technology	Law/Phenomenon in Physics
Steam engine	Laws of thermodynamics
Nuclear reactor	Controlled nuclear fission
Radio and Television	Generation, propagation and detection of electromagnetic waves
Computers	Digital logic
Lasers	Light amplification by stimulated emission of radiation, Amplification by population inversion
Production of ultrahigh magnetic fields	Superconductivity
Rocket propulsion	Newton's laws of motion
Electric generator	Faraday's laws of electromagnetic induction
Hydroelectric power	Conversion of gravitational potential energy into electrical energy
Aero plane	Bernoulli's principle in fluid dynamics

Particle accelerators	Motion of charged particles in electromagnetic fields
Sonar	Reflection of ultrasonic waves
Optical fibers	Total internal reflection of light
Non-reflecting coatings	Thin film optical interference
Electron microscope	Wave nature of electrons
Photocell	Photoelectric effect
Fusion test reactor (Tokamak)	Magnetic confinement of plasma
Giant Metre wave Radio Telescope (GMRT)	Detection of cosmic radio waves
Bose-Einstein condensate	Trapping and cooling of atoms by laser beams and magnetic fields