1. Details of Module and its Structure

Module Detail	
Subject Name	Physics
Course Name	Physics 01 (Physics-Part 1, Class XI)
Module Name/Title	Unit 1, Module 1, **Physics and its scope** Chapter 1, Physical World
Module Id	Keph_10101_eContent
Pre-requisites	Secondary school science, secondary school mathematics.
Objectives	**After going through this module, the learners will be able to:** • Develop an understanding of the physical world • Enjoy the scope and excitement of physics • Understand a relation between physics, technology and society • Know the Fundamental forces in nature • Appreciate the laws of nature
Keywords	Physical world, fundamental forces in nature, conservation laws

2. Development Team

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1. UNIT SYLLABUS

Unit 1: PHYSICAL WORLD AND MEASUREMENT

Chapter-1: Physical world

Physics- scope and excitement; Nature of physical laws; Physics, technology and society.

Chapter-2: Units and Measurements

Need for measurement: Units of measurement; Systems of units; SI units, fundamental and derived units; Length, Mass and Time measurements; Accuracy and Precision of measuring instruments; errors in measurements; significant figures.

2. MODULE-WISE DISTRIBUTION OF UNIT SYLLABUS 4 Modules

This unit is divided into four modules for better understanding.

Module 1	• Physical world • Meaning of physics • Scope and Excitement of physics
Module 2	• Need of measurement • SI units • Fundamental and derived units • Measurement of mass, length and time
Module 3	• Accuracy, precision • Significant figures • Errors
Module 4	• Expressing physical quantities dimensionally • Dimensional analysis • Application of dimensional analysis

MODULE 1

3. WORDS YOU MUST KNOW

- **Force:**

  A force is any interaction that, when unopposed, will change the motion of an object. A force can cause an object with mass to change its velocity and accelerate. Force can also be described intuitively as a push or a pull. A force has both magnitude and direction, making it a vector quantity. It is measured in the SI unit of newton and represented by the symbol F.

- **Energy:**

  In physics, energy is the ability to do work.by objects. Emery can be transferred to other objects or converted into different forms.

  Energy comes in different forms: Heat (thermal) Light (radiant) Mechanical (kinetic and potential)

4. INTRODUCTION

This module covers the physical world, which is the world around us. We aim to understand the physics related to nature and phenomena. There may be a few questions coming to your mind such as:

- **What is physics?**
- **Why should I study physics?**
- **How should I study physics?**
- **What is the scope of physics?**

In this module, you may get answers to all these questions.

Physics has got enough to do with real life. Have you ever wondered how your microwave heats the food, or how you can possibly talk with someone who is several kilometers away on your phone, or how can you enjoy a cricket match being played in some other country on your TV, computer, or cell phone? All these modern devices are based on the properties of physics and technology.

The study of physics is going to be an adventurous journey. You will find it challenging, extremely satisfying. Let us venture into the amazing world of physics.

What is science?

The word “Science" originates from the Latin verb ***Scientia***, literally meaning “**to know”.**

Right from the moment we wake up in the morning, the sunlight that enables us to see; the food that we eat; the objects that we use throughout the day – almost everything in our surroundings has a scientific origin and association.

Science is a systematic attempt at understanding natural phenomena, and then utilizes this gained knowledge to predict, modify and control these phenomena.

What is scientific method?

If we look into the accounts of discoveries and the various theories given by great scientists, we will find a common string amongst most of them- they all originated through curiosity, brought about by an observation.

These observations are followed by controlled and careful experiments to find out a possible cause. The results of the experiments, reasoning, either qualitative or quantitative, may be established and facilitated by an appropriate mathematical modeling.

This may support an existing theory, contradict an existing theory, provide basis for a new theory.

Thus, Scientific method means step by step approach to study natural phenomena and form the laws governing these phenomena.

In a nut shell, scientific method includes the following steps:

- **Systematic observations**
- **Controlled experiments.**
- **Qualitative and quantitative reasoning**
- **Mathematical modeling**
- **Verification of existing theories.**
- **Formulation of new hypotheses.**
- **Making prediction and their verification**.

The sequence of steps generally goes 'on and on 'as any existing theory is valid only' as of now'. The next moment it may be modified and abandoned .So what seems to explain a phenomenon may change with better experimentation, or another insight. This is what makes physics really exciting.

WHAT IS A SCIENTIFIC THEORY?

In physics, this term is generally used for a mathematical framework derived from a small set of basic postulates, which is capable of predictions, which are open to verification.

Need for modification of a scientific theory

The interplay of theory and observation, or experiment is the basis of progress of science. **There is no 'final' theory in science and no 'unquestioned authority' among scientists.** Observations and experiments need theories and vice versa to support one another. Sometimes, an existing theory is unable to explain the new observations. The existing theories are then modified or get replaced by new ones.

FOR EXAMPLE:

- **The alpha particle scattering experiment, in 1911, by Ernest Rutherford established the nuclear model of the atom, which then became the basis of quantum theory of hydrogen atom given by Niels Bohr, in 1913.**
- **On the other hand, the concept of antiparticle was first introduced theoretically by Paul Dirac in 1930 and confirmed two years later by the experimental discovery of positron by Carl Anderson.**

5. WHAT IS PHYSICS?

The word Physics is from Ancient Greek language meaning 'knowledge of nature', It is the natural science that studies matter, its motion and behavior through space and time .Physics studies the related entities of energy and force. Physics is one of the most fundamental scientific disciplines, and its main goal is to understand how the universe behaves.

Physics is one of the oldest academic disciplines and, through its inclusion of astronomy, perhaps the oldest. Over the last two millennia, physics, chemistry, biology, and certain branches of mathematics were a part of natural sciences, but during the scientific revolution in the 17th century, these natural sciences emerged as unique research endeavors. Physics intersects with many interdisciplinary areas of research, such as biophysics, physical chemistry etc.

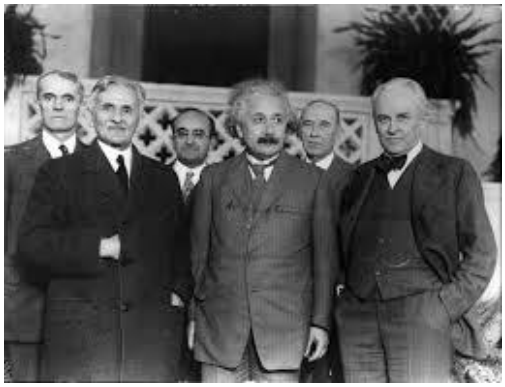
Physics is one of the oldest of the natural sciences. The word physics can be traced back to the Greek word *phusis* meaning "nature".

It was through the study of philosophy and the natural world around the ancient thinkers that the science of physics may be said to have originated.

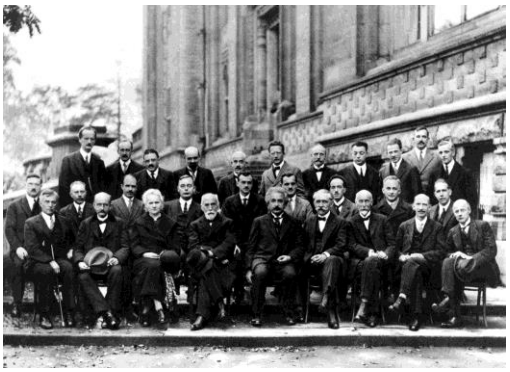
We can define physics as:

Physics is a study of basic laws of nature and their application to various phenomena. Physics includes the study of all forms of matter, and its interaction with other matter and with energy in various forms.

Who is a Physicist?

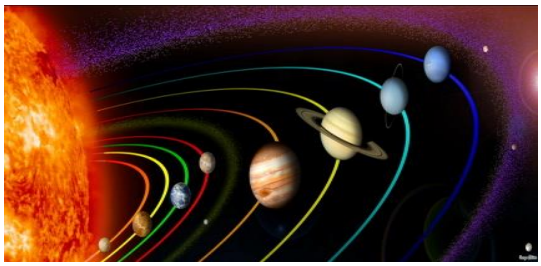


Three Nobel Laureates in Physics. Front row L-R: Albert A. Michelson, Albert Einstein and Robert A. Millikan



Solvay Conference of 1927, with prominent physicists such as Albert Einstein, Werner Heisenberg, Max Planck, Hendrik Lorentz, Niels Bohr, Marie Curie….

Physicists are inquisitive people who want to know the causes of what they see.



Some natural phenomena

Some questions for the enquiring mind:

- **How does the moon move?**
- **Why does the moon move?**
- **Why do the planets move around the sun in orderly manner?**
- **Why do the star's shine?**
- **Why is the sky blue?**
- **Why does the sky appear to be reddish during sunset and sunrise?**
- **What is a rainbow and how is it formed?**
- **Why does the wind blow?**
- **Why do objects fall downwards instead of going upwards?**
- **Why do birds fly?**
- **Why can't we fly?**
- **Why do our hands get warm when we rub them together?**

These are the kind of questions that intrigue a physicist.

Physicists like all scientists, aim to find explanations that describe the various phenomena and offer a better understanding of how the universe and the things that comprise it, work.

SOME OF THE GREAT PHYSICISTS AND THEIR CONTRIBUTIONS

S.No.	Name	Major contribution/ Discovery	Country of Origin
1.	Archimedes	Principle of buoyancy; Principle of the lever	Greece
2.	Galileo Galilei	Law of inertia	Italy
3.	Christiaan Huygens	Wave theory of light	Holland
4.	Isaac Newton	Universal law of gravitation; Laws of motion; Reflecting telescope	U.K.
5.	Michael Faraday	Laws of electromagnetic induction	U.K
6.	James Clerk Maxwell	Electromagnetic theory; Light-an electromagnetic wave	U.K
7.	Heinrich Rudolf Hertz	Generation of electromagnetic waves	Germany
8.	J.C. Bose	Ultra short radio waves	India
9.	W.K. Roentgen	X rays	Germany
10.	J.J. Thomson	Electron	U.K.
11.	Marie Sklodowska Curie	Discovery of radium and polonium; Studies on natural radioactivity	Poland
12.	Albert Einstein	Explanation of photoelectric effect; Theory of relativity	Germany
13.	Victor Francis Hess	Cosmic radiation	Austria
14.	R.A. Millikan	Measurement of electronic charge	U.S.A.
15.	Ernest Rutherford	Nuclear model of atom	New Zealand
16.	Niels Bohr	Quantum model of hydrogen atom	Denmark
17.	C.V. Raman	Inelastic scattering of light by molecules	India
18.	Louis Victor de Borglie	Wave nature of matter	France
19.	M.N. Saha	Thermal ionization	India

20.	S.N. Bose	Quantum statistics	India
21.	Wolfgang	Pauli Exclusion principle	Austria
22.	Enrico Fermi	Controlled nuclear fission	Italy
23.	Werner Heisenberg	Quantum mechanics; Uncertainty principle	Germany
24.	Paul Dirac	Relativistic theory of electron; Quantum statistics	U.K.
25.	Edwin Hubble	Expanding universe	U.S.A.
26.	Ernest Orlando Lawrence	Cyclotron	U.S.A
27.	James Chadwick	Neutron	U.K.
28.	Hideki Yukawa	Theory of nuclear forces	Japan
29.	Homi Jehangir Bhabha	Cascade process of cosmic radiation	India
30.	Lev Davidovich Landau	Theory of condensed matter; Liquid helium	Russia
31.	S. Chandrasekhar	Chandrasekhar limit, structure and evolution of stars	India
32.	John Bardeen	Transistors; Theory of super conductivity	U.S.A
33.	C.H. Townes	Maser; Laser	U.S.A
34.	Abdus Salam	Unification of weak and electromagnetic interactions	Pakistan

PRINCIPAL THRUSTS IN PHYSICS

There are two principal thrusts in Physics: **Unification and Reductionism.**

Unification

In physics we attempt to explain diverse physical phenomena in terms of a few concepts and laws.

Efforts are made to see the physical world as manifestation of some universal laws in different domains and conditions.

For example: Phenomena of apple falling to ground, moon revolving around earth and weightlessness in the rocket, all these phenomena are explained with the help of one single law: The Universal Law of Gravitation.

Reductionism

In physics another effort is to derive the properties of a bigger, more complex, system from the properties and interactions of its constituent simpler parts. This approach is called Reductionism.

For example: Thermodynamics deals with bulk systems in terms of macroscopic quantities such as temperature, internal energy, entropy, etc. In particular, temperature was seen to be related to the average kinetic energy of molecules of the system.

A question that comes to our mind after knowing what Physics is:

What is the importance and scope of this subject in today's world?

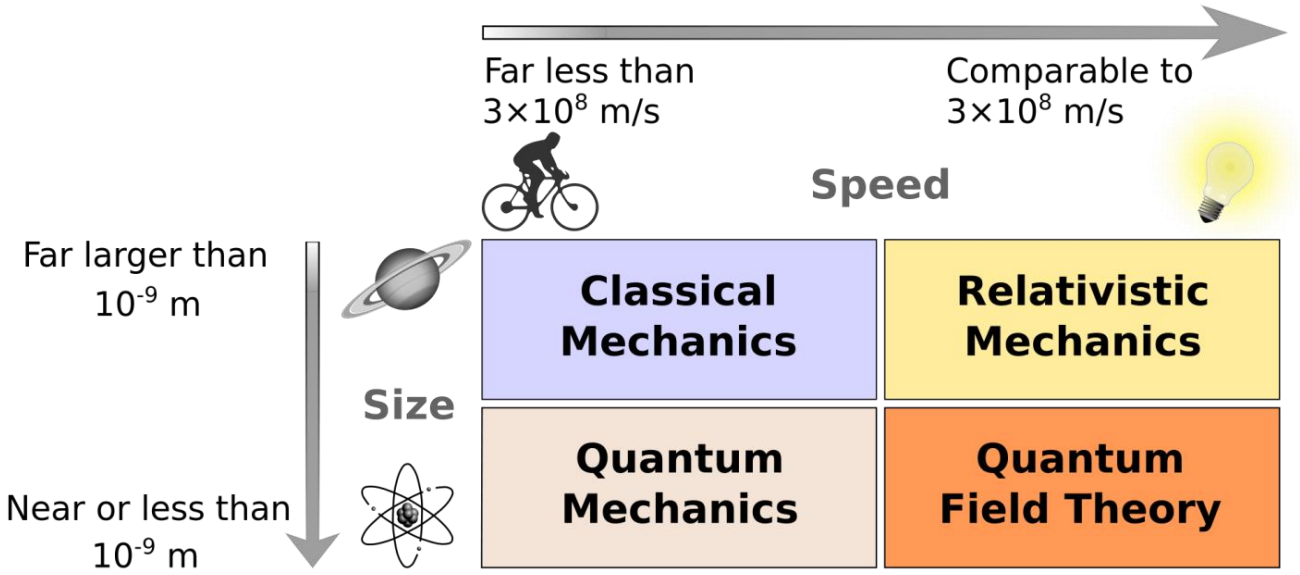
6. THE SCOPE AND EXCITEMENT OF PHYSICS

The scope of physics can be divided into two domains: **Macroscopic** and **Microscopic.**

- **Macroscopic domain aims to understand the phenomena observed on laboratory, terrestrial and astronomical scales. Classical physics deals mainly with macroscopic phenomena and includes subjects like Mechanics, Electrodynamics, Optics and Thermodynamics.**
- **Microscopic domain includes phenomena that is not 'directly observable', the phenomena at the atomic, molecular level.**

  Quantum mechanics deals with microscopic phenomena at the minute scales of nuclei, atoms and molecules.

Thus, we can say that the scope of physics is truly vast. It covers wide range of mass, length and time.



Macroscopic and Microscopic domains.

The study of physics is exciting in many ways.

- **To some people excitement comes from the elegance and universality of its basic theories, from the fact that a few basic concepts and laws can explain phenomena covering a wide range of magnitude of physical quantities.**

- **To some others, the challenge in carrying out imaginative new experiments to unlock the secrets of nature, to verify or refute theories, is thrilling.**

- **Applied physics is equally demanding. Application of physical laws to make useful device is the most interesting and exciting part and requires great ingenuity and persistence of effort.**

7. PHYSICS, TECHNOLOGY AND SOCIETY

Physics and technology are interrelated. It is not possible to have a technology without the application of some principles of Physics, so, physics has a key role in the development of any society. Any society depends on the technology, which develops because of physics.
This is illustrated with the help of a few examples:

- **The laws of Thermodynamics were used in the development of the steam engine which started the industrial revolution in the 18th century.**
- **The invention of the wheel dates back to about 10,000 years in different cultures for various purposes like grinding; spinning, making pottery etc. The evolution in technology has been able to utilize this invention for greater advantage; the wheel has revolutionized transportation and made all kinds of tasks much easier and efficient.**
- **The discovery of basic unification of the phenomena of electricity and magnetism led to wireless communication technology.**
- **The discovery of phenomena of electromagnetic induction led to electric generators and transformers.**
- **The discoveries of radio waves led to development of radio and TV communication.**
- **The discovery of X-Ray led to the revolution in medical diagnosis and therapy.**

Despite the many pros, technology has disadvantages. Modern methods of transportation have both positive and negative effects on people. They help people and goods move quickly all over the world. However, most of them pollute the environment. For example, petrol and diesel-powered vehicles add many pollutants to the atmosphere. The pollutants harm health of the people and contribute to global climate changes.

LINK BETWEEN TECHNOLOGY AND PHYSICS

Some examples

S.No.	Technology	Scientific Principles
1.	Steam engine	Laws of thermodynamics
2.	Nuclear reactor	Controlled nuclear fission
3.	Radio and Television	Generation, propagation and detection of electromagnetic waves
4.	Computers	Digital logic
5.	Lasers	Light amplification by stimulated emission of radiation
6.	Production of ultra-high magnetic fields	Superconductivity
7.	Rocket propulsion	Newton's laws of motion
8.	Electric generator	Faraday's laws of electromagnetic induction
9.	Hydroelectric power	Conversion of gravitational potential energy into electrical energy
10.	Aeroplane	Bernoulli's principle in fluid dynamics
11.	Particle accelerators	Motion of charged particles in electromagnetic fields
12.	Sonar	Reflection of ultrasonic waves
13.	Optical fibres	Total internal reflection of light
14.	Non-reflecting coatings	Thin film optical interference
15.	Electron microscope	Wave nature of electrons
16.	Photocell	Photoelectric effect
17.	Fusion test reactor (Tokamak)	Magnetic confinement of plasma
18.	Giant Microwave Radio Telescope (GMRT)	Detection of cosmic radio waves
19.	Bose-Einstein condensate	Trapping and cooling of atoms by laser beams and magnetic fields.

8. FUNDAMENTAL FORCES IN NATURE

There are four fundamental forces in nature that govern the diverse phenomena of the macroscopic and microscopic world. These are:

- **The gravitational force**
- **The electromagnetic force**
- **The strong nuclear force**
- **The weak nuclear force**

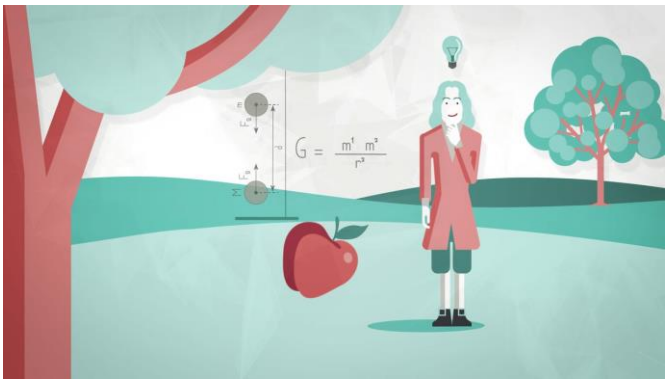
The following video is about four fundamental forces in nature.

https://youtu.be/Xj2BYpik4-c

GRAVITATIONAL FORCE:

It is the force of mutual attraction between any two objects anywhere in the universe. Newton's law of gravitation gives the force exerted by a particle of mass m_1 on another particle of mass m_2 at a distance r. The magnitude of this force is

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



where G is universal gravitational constant.

Water fall shows effect of gravity

$G = 6.67 \times 10^{-11} N\, m^2\, kg^{-2}$

Some of the properties of the gravitational force are:

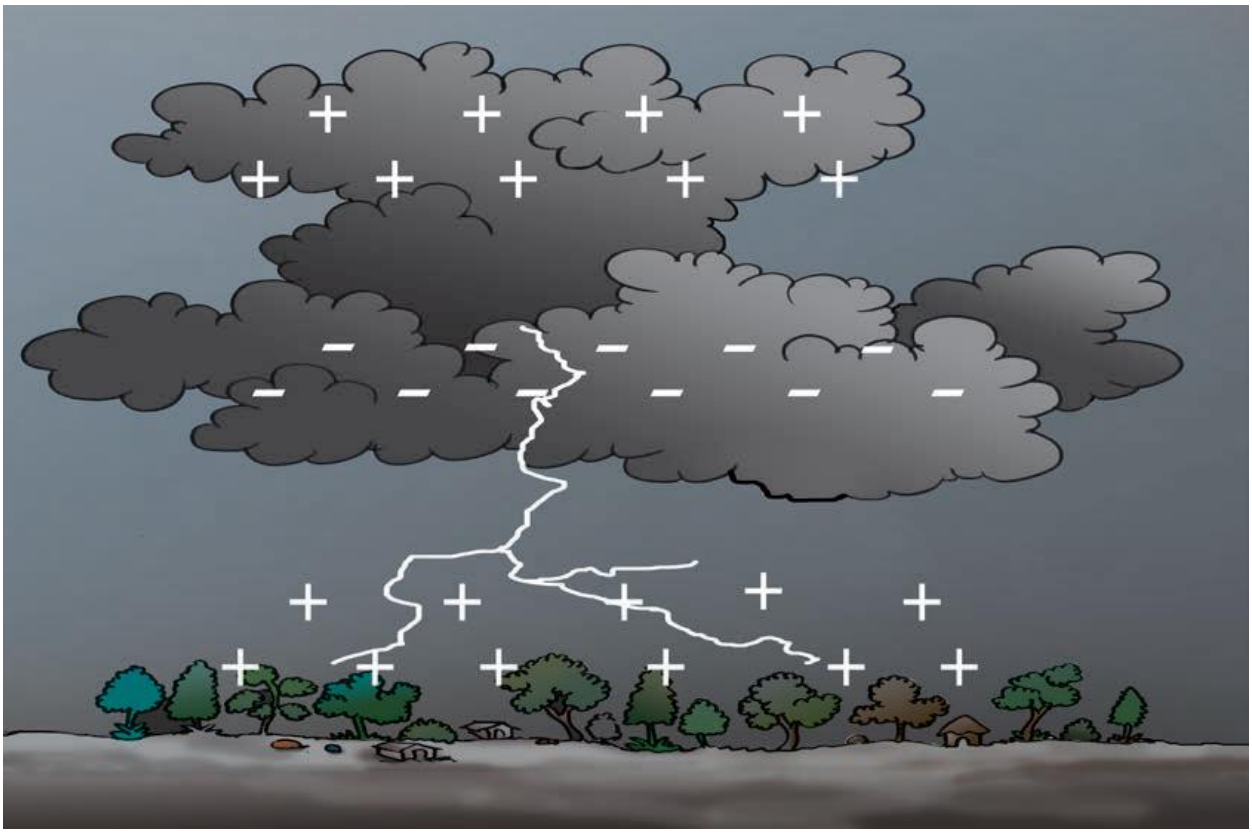
- **It is a central force i.e. it acts along the line joining the centers of two bodies.**
- **It is a universal attractive force.**
- **It obeys inverse square law, i.e., it varies inversely as square of the distance between the bodies.**
- **It is a conservative force.**
- **Gravitational force is the weakest force in nature**.

Watch the following video to understand gravitational force

https://youtu.be/yhG_ArxmwRM

ELECTROMAGNETIC FORCE:

It is the force between charged particles. It includes electric and magnetic forces.



Accumulation of charges leading to lightening

The electric force between the charges is governed by Coulomb's law.

According to Coulomb's law:

If two particles having charges q_1 and q_2 are at rest and at a distance r apart, the force between them equals.

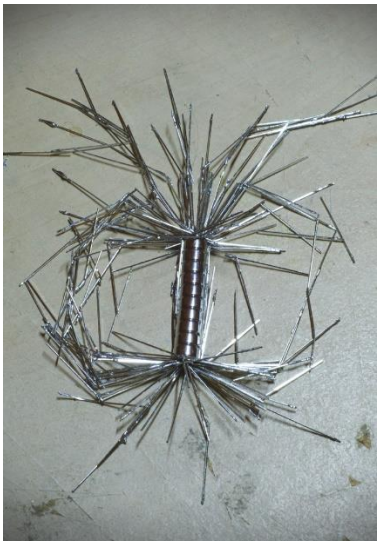
$$F = k\frac{q_1 q_2}{r^2}$$

Where $k = 9 \times 10^9\ Nm^2C^{-2}$

Some of the properties of electric force are:

- **It may be attractive or repulsive.**
- **It is a central force.**
- **It obeys inverse square law.**
- **It is a conservative force.**

Magnetic force



Effect of magnetic force on iron pins

Watch these videos to understand electromagnetic forces

https://www.youtube.com/watch?v=GMnsZuEE_m8

https://www.youtube.com/watch?v=cy6kba3A8vY

STRONG NUCLEAR FORCE:

It is the force which binds protons and neutrons in a nucleus

Some of the properties of strong nuclear force are:

- **It is charge independent.**
- **It is the strongest force in nature, 100 times stronger than the electromagnetic forces.**
- **It is basically an attractive force. However, when distance between nucleons is less than 0.8 Fermi, it become repulsive.**
- **It has a very short range, i.e. of the order of $10^{-15}m$.**
- **It is a non- central force.**
- **It does not obey inverse square law.**
- **It is a non-conservative force.**

Watch this video to understand strong nuclear force.

https://youtu.be/Yv3EMq2Dgq8?list=PLsNB4peY6C6JDc1HcVKjjYzVB0BYEXexd

WEAK NUCLEAR FORCE:

The weak nuclear force appears only in certain nuclear processes such as beta decay of a nucleus. It is not as weak as the gravitational force, but much weaker than the strong nuclear and electromagnetic force.

Watch this video to understand weak nuclear forces.

https://youtu.be/cnL_nwmCLpY

FUNDAMENTAL FORCES OF NATURE

S.No.	Name	Relative Strength	Range	Operates Among
1.	Gravitational force	10^{-39}	Infinite	All objects in the universe
2.	Weak nuclear force	10^{-13}	Very short, Sub-nuclear size (10^{-16}m)	Some elementary particles, particularly electron and neutrino
3.	Electromagnetic force	10^{-2}	Infinite	Charged particles
4.	Strong nuclear force	1	Short, Nuclear size (10^{-15} m)	Nucleons, heavier elementary particles

9. CONSERVATION LAWS

Physical quantities that remain unchanged in a process are called conserved quantities. Some of the general conservation laws in nature include the laws of conservation of mass-energy, linear momentum, angular momentum, charge etc. Some conservation laws are true for one fundamental force but not for the others.

These laws will be discussed in detail later.

Watch this video for introduction to conservation laws.

https://youtu.be/O76BZIvOTSE

Law of Conservation of Energy:

It states that energy can neither be created nor be destroyed. It can only be transformed from one form to another.

Law of Conservation of linear momentum:

It states that the linear momentum of a system remains unchanged in the absence of an external force.

Law of Conservation of Angular Momentum:

It states that angular momentum of a system remains constant if the total external torque, acting on it, is zero.

Law of Conservation of Charge:

It states that charges are neither created, nor destroyed but only transferred from one object/body to another.

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 theories of physics.

THINK ABOUT THESE

1. **What is physics?**
2. **What are the two principle thrusts in physics?**
3. **On which scientific principle does an airplane work?**
4. **Name the four fundamental forces in nature.**

5. **Arrange the weak nuclear force, electromagnetic force and gravitational force in the decreasing order of their strength.**

6. **How many times is the strong nuclear force stronger than the electromagnetic force?**

7. **What are the conserved quantities in nature?**

8. **Can gravitational force be repulsive like the electrostatic force?**

9. **What do you mean by central forces?**

10. **What is the difference between microscopic and macroscopic domains?**

11. **Name the forces which obey inverse square law.**

12. **Can electromagnetic forces be attractive as well as repulsive?**

13. **What happens to the electrostatic force when distance between the charges is doubled?**

14. **What is the order of range of strong nuclear force?**

15. **What are the steps involved in scientific methods?**

11.SUMMARY

In this module we have learnt

- Physics deals with the study of the basic laws of nature and their manifestation in different phenomena. The basic laws of physics are universal and apply in widely different contexts and conditions.

- The scope of physics is wide, covering a tremendous range of magnitude of physical

quantities.

- Physics and technology are related to each other. Sometimes technology gives rise to new physics; at other times physics generates new technology. Both have direct impact on society.

- There are four fundamental forces in nature that govern the diverse phenomena of the macroscopic and the microscopic world. These are the 'gravitational force', the 'electromagnetic force', the 'strong nuclear force', and the 'weak nuclear force'. Unification of different forces/domains in nature is a basic quest in physics.

- Physical quantities that remain unchanged in a process are called conserved quantities. Some of the general conservation laws in nature include the laws of conservation of mass, energy, linear momentum, angular momentum, charge, parity, etc. Some conservation laws are true for one fundamental force but not for the others.

- 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 physics.