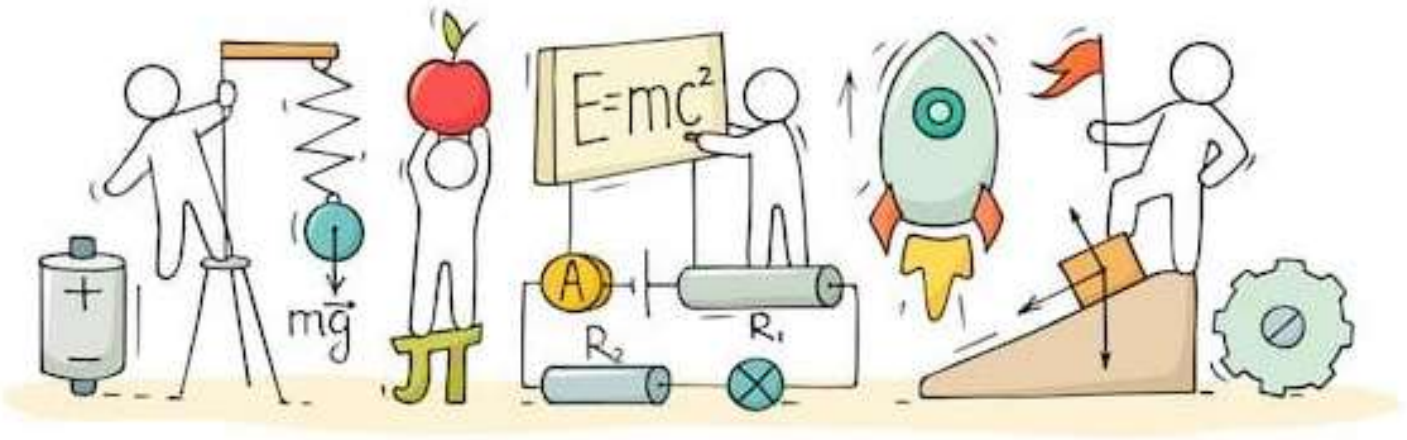
PHYSICS

Chapter 1: Physical World



Physical World

Science

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.

Scientific method can be called as a method to acquire knowledge in a systematic and in-depth way. It is having:

- Systematic observations
- Controlled experiments
- Qualitative and Quantitative reasoning
- Mathematical modelling
- Prediction and verification (or falsification) of theories
- Speculation or Prediction

Science will be not having any final theory. The observations which are made using improved, accurate tools will be creating improved knowledge and perspective. Tycho Brahe's research on planetary motion has been used by Johannes Kepler for improving Nicolas Copernicus theory.

Quantum mechanics was developed in order to deal with atomic and nuclear phenomena. Work of Ernest Rutherford on nuclear model of atom made the basis of quantum theory suggested by Niels Bohr. The discovery of antielectron (positron) was led by the Antiparticle theory of Paul Dirac by Carl Anderson.

Natural Sciences: Natural science can be considered as a branch of science which is discussing about the description, prediction, and understanding of the natural phenomena which is on the basis of an observational and empirical evidence. It will be included of the disciplines mentioned below:

- Physics
- Chemistry
- Biology

Physics

Physics is a fundamental science concerned with understanding the natural phenomena that occur in our universe.

It has many branches such as Mechanics, Electromagnetism, Thermodynamics, Modem Physics, etc. Between 1600 and 1900, three broad areas were developed, which is together called Classical Physics. These three areas of study are classical mechanics, thermodynamics and electromagnetism. But by 1905 it became apparent that classical ideas failed to explain several phenomena. Then some new theories were developed in what is called Modem Physics such as Special Relativity, Quantum Mechanics, etc.

Physical World

The physical world is referred to as the complexity in nature and solving its own complexities will

give us new insights into this physical world. It is referred to as the analysis of nature conducted in order to understand how the world around us performs.

Top Concepts

- Physics is the branch of science that deals with nature and the natural phenomenon that occur.
- Physics has two domains - microscopic as well as macroscopic.

  The microscopic domain contains atomic, molecular and nuclear phenomenon, whereas the macroscopic domain includes phenomena taking place at the laboratory, terrestrial and astronomical scales.
- Science has a great influence on technology. Some of the technological advancements which are governed by scientific concepts are given below.

Technology	Scientific concept
Sonar	Reflection of ultrasonic waves
Rocket propulsion	Newton's laws of motion
Aeroplane	Bernoulli's principle in fluid dynamics
Steam engine	Law of thermodynamics
Optical fibres	Total internal reflection of light

The Fundamental Forces of nature

Gravitational Force: it is a universal force that exists which is of mutual attraction between any two objects by virtue of their masses.

The gravitational force has the following properties:

1. It obeys the inverse square law.
2. It is always attractive in nature.
3. It is a long range force and extends up to infinity.
4. The graviton is the field particle of gravitational force.
5. It is the weakest force operating in nature.
6. It is a central force and hence a conservative force.

Electromagnetic Force: is the force between charged particles. If charges are in a state of rest, it is given by Coulumb's law whereas when they are in motion, they generate a magnetic field, hence the name electromagnetic forces as they are inseparable. They also act over a large distance as seen in the case of gravitational forces without the intervention of any medium.

The properties of electromagnetic force are as follows:

1. It obeys the inverse square law.

2. It may be attractive or repulsive in nature.
3. It is a long range force.
4. The photon is the field particle of electromagnetic force.
5. It is about 10^{36} times stronger than the gravitational force.
6. It is a central as well as a conservative force.

Strong Nuclear Force: in a nucleus it binds protons and neutrons. It is the strongest of all the fundamental forces and is charge-independent acting between proton-proton, proton-neutron, or neutron-neutron

Weak Nuclear Force: observed only in some nuclear processes. Example: β-decay of a nucleus. It is not as weak as the gravitational force but weaker than electromagnetic and strong nuclear force

The nuclear force has the following properties:

1. The strong nuclear force binds protons and neutrons in a nucleus. The weak nuclear force appears only in certain nuclear processes such as beta decay.
2. A strong nuclear force is the strongest force in nature. It is about 100 times stronger than the electromagnetic force. Weak nuclear force is stronger than the gravitational force but weaker than the electromagnetic or strong nuclear force.
3. It is a short-range force and is operative only over the size of nucleus.
4. A strong nuclear force is responsible for the stability of nuclei.

Name of force	Relative strength (w.r.t. strong nuclear force)	Rane	Operates among
Gravitational	10^{-39}	Infinite	All objects in universe
Weak nuclear	10^{-13}	Sub-nuclear size ($\approx 10^{-16}$ m)	Electron and neutrino
Electromagnetic	10^{-2}	Infinite	Charged particles
Strong nuclear	1	Nuclear size ($\approx 10^{-15}$ m)	Nucleons and heavier elementary particles

Unification of Forces

The unification of forces is the idea that it's possible to view all of nature's forces as manifestations of one single, all-encompassing force. Scientists have made great strides toward the goal of understanding how the forces can be combined

Conserved Quantities: In any physical phenomenon governed by different forces, several

quantities change with time, while several quantities remain constant. Such quantities are called conserved quantities.

- **Law of conservation of linear momentum**: It states that if no external force acts on a system, the linear momentum of the system remains conserved. The law of gravitation is exactly identical on earth and moon even when the acceleration due to gravity at moon is $\frac{1}{6}th$ than that at earth.
- **Law of conservation of energy:** In accordance to the general Law of conservation of energy, the energies will be fixed over time and get transformed from one form to another. The law of conservation of energy will be applied to the whole universe and it has been considered that the total energy of the universe is fixed. The nature develops symmetric results at different time under similar conditions. It states that energy can neither be created nor destroyed; however it may change from one form to another.
- **Law of Conservation of Mass:** A chemical reaction can be defined as a rearrangement of atoms among various molecules. The difference will be formed as heat and the reaction is exothermic when the total binding energy of the reacting molecules will be less than the total binding energy of the product molecules. The opposite will be correct for energy-absorbing reactions such as endothermic reactions. As the atoms are not destroyed, only just rearranged, the summation of the mass of the reactants will be identified as the total mass of the products in a chemical reaction. Mass will be in relation to energy through Einstein theory, $E= mc^2$, where c will be the speed of light in vacuum.
- **Law of conservation of angular momentum:** It states that if no external torque acts on a system, then the total angular momentum of the system remains conserved.

Laws Of Physics

By nature, laws of Physics are stated facts which have been deduced and derived based on empirical observations. Simply put, the world around us works in a certain way, and physical laws are a way of classifying that “working.”

Physical laws are just conclusions drawn based on years (or however long it takes) of scientific observations and experiments which are repeated over and over under different conditions to reach inferences which can be accepted worldwide. These are continuously validated by the scientific community over time.

The different properties of laws of Physics which shed information about their nature are given below:

- True, under specified conditions
- Universal and do not deviate anywhere in the universe
- Simple in terms of representation
- Absolute and unaffected by external factors
- Stable and appear to be unchanging

- Omnipresent and everything in the universe is compliant (in terms of observations)
- Conservative in terms of quantity
- Homogeneous in terms of space and time
- Theoretically reversible in time

Physics in Relation to Other Sciences

Physics is a very significant branch of science which plays a crucial role in understanding the developments pertaining to the other branches of science such as Chemistry, Biology etc.

Relation to Biology. The conceptual study of pressure and its measurement has helped us to know blood pressure and hence the functioning of heart. Invention of X-rays developed the field of diagnosis. Electron and optical microscopic designs have revolutionised the study of medical.

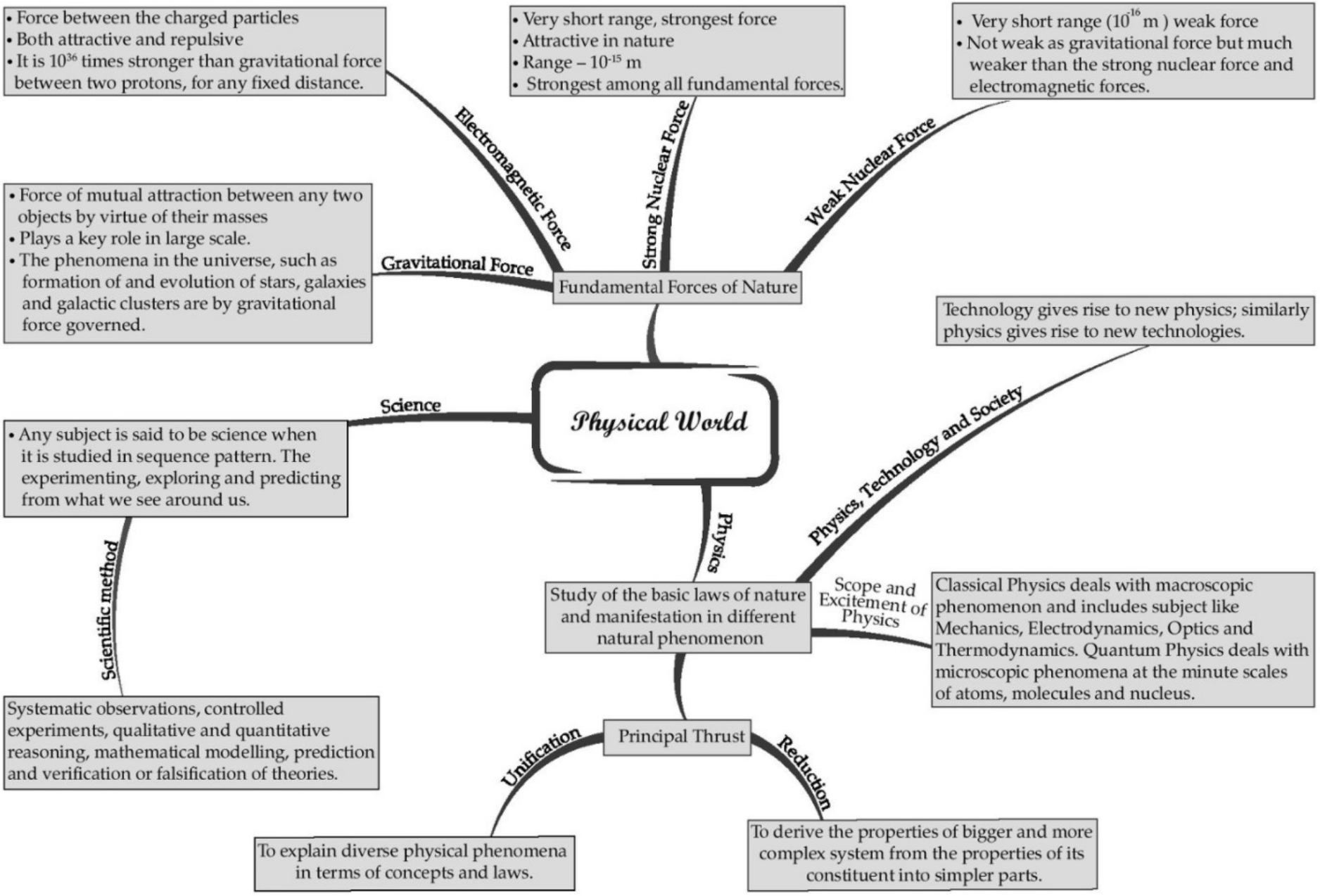
Relation to Chemistry. The concept of X-ray diffraction and radioactivity has helped to distinguish between the various solids and to modify the periodic table.

Understanding the bonding and the chemical structure of substances is easy with the help of the concept of interactions between various particles.

Relation to Mathematics. Study of physical variables led to the idea of differentiation, integration and differential equation. Meaningful interpretation of Mathematics becomes Physics.

Relation to Astronomy. Optical telescopes of reflecting and refracting type enabled man to explore the space around. Discoveries like radio telescopes have revolutionised the study of Astronomy.

CHAPTER - 1 : PHYSICAL WORLD



Important Questions

Multiple Choice questions-

1. Atomic and molecular phenomena are dealt with by

(a) Newtonian Mechanics

(b) fluid Mechanics

(c) applied Mechanics

(d) Quantum Mechanics

2. Which of the following is a possible final step in applying the scientific method

(a) Formulating a hypothesis

(b) Building a theory

(c) Analysis of test results

(d) Formulation of a question

3. Which of the following is a possible first step in applying the scientific method

(a) Conducting tests

(b) Formulating a hypothesis

(c) Formulation of a question

(d) Building a theory

4. A scientific theory

(a) cannot be changed but can be reformulated

(b) is fixed once and for all because it is logical

(c) is changed to suit new fashion among scientists

(d) can be revised if required to fit new phenomenon or data

5. The scientific method is

(a) a prescribed method for investigating phenomena, acquiring new knowledge.

(b) A procedure for proposing new hypothesis

(c) a body of techniques for investigating phenomena, acquiring new knowledge.

(d) A method for proposing new theories.

6. Newtonian mechanics could not explain

(a) fall of bodies on earth

(b) Some of the most basic features of atomic phenomena.

(c) movement of planets

(d) flight of rockets

7. Heliocentric theory proposed by Nicolas Copernicus was

(a) replaced by circular orbits to fit the data better

(b) replaced by elliptical orbits to fit the data better

(c) replaced by elliptical orbits to fit the taste of new rulers of Italy

(d) replaced by parabolic orbits to fit the data better

8. Physics is a

(a) Applied Science

(b) Mathematical Science

(c) Engineering Science

(d) Natural Science

9. The word Science originates from the Latin verb Scientia meaning

(a) to know

(b) to see

(c) to experience

(d) to observe

10. Just as a new experiment may suggest an alternative theoretical model, a theoretical advance may suggest what to look for in some for in some experiments. Which of the following experiments can be considered to support this claim?

(a) Davisson and Germier Experiment

(b) experimental discovery of positron

(c) scattering of alpha particle or the gold foil experiment

(d) Michelson Morley experiment

Very Short:

1. Name that branch of science that deals with the study of Earth.
2. Name that branch of science that deals with the study of stars.
3. Name the scientist and the country of his origin whose field of work was elasticity.
4. The word “Physics” comes from a Greek word. Name the word.
5. The word science has come from a Latin verb. Name the verb.

6. What is the meaning of the verb 'Scientia'?
7. Name the scientist and the country of his origin who received the Nobel Prize for his work on molecular spectra.
8. What is the most incomprehensible thing about the world?
9. Name a great scientist who gave the following comment on science.

   "Science is not just a collection of laws, a catalogue of unrelated facts. It is a creation of the human mind, with its freely invented ideas and concepts."

10. Which famous philosopher gave the following comments on science?

    "We know very little and yet it is astonishing that we know so much, and still more astonishing that so little knowledge of science can give so much power."

Short Questions:

1. Differentiate between Biological and Physical sciences?
2. What is the relation between Physics and Technology?
3. What is the relation between Physics and society?
4. Is Science on speaking terms with humanities?
5. What is the relation between Physics and Technology?
6. Is Physics more of a philosophy or more of a mathematical science?
7. Define Biophysics.
8. Define Technology?

Long Questions:

1. How Physics is related to other sciences?
2. Write a short note on origin and Fundamental forces in nature.
3. Distinguish between the studies in the fields of science, engineering, and technology. Give an outline of the two or three industrial revolutions brought about by advancements in technology over the last twenty-five years or so.

Assertion Reason Questions:

1. Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

   (a) Both A and R are true, and R is the correct explanation of A.

   (b) Both A and R are true, but R is not the correct explanation of A.

   (c) A is true but R is false.

   (d) A is false and R is also false.

Assertion: The concept of energy is central to Physics and its expression can be written for every physical system.

Reason: Law of conservation of energy is not valid for all forces and for any kind of transformation between different forms of energy.

2. Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) are as given below

   (a) Both A and R are true, and R is the correct explanation of A.

   (b) Both A and R are true, but R is not the correct explanation of A.

   (c) A is true but R is false.

   (d) A is false and R is also false.

Assertion: Physics generates new technology.

Reason: Technology give rise to new physics.

✓ Answer Key:

Multiple Choice Answers-

1. Answer: (d) Quantum Mechanics
2. Answer: (c) Analysis of test results
3. Answer: (c) Formulation of a question
4. Answer: (d) can be revised if required to fit new phenomenon or data
5. Answer: (c) a body of techniques for investigating phenomena, acquiring new knowledge.
6. Answer: (b) Some of the most basic features of atomic phenomena.
7. Answer: (b) replaced by elliptical orbits to fit the data better
8. Answer: (d) Natural Science
9. Answer: (a) to know
10. Answer: (b) experimental discovery of positron

Very Short Answers:

1. Answer: Geology.
2. Answer: Astronomy.
3. Answer: Robert Hook, England.
4. Answer: The word is ‘fuses meaning ‘Nature’.
5. Answer: The name of the Latin verb is ‘Scientia’.
6. Answer: To ‘know’

7. Answer: C.V. Raman, India.
8. Answer: It is comprehensible.
9. Answer: Albert Einstein.
10. Answer: Bertrand Russel.

Short Questions Answers:

1. Answer:

Biological Sciences	Physical Sciences
(i) They deal with living things.	(i) They deal with non-living things.
(ii) The study of the biological specimens is conducted at the molecular level.	(ii) The study of matter is conducted at atomic or ionic levels i.e. at much smaller levels.

2. Answer: Broadly speaking, physics and technology both constitute science. Physics is the heart and technology is the body of science.

   The application of the principles of physics for practical purposes becomes technology, e.g.

   - Airplanes fly on the basis of Bernoulli's theorem.
   - Rockets propulsion is based on Newton's second and third laws of motion.
   - The generation of power from the nuclear reactor is based on the phenomenon of controlled nuclear fission.
   - Lasers are based on the population inversion of electrons and so on. Thus, we can say that to some extent technology is applied to Physics.

3. Answer: Most of the development made in Physics has a direct impact on society, e.g.

   - Exploration of new sources of energy is of great importance to society.
   - Rapid means of transport are no less important for society.
   - society has-been enriched due to the advances in electronics, lasers, and computers.
   - The development of T.V., radio, satellites, telephone, the telegraph has revolutionized the means of communications which have a direct impact on society and so on.

4. Answer: Yes, there is a deep relation between the development of humanity on account of science. Many socio-economic, political, and ethical problems are being tackled and solved by science. Science has greatly helped in developing art and culture. Many musical

instruments have been developed due to the theories in Physics. The steam engine is inseparable from the industrial revolution which had a great impact on human civilization.

5. Answer: The interplay between physics and technology is the basic to the progress of science which is ever dynamic. Laws in waves and oscillation opened several technological fields which include telescopy, ultrasounds, microscopy, X-rays, and laser. Powerhouses, big cranes, healing devices, etc. work on the principle of electromagnetism. Atomic energy and nuclear weapons are on account of fission. Similarly, Radar, television, the internet, etc. are all based on simple laws of physics. So until there is no theory i.e. physics, there can be no experiment i.e. technology. Hence both are deeply related.
6. Answer: Physics is not a purely abstract science devoid of philosophy. Physicists are natural philosophers and Einstein is an example to quote. So Philosophy has provided the backbone to Physics.
7. Answer: It is defined as the understanding of biological processes based upon the principles of Physics. For example, spectroscopic techniques are used to study the constitution of biological molecules and disorders in them. Laws of thermodynamics are used to explain various biological activities of predators and also the activities of molecules.

   Hence the application of Physics to bioscience is now well known to all of us.
8. Answer: It is defined as the study of newer techniques of producing machines, gadgets, etc. by using scientific discoveries and advancements. It is largely dependent on Physics.

Long Questions Answers:

1. Answer: Physics is so important to a branch of science that without the knowledge of Physics, other branches of science cannot make any progress.

   This can be seen from the following:

   (a) Physics in relation to Mathematics: The theories and concepts of Physics lead to the development of various mathematical tools like differential equations, equations of motion, etc.

   (b) Physics in nation to Chemistry: The concept of interaction between various particles leads to understanding the bonding and the chemical structure of a substance. The concept of X-ray diffraction and radioactivity has helped to distinguish between the various solids and to modify the periodic table.

   (c) Physics in relation to Biology: The concept of pressure and its measurement has helped us to know the blood pressure of a human being, which in turn is helpful to know the working of the heart. The discovery of X-rays has made it possible to diagnose the various diseases in the body and fracture in bones.

The optical and electron microscopes are helpful in the studies of various organisms. Skin diseases and cancer can be cured with the help of high-energy radiation like x-rays, ultraviolet rays.

(d) Physics in relation to Geology: The internal structure of various rocks can be known with the study of the crystal structure. The age of rocks and fossils can be known easily with the help of radioactivity i.e., with the help of carbon dating.

(e) Physics in relation to Astronomy: Optical telescope has made it possible to study the motion of various planets and satellites in our solar system.

The radio telescope has helped to study the structure of our galaxy and to discover pulsars and quasars (heavenly bodies having star-like structures). Pulsars are rapidly rotating neutron stars. Doppler's effect predicted the expansion of the universe. Kepler's laws are responsible to understand the nature of the orbits of the planets around the sun.

(f) Physics in the relation to Meteorology: The variation of pressure with temperature leads to the forecast of the weather.

(g) Physics in relation to Seismology: The movement of the earth's crust and the types of waves produced help us in studying the earthquake and its effect.

2. Answer: These are the following four basic forces in nature:

(a) Gravitational forces

(b) Electromagnetic forces

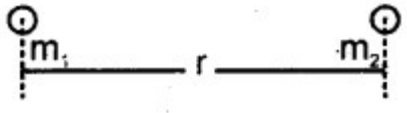
(c) Weak forces

(d) Strong force or nuclear forces.

Some of the important features of these forces are discussed below:

(a) Gravitational forces: These are the forces of attraction between any two bodies in the universe due to their masses separated by a definite distance. These are governed by Newton's law of gravitation given by

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



where m_1, m_2 are the masses of two bodies

r = distance between them

G = universal gravitational constant

= 6.67×10^{-11} Nm^2kg^{-2}

Characteristics of gravitational forces:

- They are always attractive. They are never repulsive. They exist between macroscopic as well as microscopic bodies.
- They are the weakest forces in nature.
- They are central forces in nature i.e., they set along the line joining the centres of two bodies.
- They are conservative forces.
- They obey inverse square law i.e., F ∝1r2 they vary inversely as the square of the distance between the two bodies.
- They are long-range forces i.e., gravitational forces between any two bodies exist even when their distance of separation is quite large.
- The field particles of gravitational forces are called gravitons. The concept of the exchange of field particles between two bodies explains how the two bodies interact from a distance.

(b) Electromagnetic forces: They include the electrostatic and magnetic forces. The electrostatic forces are the forces between two static charges while magnetic forces are the forces between two magnetic poles. The moving charges give rise to the magnetic force. The combined action of these forces is called electromagnetic forces.

Characteristics of electromagnetic forces:

- These forces are both attractive as well as repulsive.
- They are central forces in nature.
- They obey inverse square law.
- They are conservative forces in nature.
- These forces are due to the exchange of particles known as photons which carry no charge and have zero rest mass.
- They are 1036 times stronger as compared to gravitational forces and 1011 times stronger than weak forces.

(c) Strong forces: They are the forces of nuclear origin. The particles inside the nucleus are charged particles (protons) and neutral particles (neutrons) which are bonded to each other by a strong interaction called nuclear force or strong force. Hence they may be defined as the forces binding the nucleons (protons and neutrons) together in a nucleus. They are responsible for the stability of the atomic nucleus.

They are of three types:

- n-n forces are the forces of attraction between two neutrons.
- p-p forces are the forces of attraction between two protons.

- n-p forces are the forces of attraction between a proton and a neutron.

Characteristics of Nuclear forces:

- They are basically attractive in nature and become repulsive when the distance between nucleons is less than O.S fermi.
- They obey inverse square law.

(a) and

(b) types are the forces that we encounter in the macroscopic world while

(c) and

(d) types are the forces that we encountered in the microscopic world.

(c) Weak forces: They are defined as the interactions which take, place between elementary particles during radioactive decay of a radioactive substance. In P-decay, the nucleus changes into a proton, an electron, and a particle called anti-neutrino (which is uncharged). The interaction between the electron and the anti-neutrino is known as weak interaction or weak force.

Characteristics of Weak forces:

- They are 1025 times stronger than the gravitational forces.
- They exist between leptons and leptons, leptons, and mesons. etc.

3. Answer:

Science is concerned with the unfolding of the basic aspects of nature. It formulates simple laws and finds the rhythm in nature, materials, and energy. Using basic principles of science, the ways to use them for the production of different kinds of articles is called technology, i.e., it is the application of science.

The execution of the application of technology in engineering. The production of articles using machines and implements in engineering. This involves the design, development, and manufacturing of articles.

The most notable technology development in the last 25 years is in the field of information technology, computers, and electronic media. The revolution in information technology has opened up fields on the internet, satellite linking of information systems and services other peripheral developments in the industry.

Computers have changed the face of society and made life easy in several fields. It has improved work efficiency in many segments of the industry and public life. Computers have touched the lives of children playing video games and adults alike. It has helped big organizations like railways, banks, and financial institutions like the insurance sector.

India has become one of the biggest centres of software exports and a big foreign exchange earner. Advance scientific research and industrial designing are being done by

computers. TV has entered most Indian houses and community centres-courtesy revolution in electronic media.

The younger generation is mad after the stereo music with CD facilities. The transistors and tape recorders are left far behind. Electronic media has changed the face of the entertainment industry as well as information dissemination. Quick transmission of news, views, and comments are accepted as natural ones by listeners and viewers.

Assertion Reason Answer:

1. (c) A is true but R is false.

   Explanation:

   Law of conservation of energy is always valid for all forces and for any kind of transformation between different forms of energy.

   Therefore, A is true, but R is false.

2. (b) Both A and R are true, but R is not the correct explanation of A.

   Explanation:

   Sometimes physics generates new technology and at others technology gives rise to new physics. Both have desired impact on society. Therefore, both A and R are true, but R is not the correct explanation of A.p