1 Physical World

Facts that Matter

• Science

Science is a systematic and organised attempt to acquire knowledge about the surroundings through observations, experiments and verifications.

• Scientific Method

Several inter-related steps are involved in scientific method. Some of the most significant steps are as follows:

- The systematic observations
- Mathematical modelling
- Reasoning
- Theoretical prediction

• 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, Modern 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 Modern Physics such as Special Relativity, Quantum Mechanics, etc.

• Scope and Excitement of Physics

The scope of Physics is very broad and covers a wide range of magnitude of physical quantities such as length, mass, time, energy, etc.

It deals with the macroscopic world like galaxies and universe as well as microscopic world like nucleus of an atom and fundamental particles like electrons, protons, neutrons etc.

Immense excitement is involved in the study of physics since it explains every naturally occuring phenomena with a set of rules, so that clear understanding can be achieved. The challenge to carry out imaginative new experiments to unlock the secrets of nature, to verify or refute theories, is really exciting.

• 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.

(*i*) Physics in relation to Mathematics. Study of physical variables led to the idea of differentiation, integration and differential equation. Meaningful interpretation of Mathematics becomes Physics.

(*ii*) **Physics in 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.

(*iii*) **Physics in 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.

(*iv*) **Physics in 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 science.

(*v*) **Physics in relation to Meteorology.** The discoveries regarding the study of pressure variations help us to forecast the weather.

Various other inventions of physics have opened new vistas of study in the field of sciences and social sciences.

• Physics in Relation to Technology and Society

Advancement in physics has led to new technologies and vice-versa. Sometimes technology gives rise to new dimension of physics; at other times physics generates new technology. In fact, the technological development is closely related to the application of science and physics in particular. Physics has a dominant influence on society. It has helped the human being to develop its ideas. Development of digital communication systems, rapid mass transport system, lasers making bloodless surgeries, etc., has made human life easy and pleasant.

• There are four fundamental forces in nature that govern the diverse phenomena of the microscopic and macroscopic world. These are the 'gravitational force', the 'electromagnetic force'; the 'strong nuclear force', and the 'weak nuclear force'. Unification of forces is a basic quest in physics. The electromagnetic and the weak nuclear forces have now been unified and are seen as aspects of a single 'electro-weak' force. Attempts are being made to unify electro-weak and the strong force.

• Conservation of energy, momentum, angular momentum, charge, etc., are considered to be the fundamental laws in physics. Conservation laws have a deep connection with symmetries of nature. Symmetries of space and time, and other types of symmetries play a central role in modern theories of fundamental forces in nature.

• IMPORTANT TABLES

Table 1.1 Some 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 Galilei	Law of inertia	Italy
Christiaan Huygens	Wave 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 ionisation	India
S.N. Bose Wolfgang Pauli	Quantum statistics Exclusion principle	India 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 Jehangir Bhabha	Cascade process of cosmic radiation	India
Lev Davidovich Landau	Theory of condensed matter; Liquid helium	Russia
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

Table 1.2. Link between technology and physics

Technology	*Scientific principle(s)*
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
Production of ultra-high 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
Aeroplane	Bernoulli's principle in fluid dynamics
Particle accelerators	Motion of charged particles in electromagnetic fields
Sonar	Reflection of ultrasonic waves
Optical fibres	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 Metrewave Radio Telescope (GMRT)	Detection of cosmic radio waves
Bose-Einstein condensate	Trapping and cooling of atoms by laser beams and magnetic fields.

Table 1.3. Fundamental forces of nature

Name	*Relative strength*	*Range*	*Operates among*
Gravitational force	10^{-39}	Infinite	All objects in the universe
Weak nuclear force	10^{-13}	Very short, Sub-nuclear size ($\sim 10^{-16}$ m)	Some elementary particles, particularly electron and neutrino
Electromagnetic force	10^{-2}	Infinite	Charged particles
Strong nuclear force	1	Short, nuclear size ($\sim 10^{-15}$m)	Nucleons, heavier elementary particles

Table 1.4. 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 Michael Faraday	1820 1830	Showed that electric and magnetic phenomena are inseparable aspects of a unified domain: electromagnetism.
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 electro-magnetic 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.

NCERT TEXTBOOK QUESTIONS SOLVED

1.1. *Some of the most profound statements on the nature of science have come from Albert Einstein, one of the greatest scientists of all time. What do you think did Einstein mean when he said: ''The most incomprehensible thing about the world is that it is comprehensible''?*

Sol. The whole of physical world is complex in nature. The biological world has its own complexities. Moreover, vastly different orders of magnitudes are involved in space, time and mass. Inspite of all this, almost all the physical phenomena can be expressed in terms of few basic laws. When viewed in this context, Einstein's statement becomes very clear.

1.2. *''Every great physical theory starts as a hearsay and ends as a dogma''. Give some examples from the history of science of the validity of this incisive remark.*

Sol. A common observation in our daily life is that light travels in straight line. When Huygens propounded his wave theory, it was against the accepted belief. However, soon it became a dogma as reflection, refraction etc., could be successfully explained on the basis of wave theory. When photoelectric effect was discovered then it was found that wave theory of light cannot explain the phenomena and we came to a conclusion that light truely has dual characteristic. It may behave both as wave and a particle.

We may consider other similar examples from the history of science.

1.3. *''Politics is the art of the possible''. Similarly, ''Science is the art of the soluble''. Explain this beautiful aphorism on the nature and practice of science.*

Sol. Science is a systematised study of observations. A scientist patiently analyses these observations and comes out with certain laws. As an illustration, Tycho Brahe worked for twenty long years to make observations on planetary motions. It is from this huge reservoir of observations that Kepler formulated his three famous laws of planetary motion. Thus, science is the art of the soluble just as politics is the art of the possible.

1.4. *Though India now has a large base in science and technology, which is fast expanding, it is still a long way from realising its potential of becoming a world leader in science. Name some important factors, which in your view have hindered the advancement of science in India.*

Sol. Some of the important factors which have hindered the growth of science in India are given below:

(*i*) Lock of infrastructure and funds for quality research work in science.

(*ii*) Science education is neither properly oriented nor directed. It needs specific directions depending on our requirements.

(*iii*) The rural based science education is nearly non-existent so that majority of population is deprived of the benefits of advancements in science and technology.

(*iv*) Poor pay scales and other facilities to scientists as compared to administrators.

(*v*) Indian society is full of superstitions and is highly traditional. Therefore, they are slow in adopting the new scientific trends.

(*vi*) There is practically no co-ordination between the researchers and the industrialists. The industrialists are the actual consumers of new research and technology. The industrialists of this country have little confidence in the ability of the Indian scientists.

1.5. *No physicist has ever ''seen'' an electron. Yet, all physicists believe in the existence of electrons. An intelligent but superstitious man advances this analogy to argue that 'ghosts' exist even though no one has 'seen' one. How will you refute his argument?*

Sol. Many phenomena which depend upon the existence of electrons have been predicted and actually observed in everyday life. There is no phenomenon which can be explained on the basis that ghosts exist though they are not seen. So, obviously, the comparison between two situations does not make any sense.

1.6. *The shells of crabs found around a particular coastal location in Japan seem mostly to resemble the legendary face of a Samurai. Given below are two explanations of this observed fact. Which of these strikes you as a scientific explanation?*

(a) A tragic sea accident several centuries ago drowned a young Samurai. As a tribute to his bravery, nature through its inscrutable ways immortalised his face by imprinting it on the crab shells in that area.

(b) After the sea tragedy, fishermen in that area, in a gesture of honour to their dead hero, let free any crab shell caught by them which accidentally had a shape resembling the face of a Samurai. Consequently, the particular shape of the crab shell survived longer and therefore in course of time the shape was genetically propagated. This is an example of evolution by artificial selection.

[Note: This interesting illustration taken from Carl Sagan's 'The Cosmos' highlights the fact that often strange and inexplicable facts which on the first sight appear 'supernatural' actually turn out to have simple scientific explanations. Try to think out other examples of this kind].

Sol. The explanation given in option (*b*) strikes as a scientific explanation.

1.7. *The industrial revolution in England and Western Europe more than two centuries ago was triggered by some key scientific and technological advances. What were these advances?*

Sol. Some of the key advances during that period in science and technology include the application of heat and thermodynamics to form the steam engine. Discovery of electricity helped in designing dynamos and motors. Study of gravitation led to the study of motion and making guns and cannons. This gave power in the hands of western countries and they ruled over rest of the world. The discovery of explosives not only helped army but also mineral exploration. These are some examples of scientific and technological advances which helped England and Europe to have their prominent positions in the world. In fact, the progress in chemistry, physics and natural sciences brought the industrial revolution in England and western Europe.

1.8. *It is often said that the world is witnessing now a second industrial revolution, which will transform the society as radically as did the first. List some key contemporary areas of science and technology, which are responsible for this revolution.*

Sol. Some key contemporary areas of science and technology, which are chiefly responsible for a new industrial revolution taking place now and likely to take place in near future are:

(*i*) Design of super-fast computers.

(*ii*) Biotechnology.

(*iii*) Developments in the field of space sciences.

(*iv*) Development of super-conducting materials at room temperature.

(*v*) Advancements in the field of electronics, information technology and nanotechnology.

1.9. *Write in about 100 words a fiction piece based on your speculation on the science and technology of the twenty-second century.*

Sol. (*i*) The development on the front of genetic engineering and biotechnology will include:

(*a*) Production of man, animals and plants with specific characteristics.

(*b*) High yielding variety of plants and specific crops would be sown.

(*ii*) Multiple use of laser in various fields or even more developed device which will transform the world. Man would treat himself as the king of universe.

(*iii*) Man may travel in space with unthinkable speeds and transportation would be totally revolutionised.

(*iv*) Man would travel deeper into the space and may settle on other planets, befriend strange creatures from other worlds or may wage a war with them.

(*v*) In the field of communication, 22^{nd} century has many surprises in store. Two persons sitting on the globe or on moon would talk on phone face to face.

(*vi*) Man may partially conquer diseases and slow down ageing.

1.10. *Attempt to formulate your 'moral' views on the practice of science. Imagine yourself stumbling upon a discovery, which has great academic interest but is certain to have nothing but dangerous consequences for the human society. How, if at all, will you resolve your dilemma?*

Sol. A scientist aims at truth. A scientific discovery reveals a truth of nature. So, any discovery, good or bad for mankind, must be made public. A discovery which appears dangerous today may become useful to the mankind some time later. In order to prevent misuse of scientific technology, we must build up a strong public opinion. Scientists should in fact take up two roles – to discover truth and to prevent its misuse.

1.11. *Science, like any knowledge, can be put to good or bad use, depending on the user. Given below are some of the applications of science. Formulate your views on whether the particular application is good, bad or something that cannot be so clearly categorised:*

(a) Mass vaccination against small pox to curb and finally eradicate this disease from the population. (This has already been successfully done in India.)

(b) Television for eradication of illiteracy and for mass communication of news and ideas.

(c) Prenatal sex determination.

(d) Computers for increase in work efficiency.

(e) Putting artificial satellites into orbits around the Earth.

(f) Development of nuclear weapons.

(g) Development of new and powerful techniques of chemical and biological warfare.

(h) Purification of water for drinking.

(i) Plastic surgery.

(j) Cloning.

Sol. (*a*) Good, because it helped in eradicating a dreaded disease from the Earth.
(*b*) Good, because it helps in literacy campaign and is an effective method of mass communication and entertainment.
(*c*) Bad, because it leads to practice of abortion in case of female foetus.
(*d*) Good, because it increases work efficiency.
(*e*) Good, because it helped in worldwide communication process.
(*f*) Bad, because nuclear weapons may cause mass destruction of mankind.
(*g*) Bad, because these techniques may be used for destructive purposes.
(*h*) Good, because pure water supply will improve the health of people.
(*i*) Plastic surgery is something which cannot be classified as either good or bad. The technique helps to remove certain type of deformations in needy persons. But plastic surgery for cosmetic purposes is not good.
(*j*) Cloning is bad because it has the potential to destroy the normal family life of human society.

1.12. *India has had a long and unbroken tradition of great scholarship in mathematics, astronomy, linguistics, logic and ethics. Yet, in parallel with this, several superstitious and obscurantistic attitudes and practices flourished in our society and unfortunately continue even today among many educated people too. How will you use your knowledge of science to develop strategies to counter these attitudes?*

Sol. In order to popularise scientific explanations of everyday phenomena, mass media like radio, television and newspapers should be used. We shall use our knowledge of science to educate masses and shall try to tell them the real cause of an event so that their superstitious beliefs are rejected.

1.13. *Though the law gives women equal status in India, many people hold unscientific views on a woman's innate nature, capacity and intelligence; and in practice give them a secondary status and role. Demolish this view using scientific arguments, and by quoting examples of great women in science and other spheres; and persuade yourself and others that, given equal opportunity, women are on par with men.*

Sol. There is no difference in the capacity of women and men as far as work, intelligence, decision making is concerned. The nature makes little difference in man and woman in their anatomy and feeling.

The nutrition content of pre-natal and post-natal diet contributes a lot towards the development of human mind. If equal opportunities are afforded to both men and women, then the female mind will be as efficient as male mind.

The list of successful women from various fields is very large. Names of Kalpana Chawla, Sarojini Naidu, Madame Curie, Indira Gandhi, Margaret Thatcher, Mother Teresa, Florence Nightingale drawn from fields varying from science to sociology are very well-known to the world.

1.14. *''It is more important to have beauty in the equations of physics than to have them agree with experiments.'' The great British physicist P.A.M. Dirac held this view. Criticize this statement. Look out for some equations and results in this book which strike you as beautiful.*

Sol. Generally it is considered that physics is a dry subject and its main aim is to give qualitative and quantitative treatment *i.e.,* any derived relation or equation must be verified through experimentation. It is felt that truth of an equation is more important than the simplicity, wonderfulness, symmetry or beauty of the equation. But frankly, if a relation is true to experimentation and simultaneously it is simple, interesting, symmetrical, wonderful or beautiful, it will certainly add to the charm of the relation.

1.15. *Though the statement quoted above may by disputed, most physicists do have a feeling that the great laws of physics are at once simple and beautiful. Some of the notable physicists, besides Dirac, who have articulated this feeling are: Einstein, Bohr, Heisenberg, Chandrasekhar and Feynman. You are urged to make special efforts to get access to the general books and writings by these and other great masters of physics. Their writings are truly inspiring.*

Sol. General books on Physics make an interesting reading. Students should consult a good Library to go through some of these immortal works. 'Surely you are joking, Mr. Feynman' by Feynman is one of the books that would assume the students. Some other interesting books are: *Physics for the Inquiring Mind* by EM Rogers; *Physics, Foundations and Frontiers* by G. Gamow; *Thirty Years That Shook Physics* by G. Gamow; *Physics Can Be Fun* by Perelman.

1.16. *Textbooks on science may give you a wrong impression that studying science is dry and all too serious and that scientists are absent-minded introverts who never laugh or grin. This image of science and scientists is patently false. Scientists, like any other group of humans, have their share of humorists, and many have led their lives with a great sense of fun and adventure, even as they seriously pursued their scientific work. Two great physicists of this genre are Gamow and Feynman. You will enjoy reading their books listed in the Bibliography.*

Sol. The statement ''scientists, like any other group of humans, have their share of humorists'' is true. We can cite the example of many scientists who were fun loving, adventurists, jovial. One can add the name of C.V. Raman who enjoyed music in addition to doing serious scientific works and so was Homi Jahagir Bhaba. Students should go through the listed books of bibliography to visualise actual image of science and scientists. (*see our website.*)

ADDITIONAL QUESTIONS SOLVED

I. VERY SHORT ANSWER TYPE QUESTIONS

Q. 1. *Name the two most important contributions of Albert Einstein.*

Ans. The two most important contributions of Albert Einstein are 'theory of relativity' and 'explanation of photoelectric effect'.

Q. 2. *Who proposed the wave theory of light?*

Ans. Huygens.

Q. 3. *Name three conservation laws from nature.*

Ans. Three important laws of conservation from nature are:
→ Law of conservation of energy.
→ Law of conservation of momentum.
→ Law of conservation of angular momentum.

Q. 4. *Name the scientist and the country of his origin whose field of work was 'cosmic rays'.*

Ans. Hess, Austria.

Q. 5. *What do you understand by the term scientific method?*

Ans. The systematic observations, reasoning, mathematical modelling and theoretical prediction form the scientific method.

Q. 6. *Which scientist received Nobel prize for his work on Molecular spectra?*

Ans. C.V. Raman (the great Indian scientist) received Nobel prize for his work on molecular spectra.

Q. 7. *Name the scientific principle behind stream engines.*

Ans. Laws of Thermodynamics.

Q. 8. *What do you mean by conserved quantities?*

Ans. Conserved quantities are those physical quantities that remain unchanged in a process.

Q. 9. *Name that branch of science which deals with the study of stars.*

Ans. Astronomy.

Q. 10. *Name that branch of science which deals with the study of Earth.*

Ans. Geology.

Q. 11. *Out of the four fundamental forces, which force is weakest and which is strongest?*

Ans. Weakest force — Gravitational force.
Strongest force — Strong nuclear force.

Q. 12. *Name the contribution made by the following physicists:*
(a) S. N. Bose *(b) J. C. Maxwell*
(c) Paul Dirac *(d) Max Planck*

Ans. (*a*) S. N. Bose — Quantum Statistics
(*b*) J. C. Maxwell — Electromagnetic Theory
(*c*) Paul Dirac — Relativistic Theory of Electron
(*d*) Max Planck — Quantum Theory

Q. 13. *Name the scientist and the country of his origin whose field of work was 'elasticity'.*

Ans. Robert Hooke, England.

Q. 14. *What is unified field theory?*

Ans. The theory with which scientists try to unify all forces is called unified field theory.

Q. 15. *Name the force which builds the universe.*

Ans. Quark-Quark force caused by the exchange of particles called 'gluons' is the basic force.

II. SHORT ANSWER TYPE QUESTIONS

Q. 1. *Give the salient features of Einstein's theory.*

Ans. According to Einstein
(*i*) Mass and energy are interconvertible.
(*ii*) Space and time are interconnected.

Q. 2. *What do you mean by mass energy equivalence? Give example.*

Ans. Mass-energy equivalence was propounded by Albert Einstein. It states that energy and mass are interconvertible.

Example. An e^- (electron) collides with an e^+ (positron) and the two annihilate giving two photons. The total mass of e^- and e^+ is converted into energy.

Q. 3. *Name the phenomena/fields with which microscopic domain of physics deals. Which theory explains these phenomena?*

Ans. The microscopic domain of physics deals with the constitution and structure of matter at atomic and nuclear scale.

The quantum theory is currently accepted as the proper framework for explaining microscopic phenomena.

Q. 4. *Name three imporant discoveries of physics, which have revolutionised modern chemistry.*

Ans. Three important discoveries of physics, which have revolutionised modern chemistry, are:
(*i*) study of radioactivity.
(*ii*) quantum theory
(*iii*) study of isotopes and determination of their masses by mass spectrographs.

Q. 5. *How is the fate of society linked to the developments in physics?*

Ans. The end of 20th century is a witness of the intricate relation between science and society. If one can say that it has entered the nerves of the society, it will not be an exaggeration. Even the marriages are being fixed on internet and celebrated in aeroplanes. Think of discos. You can make images of criminals by computers apart from host of other activities like reservation, animation, designing, printing etc. These effects on society are in addition to the ones which revolutionized and societies by mechanical revolution of first half of the 20th century like X-rays, nuclear energy, wireless, satelite, electronics, computer and robots.

Q. 6. *Is physics more of a philosophy or more of a mathematical science?*

Ans. Physics is not a purely abstract science devoid of philosophy. Institution and philosophy have provided back-bone to physics. Physicists are natural philosophers and Einstein is an example to quote.

Q. 7. *Match the scientist in column A against the country of origin in column B.*

	A		*B*
	(i) Newton	*(i)*	USA
	(ii) Michelson	*(ii)*	Denmark
	(iii) Bhabha	*(iii)*	Italy
	(iv) Landau	*(iv)*	France
	(v) Bohr	*(v)*	India
	(vi) Archimedes	*(vi)*	U.S.S.R.
	(vii) Galileo	*(vii)*	Germany
	(viii) Curie	*(viii)*	Britain
	(ix) Heisenberg	*(ix)*	Japan
	(x) Yukawa	*(x)*	Greece
	(xi) Boyle	*(xi)*	England
	(xii) Bernouli	*(xii)*	Switzerland
	(xiii) Ohm	*(xiii)*	Germany
	(xiv) Faraday	*(xiv)*	England
	(xv) Rutherford	*(xv)*	England
Ans.	(*i*) [*i, xi*]	(*ii*)	[*ii, i*]
	(*iii*) [*iii, v*]	(*iv*)	[*iv, vi*]
	(*v*) [*v, ii*]	(*vi*)	[*vi, x*]
	(*vii*) [*vii, iii*]	(*viii*)	[*viii, iv*]
	(*ix*) [*ix, vii*]	(*x*)	[*x, ix*]
	(*xi*) [*xi, xi*]	(*xii*)	[*xii, xii*]
	(*xiii*) [*xiii, xiii*]	(*xiv*)	[*xiv, xiv*]
	(*xv*) [*xv, xv*].		

Q. 8. ***Match the technology in column A to its related scientific principle(s) in column B.***

A. Technology	B. Scientific principle(s)
1. Steam engine	1. Propagation of electromagnetic waves
2. Nuclear reactor	2. Newton's laws of motion
3. Radio and television	3. Superconductivity
4. Computers	4. Role of DNA in heredity
5. Lasers	5. Thermodynamics

6.	Production of ultra high magnetic fields	6. Faraday's law of induction
7.	Rocket propulsion	7. Conversion of gravitational potential energy into electrical energy
8.	Genetic engineering	8. Motion of charged particles in electromagnetic fields.
9.	Electric generator	9. Fission of uranium by slow neutrons
10.	Hydroelectric power	10. Amplification by population inversion
11.	Aeroplane	11. Digital logic of electronic circuits
12.	Particle accelerators	12. Bernoulli's principle in fluid dynamics

Ans. **1.** (1, 5) **2.** (2, 9) **3.** (3, 1)
4. (4, 11) **5.** (5, 10) **6.** (6, 3)
7. (7, 2) **8.** (8, 4) **9.** (9, 6)
10. (10, 7) **11.** (11, 12) **12.** (12, 8).

Q. 9. *Name four fundamental forces in nature.*

Ans. Four fundamental forces present in nature are:
(*i*) Gravitational force (*ii*) Electromagnetic force
(*iii*) Weak nuclear force (*iv*) Strong nuclear force.

Q. 10. *Name three important discoveries of physics, which have contributed a lot in development of biological sciences.*

Ans. The most important discoveries of physics, which have contributed in development of Biology are:
(*i*) Ultrasonic waves. (*ii*) X-rays and neutron diffraction technique.
(*iii*) Electron microscope. (*iv*) Radio isotopes.

Q. 11. *Briefly explain how physics is related to technology.*

Ans. Progress in the field of science and technology is interrelated. Sometimes technology gives rise to new physics and at other times physics generates new technology. The discipline of thermodynamics arose mainly to understand and improve the working of heat engines. Similarly discovery of basic laws of electricity and magnetism led to development of wireless communication technology. Therefore, we can conclude that physics and technology are closely related.

Q. 12. *Why do we need quantum theory?*

Ans. Many phenomena at microscopic level are not explained by classical theory. So quantum theory is needed, *e.g.,* photoelectric effect, interaction among elementary particles.

III. MULTIPLE CHOICE QUESTIONS

1. Who discovered cosmic radiations?
(*a*) Curie (*b*) Hubble (*c*) P.M.S. Blackett (*d*) Maxwell

2. Who gave Universal Law of Gravitation?
(*a*) Einstein (*b*) Sir Isaac Newton
(*c*) J. D. Van der Waals (*d*) Galileo

3. What is the relative magnitude of electromagnetic force with respect to strong nuclear forces?
(*a*) 10^{-38} (*b*) 10^{-13} (*c*) 10^{-32} (*d*) 10^{-2}

4. Who discovered scattering of light?
(*a*) C. V. Raman (*b*) W. Wein (*c*) Hess (*d*) W. L. Bragg

5. Which scientific principle is steam engine based on:
(*a*) Motion of charged particles in electric and magnetic field
(*b*) Newton's laws of motion
(*c*) Thermodynamics
(*d*) Propagation of electromagnetic waves

6. Who gave theory of relativity?
(*a*) Einstein (*b*) C. D. Anderson (*c*) Huygens (*d*) Newton

7. Who proposed the wave theory of light?
(*a*) G. P. Thomson (*b*) Huygens (*c*) M. Planck (*d*) Maxwell

8. Which scientific principle is 'electric generator' based on:
(*a*) Bernoulli's principle
(*b*) Thermodynamics
(*c*) Faraday's law of electromagnetic induction
(*d*) Propagation of electromagnetic waves

9. The name of the particle 'Boson' is associated with the name of :
(*a*) J.C. Bose (*b*) S.N. Bose
(*c*) Issac Newton (*d*) Albert Einstein

10. Which of the following statement regarding 'Prahar' missile developed by DRDO and test fired in the month of July, 2011 are correct?
(*a*) It is a single stage missile
(*b*) Its striking range is 500 km.
(*c*) It is fueld by solid propellants
(*d*) Several 'Prahar' missiles can be fired in one salvo
Select the correct answer using the code given below :
(*i*) 1, 2, 3 and 4 (*ii*) 1 and 3 only
(*iii*) 1, 3 and 4 only (*iv*) 2 and 4 only

11. Who proposed the wave theory?
(*a*) Maxwell (*b*) Huygens (*c*) M. Plank (*d*) G.P. Thomson

12. The range of strong nuclear force is about
(*a*) 10^{-15} m (*b*) 10^{-14} m (*c*) 10^{-16} m (*d*) 10^{-10} m

13. Who did not discover radioactivity?
(*a*) Becqurel (*b*) Pierre curie (*c*) Marie curie (*d*) Rutherford

14. Arrange four types of basic forces in the order of increasing strength in code using *a, b, c* and *d*.
(*a*) Gravitational forces (*b*) Electromagnetic forces
(*c*) Nuclear forces (*d*) Electrostatic forces

15. Who discovers famous theory of relativity?
(*a*) Einstein (*b*) J.C. Bose (*c*) Newton (*d*) J.J. Thomson

16. Select the relative word for blank.
Planet : Sun : : Moon : ...
(*a*) Satellite (*b*) Universe (*c*) Earth (*d*) Mars

17. C.V. Raman got Nobel prize for his discovery about

(*a*) Ultrasonic (*b*) Molecular spectra

(*c*) Theory of vision (*d*) Theory of vibration in musical instrument

18. To which country, scientist J.J. Thomson belong?

(*a*) U.S.A. (*b*) U.K. (*c*) India (*d*) Pakistan

Ans. **1.**—(*c*) **2.**—(*b*) **3.**—(*d*) **4.**—(*a*) **5.**—(*c*)
6.—(*a*) **7.**—(*b*) **8.**—(*c*) **9.**—(*b*) **10.**—(*c*)
11.—(*b*) **12.**—(*a*) **13.**—(*d*) **14.**—(*bd ca)* **15.**—(*a*)
16.—(*c*) **17.**—(*b*) **18.**—(*b*)

IV. QUESTIONS ON HIGH ORDER THINKING SKILLS (HOTS)

Q. 1. *In science sometimes we observe certain phenomenon experimentally but are unable to give a logical equation or theory for that.*

Sometimes, it also happens that we have a scientific theory supported by mathematical formulation yet are unable to test it immediately. Cite one such example.

Ans. Einstein worked to establish a relation between the energy and mass of body. He was of the view that these are the two sides of the same coin or two facets of the same physical quantity. He succeeded when he gave his mass energy equation $E = mc^2$. But its experimental verification came 40 years later in 1945 when atomic bomb was exploded over Japan.

Q. 2. *Why do we call physics an exact science?*

Ans. The physics is called an exact science because it is based on measurement of fundamental quantities.

Q. 3. *Does imagination play any role in physics?*

Ans. Imagination plays vital role in physics. Development of theories and concepts in physics originate from hypothetical imaginations. Heisenberg uncertainty principle, Huygens' principle, Maxwell equations, Schrodinger wave equation, Bohr's theory etc., were the imaginations of scientists which are successfully employed to explain the various phenomena occurring in nature.

Q. 4. *Two principal thrusts in physics are unification and reduction. Justify by giving illustrations.*

Ans. By unification we mean explanation of diverse physical phenomena in terms of a few concepts and laws. As an example, the law of gravitation describes the motion under gravity, motion of Moon and satellites as well as motion of planets. Again, Maxwell's equations of electromagnetism govern all electric and magnetic phenomena.

By reductionism approach we try to derive the properties of a bigger, more complex, system from the properties and interactions of its constituent simpler parts. As an example thermodynamics deals with bulk systems in terms of macroscopic quantities like temperature, internal energy, entropy etc. The kinetic theory and statistical mechanics interpreted these quantities in terms of the properties of the molecular constituents of the bulk system.

Q. 5. *Physics has a very limited scope and only in practice of a few blessed ones. Do you agree?*

Ans. No, it is not true. Physics has unlimited scope and its conceptual base can be noticed in immense number of activities/fields. Can a cricket or a hockey player say that physics has nothing to do with his game? No, he is using collision phenomenon every second of his game along with Newton's laws of motion. Can you say that you walk without physics, talk without physics, eat without physics and so on, all that need friction. A musician uses physics. Physics is applied in every walk of life. Therefore we can not say that physics is noticed only in the practice of few blessed ones.

Q. 6. *The physicists think at a level far higher than a normal individual. Explain.*

Ans. For progress every leader has to be a thinker at a higher level in his field than ordinary man. This is more so in case of physicists as the technological development meant for uplifting the living condition of mankind is dependent on the far sight of the physicists in particular. The physicist must think at a level which is philosophical and mathematically quantifying so that they can visualise the requirement of people at least a quarter of century in advance.

V. VALUE-BASED QUESTIONS

Q. 1. *Ravinder and Mohender were discussing the role of Physics in society. Ravinder said to Mahender that Physics does not have any impact on society. He had no knowledge of science as he was the student of Arts stream. Ravinder who is the science student of class XII explained him that the fate of society is intimately linked with Physics because whatever is discovered in Physics, it immediately effects the society. The advancement in the field of communication such as radios, computers, TVs and mobile phones connect the people with each other. Nuclear energy have brought a profound change in the thinking and living style of the human beings.*

(i) What values are displayed here by Ravinder?

(ii) Give any five discoveries which has effected the society more.

Ans. (*i*) The values displayed by Ravinder are : Intelligence, sharp mind, awareness and helping nature.

(*ii*) (a) Supperconductivity.
(b) Einstein's Equation $E = mc^2$.
(c) Photoelectric effect.
(d) Theory of relativity.
(e) X-rays.

Q. 2. *Deepa's uncle was surprised to see the fast changes in the world. He is not so educated. He asked Deepa to tell him the names and qualities of some persons who have contributed for bringing the rapid changes in the world. Deepa who is science graduate explained about some discoveries and the names of scientist who have done a marvellous work in physics.*

(i) Why Deepa's uncle was so curious to know things changed recently?

(ii) What values are displayed by Deepa?

(iii) Name at least three Indian scientists.

Ans. (*i*) Deepa's uncle is not educated and he is comparing the period of his early life when he could no have communication system, computers, LED's and LCDs. etc. with his present period.

(*ii*) Sympathy, helping, awareness and intelligence are the values displayed by Deepa.

(*iii*) Names of Indian Scientists are:

(*a*) H.J. Bhaba (*b*) S.N. Bose

(*c*) C.V. Raman (*d*) J.C. Bose

Q. 3. *Usha and Ritu are two sisters. Usha wants to explain some technologies to Ritu. Initially Ritu did not show any interest in knowing about the technologies. But Usha explained about the uses and application of some important discoveries.*

(i) What values are displayed by Usha?

(ii) Name some technologies and related principles.

Ans. (*i*) The values displayed by Usha are : dedicated, intelligence, helping nature and awareness:

(*ii*) **Technology**	**:**	**Principle**
(a) Aeroplane	:	Bernoulli's theorem
(b) Rocket propulsion	:	Newton's second and third laws of motion
(c) Nuclear reactor	:	Nuclear fission
(d) Optical fibres	:	Total internal reflection of light

TEST YOUR SKILLS

1. Which experiment led to nuclear model of the atom?

2. For which discovery in physics is J. C. Bose remembered?

3. Who discovered neutron and electron?

4. Define binding energy.

5. What is Physics?

6. What is Science?

7. Which discovery showed that electric and magnetic phenomena are in general inseparable?

8. List the various gadgets you use in your house and write the physical principle behind them.

9. Differentiate between physical and biological sciences.

10. Discuss three most important branches of physics.

❑❑❑