CHAPTER # 1

INTRODUCTION

**LAWS OF NATURE: -**

The principles and laws which have been inducted by the Almighty Allah and every creature of the universe is following these laws. These laws are known as “THE LAWS OF NATURE”.

**PHYSICS: -**

“Physics” is derived from a Greek word “physikos” meaning “natural”.

Physics is that branch of science which offers the study of the properties of matter and energy along with the interaction between them.

**BRANCHES OF PHYSICS: -**

In the present era the research in physics has so much increased its sphere that it is necessary to undertake the study of physics under different branches.

The physicists have divided the subject of physics into various branches. Main branches of physics are stated below.

1. **MECHANICS: -**

It is concerned with the motion of objects with or without reference of force.

1. **ELECTRICITY: -**

It is concerned with the physical phenomena involving electric charges and their effects when at rest and in motion.

1. **ELECTROMAGNETISM: -**

It deals with observations, laws, principles and methods that relate electricity and magnetism.

1. **SOLID STATE PHYSICS: -**

It is concerned with the structure and properties of solid materials.

1. **ATOMIC PHYSICS: -**

It is concerned with the structure and properties of atoms as determined by the electrons outside the nucleus.

1. **NUCLEAR PHYSICS: -**

It is concerned with the structure, properties and reactions of the nuclei of atoms.

1. **PLASMA PHYSICS: -**

It is concerned with the properties of highly ionized atoms forming a mixture of base nuclei (nuclei without electrons) and electrons called an ion plasma.

1. **BIO PHYSICS: -**

It is concerned with the applications of physical methods and explanation to Bio physical systems and structures.

1. **ASTRO PHYSICS: -**

It is concerned with the study of physics of astronomical bodies.

In addition to these there are also other branches, law temperature physics, particle physics, optics etc.

**IMPORTANCE OF PHYSICS IN DAILY LIFE: -**

1. Electric appliances in our homes like fan, electric bulb, refrigerator, grinder, juicer all use electric power.
2. Buses, cars, aero planes all run by engines which are manufactured on the principles of thermodynamics.
3. In electronic devices and appliances like video games etc. solid state physics plays a vital role.
4. Laser technology is widely used in defense system, metallurgy, medical science and astronomy which has its roots in atomic physics.
5. Production of nuclear energy in the area of nuclear physics.

**SCIENTIFIC METHOD**

Following are the steps of scientific methods.

**OBSERVATION: -**

In a scientific work the most important thing is observation. Observation is taken very carefully and systematically. In this way all possible information’s are collected about a physical phenomenon under investigation.

**HYPOTHESIS: -**

Keeping these observations in mind a scientist makes some hypothesis or postulates to explain phenomenon.

“A hypothesis is a notion of a scientist on which he tries to explain the phenomenon.”

**THEORY: -**

On the basis of hypothesis he designs a theory and gives an elaborated explanation about the phenomenon.

**EXPERIMENTS: -**

The theory is checked by experiments. If theoretical and experimental results agree with each other, the theory is regarded as correct otherwise discarded. This is one method of investigation of a problem in physics.

**PREDICTION: -**

Sometimes a scientist presents a theory on the basis of rational reasoning and predicts some phenomena to take place under certain conditions. Experiments are designed to test the theory Again if predicted results are obtained the theory is supposed to be correct and then this theory become a Law.

**LAW: -**

A law is such a statement regarding the behavior of nature which explains the observations and experiments of the past and can predict certain other aspects of nature.

**NEWTON’S HYPOTHESIS: -**

Newton made a hypothesis about the nature of light. According to him

“Light consists of extremely small particles moving with a very high velocity.”

He called them corpuscles. Based on this hypothesis he developed a theory, called Corpuscular Theory of Light.

**ADVANTAGES: -**

This theory could explain reflection, refraction and formation of shadows.

**DISADVANTAGES: -**

A/c to this theory light travels faster in denser medium (water) than rarer medium (air) but actually does not.

It could not explain the phenomenon of interference, polarization and diffraction of light.

**HUYGEN’S WAVE THEORY: -**

According to Christian Huygens, “light is a form of energy and it travels in the form of wave”.

**ADVANTAGES: -**

Light travels faster in rarer medium than denser medium.

It could explain the phenomenon of interference, diffraction and polarization of light.

**DISADVANTAGES: -**

Wave theory was unable to explain the phenomenon of Photo electric a Compton effects.

**NOTE:-** Foucault determined speed of light in water experimentally which showed that light travels slower in water (denser) than air (rarer).

**QUANTUM THEORY OF LIGHT: -**

Einstein presented another theory regarding the nature of light called the Quantum Theory of Light.

A/c to quantum theory, “light has dual nature, sometimes it behaves like a wave and sometimes like a particle.” (but never both at the same time). It consists of packets of energy, called photons.

**ERRORS AND TYPES**

**ERROR: -**

An error is defined as the difference between the measured and actual value.

**CLASSIFICATION OF ERRORS: -**

In an experiment certain errors may arise due to experimenter or to the instrument used or due to both. Errors are classified into three types.

1. Personal Error
2. Systematic Error
3. Random Error
4. **PERSONAL ERROR: -** This error arises due to tendency of a person who takes reading in favour of a particular reading such procedure produces errors in taking observations. This type of an error can be removed by avoiding this bias. These errors occur due to faulty procedures by the observer, so called Personal errors.
5. **Systematic Error: - (INTSRUMENTAL ERROR): -** This type of an error arises due to a fault in the measuring instrument. This is called the zero error of the instrument. It may be positive or negative. This error can be overcome by adopting the relevant zero error correction.
6. **RANDOM ERROR: -** It is also called “accidental error”. This type of error arise due to external conditions which are at a certain time beyond the control of the experimenter. This error can be minimized by maintaining certain conditions in the laboratory.

**EXAMPLES: -**

Changes in temperature, humidity and voltage etc. may be controlled.

**CONTRIBUTION OF MUSLIM & PAKISTANI SCIENTIST**

* **ABU ALI HASSAN IBN-AL-HAITHAM: - (965-1039)**

The contribution of Ibn-al-Haitham in the field of physics are given below.

1. Al-Haitham described the nature of light and declared it as a form of energy and gave a formal definition of ray of light.
2. He constructed a pinhole Camera and managed to obtain the image of Solar Eclipse.
3. He gave the two laws of Reflection.
4. He gave the description of luminous, Non-luminous, opaque and ‘Transparent’ objects.
5. He carried out on the formation of image by spherical mirror.
6. He discovered that a ray of light passing through a medium takes a path which takes the least time to traverse. This principle is called the “FERMATE PRINCIPLE OF LEAST TIME”.

* **YAQUB IBNE ISHAQ ALKINDI: -**

His contributions are stated below:

1. He was honored with the title of the first “ARAB PHILOSOPHER”.
2. He wrote research monographs on ‘Meteors’ specific Gravity and tides.
3. He wrote many articles about minerals, gems and scents.
4. He has 241 books to his credit.
5. He explained music for scientific point of view & explains the appearance of blue colour of the sky and did considerable work in medicine.
6. He explained clearly the idea that gold cannot be made from other metals.

* **ABU REHAN M. BIN AHMED ALBERUNI: -**

1. Al beruni wrote more than 150 books on various subjects like mathematics, physics, chemistry, biology, geology, cosmology etc.
2. He proved that earth is round not flat and also measured the circumference of the earth.
3. He gave the method of determining the latitude and longitude of a place.
4. He found densities of various metals.
5. His famous book is “KANOON-AL-MASOODI”. George Sarton called this book as the “encyclopedia of Astronomy”.
6. One of his major achievements was the discovery of idea that some physical laves which are valid an our planet are also valid on other planets and stars.

* **Dr.ABDUS SALAM: -**

Dr. Abdus Salam was awarded scholarship for higher studies in U.K. He was born in 1926 in Jhang, Punjab. He come back in 1950 but again went to U.K for his research work.

He was awarded Noble Prize in 1929 for his work on Grand Unification Theory (GUT). He established International Centre for theoretical physics at Trieste where scientists from the developing countries are provided opportunities for their research work.

* **Dr. ABDUL QADEER KHAN: -**

He was born on 1st April 1936 at Bhopal, India. He obtained MSC Metallurgy degree from Holland and was selected as research assistant there. He obtained Ph.D. degree from the University of Leaven Belgium. He worked as an expert it Urenco Enrichment Plant in Holland as a Joint Venture of the Govt. of Holland to honour him, the former Engg. Research Laboratories has now been named as A.Q. Khan Research Laboratories. He has been awarded “Hilal-e-Imtiaz” by the govt. of Pakistan. He contributed in making Pakistan a nuclear state.

**CHAPTER # 2**

**MEASUREMENT**

**PHYSICAL QUANTITIES: -**

Physical quantities are divided into two groups.

1. Fundamental quantities
2. Derived quantities

**FUNDAMENTAL QUANTITIES: -**

The basic physical quantities I.e. length, mass and time are known as Fundamental quantities.

**DERIVED QUANTITIES: -**

The physical quantities derived from fundamental quantities are known as derived quantities.

**MEASUREMENT: -**

Measurement means the comparison of an unknown quantity with a standard to see how many times it is big or small as compared to the standard.

**UNIT: -**

A unit is fixed by definition and a standard is an embodiment of a unit under certain physical conditions.

**SYSTEM OF UNITS: -**

A set of fundamental and derived units is known as system of Units.

**KINDS OF SYSTEM OF UNITS**

There are three system of units.

1. Centimeter, Gram, Second system (C.G.S)
2. International System of Units (S.I)
3. British Engineering system of units
4. **C.G.S SYSTEM: -**

In this system three fundamental quantities Length, Mass and Time are measured in centimeter, Gram and second respectively.

**DEMERITS: -**

In this system the electromagnetic units were either too large or too small. For overcoming the difficulties a large no. of multiples and sub-multiples units were adopted. This required large no. of conversion factors that had to be memorized.

1. **INTERNATIONAL SYSTEM OF UNITS: - (S.I)**

In this system seven quantities have been adopted as fundamental quantities. They are length, mass, time, electric current, amount of substance, thermodynamic temperature and luminous intensity. Units of these quantities are metre, kilogram second Ampere, mole, kelvin and Candela respectively.

**ADVANTAGES: -**

The advantages of S.I units are:

* These units are used all over the world.
* This system of units is convenient for scientific work and provides a simple method for calculations (as the bigger and smaller units can be obtained by a simple division or multiplication by powers of .

1. **BRITISH ENGINEERING SYSTEM: -**

It is an old system of units in which length, force and time are fundamental quantities. The units are foot, pound and second respectively.

**NOTES: -**

In this system mass is a derived quantity and its unit is derived from the unit of force i.e. pound and is called slug.

**FUNDAMENTAL UNITS**

**BASIC S.I UNITS**

|  |  |  |  |
| --- | --- | --- | --- |
| **QUANTITY** | **SYMBOL** | **UNIT** | **SYMBOL** |
| Length |  | metre |  |
| Mass |  | kilogram |  |
| time |  | second |  |
| Electric Current |  | ampere |  |
| Thermodynamic temp |  | kelvin |  |
| Amount of Substance |  | mole |  |
| Luminous Intensity |  | Candela |  |

**DERIVED UNITS: -**

The units which are used to express the derived quantities are known as derived units. They are obtained by multiplication of fundamental units speed, acceleration, force, volume, pressure, work etc. are the examples of derived quantities & their units are given below.

|  |  |  |  |
| --- | --- | --- | --- |
| **QUANTITY** | **SYMBOL** | **UNIT** | **SYMBOL** |
| Speed |  |  |  |
| Acceleration |  |  |  |
| Volume |  |  |  |
| Force |  |  |  |
| Pressure |  |  |  |
| Work |  |  |  |
| Charge |  |  |  |

**EXAMPLES: -**

* The volume of a box is given by the formula.

i.e.

* Here metre is a fundamental unit while i.e. is a derived unit.

**S.I PREFIXES**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Factor** | **Prefix** | **Symbol** | **Factor** | **Prefix** | **Symbol** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

**SIGNIFICANT FIGURES: -**

The number in which the last digit is in doubt is called significant figures.

**OR**

The certain digits of a measured quantity plus one uncertain digit (last digit) are called significant figures.

**OR**

The reliable digits known with certainty in a given number is called significant figures.

**EXPLANATION: -**

Let the length of a rod which is measured by a scale graduated in centimeters. We take a large no. of readings. The average value of these readings will be more accurate. Let this value be . In this number the last digit placed to the right of decimal point is uncertain . The reason for uncertainty is that scale can read correctly up to units placed of a number where this as the digit lies on the first place of decimal point and hence uncertain. The remaining digits are known with certainly.

**RULES FOR DETERMINING S.F**

1. All non-zero digits are significant.

**E.g.**

1. has two significant figures.
2. has four significant figures.
3. Zeros lying between two non-zero digits are significant.

**E.g.**

1. has three significant figures.
2. has five significant figures.
3. All zeros which locate the decimal point in a number less than one are not significant.

**E.g.**

1. has two significant figures.
2. has three significant figures.
3. All zeros which locate the decimal point in a number greater than one are not significant.

**E.g.**

1. has one significant figures.
2. has three significant figures.
3. Final zeros which are located to the right of decimal point are significant.

**E.g.**

1. has three significant figures.
2. has five significant figures.

**USE OF S.F IN ADDITION & SUBTRACTION & MULTIPLICATION**

When two or more numbers are used in calculation the number of significant figures with answers is limited by no. of significant figures in the original data.

For Example: Add

has four significant figures. However one of the known value i.e. has only two significant figures. Therefore the answer should be rounded off to two significant figures i.e.

Therefore the Final answer is

**SIGNIFICANT ZEROS: -**

Consider a number . This number may have two; three or four significant figures depending upon whether the zeros represent measurements or are marely used to locate the position of decimal point scientific notation avoid this ambiguity. The above no can be written as . These nos. in scientific notation have two, three and four significant figures respectively.

**ROUNDING OF DATA: -**

It is the procedure of discarding the in significant digits from a number expressed in a quantity.

**RULES FOR ROUNDING OFF DATA: -**

1. If last dropping digit (L.D.D) is greater than a five, then the last remaining digit (L.R.D) is increased by one unit.

**Examples:**

(L.D.D)

(L.R.D)

To Round off to significant figures.

Similarly Add 1 in 7

→ 2 Significant figures

1. If the last dropping digit (L.D.D) is less than five, then last remaining digit (L.R.D) remains unchanged.

**Examples:**

1. If the last dropping digit (L.D.D) is exactly five, then the last remaining digit (L.R.D) is increased by if odd and remains unchanged if even.

**Examples:**

Here, L.D.D is exactly five

L.R.D is even

L.R.D remains unchanged

Hence

Here, L.D.D is exactly five

L.R.D is odd

Add in L.R.D

Hence

**SCIENTIFIC NOTATION: -**

The short hand expression of a very large or small number by means of exponents is called exponential rotation or scientific notation.

**Examples:**

1. (Avogadro’s no) is written as

Since the decimal point has moved place to the left, therefore exponent is .

1. (mass of electron) is written as

Since the decimal point has moved places to the right, therefore exponent is .

**RULE: -**

* If the decimal point moves towards left then the exponent is positive.
* If the decimal point moves towards right then the exponent is negative.

**CHAPTER # 3**

**KINEMATICS OF LINEAR MOTION**

**KINEMATICS: -**

The branch of physics which deals with the description of motion of objects without reference to the force or agents causing motion is called Kinematics.

**REST: -**

A body is said to be in the rest, if it does not change its position with respect to its surroundings.

**EXAMPLES: -**

A book lying on a table is said to be in the state of rest.

If you are standing at a bus stand near a bus in such a way that the position of the bus with respect to you is not changing, then the bus is said to be in the state of rest.

Suppose you are sitting in a room, your position with respect to the surrounding walls and roofs is not changing you are said to be in the state of rest.

**MOTION: -**

A body is said to be in the state of motion, if it changes its position with respect to its surroundings.

**EXAMPLES: -**

The revolution of earth around the sun is an example of motion.

Suppose a bus is moving towards or away from you in such a way that the position of the bus with respect to you changes continuously, then the bus is said to be in the state of motion.

Sometimes it happens that a body is at rest with respect to some other body but at the same time it is in the state of motion with respect to another body.

**EXAMPLE: -**

If a person is sitting in a compartment of a moving train find that all the things around him in the compartment are stationary, but for a person standing on the platform all the things in the compartment are in motion.

**DYNAMICS: -**

The word dynamics is taken from a Greek word dynami meaning power. It is defined as, “It is that branch of physics which deals with the causes of motion and how they affect the motion.”

**DIFFERENCE B/W KINEMATICS & DYNAMICS: -**

In Kinematics we study the position and motion of an object in space at a certain time without considering the causes of motion, which in dynamics we study the pushes or pulls which cause or resist the motion. Dynamics also deals with the causes of motion & factors that affect the motion.

**MECHANICS: -**

Mechanics is the branch of physics that deals with the Kinematics and dynamics of objects.

**TYPES OF MOTION: -**

There are many types of motion, but the three main types are.

1. **TRANSLATORY MOTION: (LINEAR MOTION)**

The motion which is associated with bodies moving in a straight line is called Translatory motion.

**OR**

The motion of a body in which every particle of the body is being displaced by the same amount is known as Linear or Translatory motion.

**Examples of Linear Motion:**

* Motion of a car on a road.
* Moving of train on its track.

1. **ROTATORY MOTION: (CIRCULATORY MOTION)**

If an object spins or rotates about a fixed point or axis, its motion is called rotational motion.

**OR**

The motions of bodies moving in circle is called rotational motion.

**Examples of Rotational Motion:**

* The rotation of earth about its axis.
* The blades of a moving electric fan.
* The wheels of a moving car.

1. **VIBRATORY OR OSCILLATORY MOTION:**

Consider a block which is suspended from a rigid support by means of a spring. When the block is pulled in the downward direction and released, it starts moving up and down about its mean position. This type of motion is vibratory motion.

**OR**

If a pendulum swings from one side to the other side and back, the motion of the pendulum is to and fro motion.

Such to and fro motion of an object about a mean position at regular interval of time is called Oscillatory & Vibratory motion.

**Examples of Vibratory Motion:**

* To & fro motion of a swing.
* Movement of the string of a sitar or violin.
* The periodic swing of a clock’s pendulum.

**SCALAR AND VECTOR QUANTITIES**

**PHYSICAL QUANTITY: -**

Any quantity which can be measured by any method is called a physical quantity. All the physical quantities are divided into two groups.

1. Scalar quantities.
2. Vector quantities.

**SCALARS: -**

The physical quantities, which are completely specified by their magnitude only, are called scalar quantities. For example, mass, time, distance, speed, work, energy, temperature, charge, etc.

The scalar quantities can be added, subtracted and multiplied by simple arithmetic methods.

**VECTORS: -**

The physical quantities, which are completely specified by their magnitude and direction both, are known as vector quantities. For example, displacement, velocity, acceleration, force, momentum, torque, etc.

The vector quantities acting along different directions cannot be added, subtracted and multiplied by simple arithmetic methods. They are added, subtracted and multiplied by geometric or trigonometric methods. Some of the methods of vector addition are:

1. Head to Tail rule.
2. Rectangular Method.
3. Parallelogram Method.

**REPRESENTATION OF VECTORS: -**

A vector quantity can be represented graphically by a directional line segment. The length of the line segment gives magnitude whereas the arrow head gives its direction.

**DISTANCE & DISPLACEMENT: -**

Consider two points such that a body is placed at the point . The body can move from the point to the point along different paths , as shown in the fig. It can be seen from the fig that the body has travelled the distance in a straight line along the path only. The distance travelled by the body between the points along the path is the shortest distance and is covered in a definite direction. The distance covered by a body in a particular direction is known as displacement.

Distance possesses magnitude only whereas displacement has magnitude as well as direction, hence distance is scalar and displacement is a vector quantity.

1. **SPEED: -**

The distance covered by a body in unit time in any direction is called Speed.

1. **VARIABLE SPEED: -**

If a body is moving in such a way that it does not cover equal distances in same intervals of time then it is said to have Variable Speed.

**OR**

A body is said to have Variable Speed if its speed is changing continuously.

1. **AVERAGE SPEED: -**

If the speed of the body is obtained by dividing the total distance by the time taken, then the speed is said to be Average Speed. Average speed is symbolically represented by . If a body covers a distance in time then its average speed is given by the equation.

1. **UNIFORM SPEED: -**

If a moving body covers equal distance in equal intervals of time however small in any direction, then its speed is called Uniform Speed.

1. **INSTANTANEOUS SPEED: -**

Speed for a very short interval of time is called Instantaneous Speed.

**OR**

Distance covered by a body in a short interval of time in any direction is called Instantaneous Speed.

1. **VELOCITY: -**

The distance covered by a body in unit time in a definite direction is called velocity. It is a vector quantity.

1. **VARIABLE VELOCITY: -**

If a body does not cover equal distance in equal intervals of time in specified direction then it is said to have a variable velocity.

**OR**

Variable speed in a definite direction is called variable velocity.

1. **AVERAGE VELOCITY: -**

The average velocity of a body is obtained by dividing the total displacement by the time taken.

1. **UNIFORM VELOCITY: -**

If a body covers equal distance in equal intervals of time and the speed and direction of the body remain the same, then it is said to possess uniform velocity.

1. **INSTANTANEOUS VELOCITY: -**

Velocity of a body for a very short interval of time is called Instantaneous velocity.

**OR**

Instantaneous speed in a definite direction is called instantaneous velocity.

**UNITS OF VELOCITY: -**

The units of velocity are given below:

**ACCELERATION: -**

The rate of change of velocity is called acceleration.

**OR**

Change in velocity per unit time is called acceleration.

**NOTE: -**

When the velocity of a body changes, acceleration is produced. The change may be in magnitude, direction or both of a body.

**EXPLANATION: -**

Consider a body whose velocity changes from in a short interval of time . As velocity of a body is changing hence an acceleration is produced in it.

Or,

Acceleration may be positive or negative.

**POSITIVE ACCELERATION: -**

If the velocity of a body increases continuously then the acceleration is said to be positive or simply acceleration.

**DIRECTION: -**

The direction of positive acceleration is same as that of the motion.

**RETARDATION OR DECELERATION: -**

If the velocity of a body decreases continuously then the acceleration is said to be negative or is called deceleration or retardation.

**DIRECTION: -**

The direction of negative acceleration is opposite to that of motion.

**EXAMPLES OF ACCELERATION: -**

The falling body whose velocity increases every moment is said to have acceleration.

A body moving with uniform speed in a circle possesses acceleration due to change of direction.

**EXAMPLES OF RETARDATION: -**

When we apply brakes in a moving vehicle then it has Retardation.

**UNIFORM ACCELERATION: -**

If the rate of change of velocity in every interval of time is same, then the body is said to have uniform acceleration.

**OR**

The acceleration is said to be uniform of the velocity of the moving body changes by an equal amount in equal intervals of time.

**EXAMPLE: -**

If the change in velocity of a car moving in a straight line is same throughout then the car is said to have uniform acceleration.

**CHAPTER # 4**

**FORCE AND MOTION**

**FORCE: -**

Force is an agent which produces or tends to produce, stops or tends to stop the motion of a body.

Force can also distort or tends to distort the shape of a body to which it is applied.

**NEWTON’S FIRST LAW OF MOTION**

Newton’s first law of motion states that.

“Every object continues its state of rest or uniform motion in a straight line unless it is acted upon by an external force which changes its state of rest or of uniform motion.”

**EXAMPLES: -**

A book lying in a shelf remains at rest in its position unless somebody removes it by applying a force.

A boy riding a bicycle does not come to rest immediately when he stops pedaling. The bicycle continuous to move forward but ultimately comes to rest due to opposing action of air resistance and road friction.

**CONCLUSIONS: -**

The following two important conclusions can be drawn from the first law of motion. Force is an agent which produces or tends to produce change in the state of rest or of uniform motion of an object.

All the material objects possess the property of opposing any change in their state of rest or of uniform motion. This property of matter by virtue of which an object resists a change in its state of rest or motion is called inertia. Thus, Newton’s first law of motion is also called the law of inertia.

Mass is the direct measure of inertia i.e. greater the mass of an object the greater will be the inertia because relatively greater force is needed to change its state.

**EXAMPLES OF INERTIA: -**

1. A small coin is put on a card and placed over a glass. When the card is flicked away with the finger. The coin drops.
2. If a moving bus stops suddenly the passenger standing in it feels a jerk in the backward direction and as a result he may fall. It is due to the fact that the lower part of the body which is in contact with the floor is carried in motion while the upper part remains at rest due to inertia and so the passenger feels a jerk in the backward direction.

**NEWTON’S SECOND LAW OF MOTION**

Newton derived a definite relationship between the force acting on an object, the mass of the object and the acceleration produced.

**STATEMENT: -**

The second law of motion states,

“When a force acts on an object, it produces an acceleration in the object which is in the same direction of force. This acceleration is directly proportional to the magnitude of the applied force.”

**EXPLANATION: -**

Consider two objects one heavier and the other lighter. If we apply the same force on both the objects then the acceleration produced in the lighter object will be greater than that produced in the heavier object.

**DERIVATION: -**

If a force is applied on an object of mass which produces acceleration in the direction of the applied force then the relationship between the applied force and acceleration can be expressed as,

(For Constant mass)

Similarly for acceleration and mass the relationship can be written as,

(For Constant force)

Combining eq. (1) & (2)

Where, is a constant of proportionality

The value of then

The S.I unit of force is Newton

“The force acting on a body is said to be 1 Newton if it produces an acceleration of in the body of mass , in the direction of the applied.”

**NEWTON’S THIRD LAW OF MOTION**

Newton’s third law of motion states.

“To every action there is always an equal and opposite reaction.”

The two forces are equal in magnitude but opposite in direction.

According to third law of motion

Where the shows that the two forces are parallel but opposite in direction.

**EXAMPLES: -**

1. When we walk on the ground, then we push the ground backward and as a reaction the earth pushes us onward, and due to this reason we move onward.
2. Consider a book placed on a table, it pushes the table with a certain force in the downward direction called action as a result the table pushes the book in the upward direction with the same force called reaction. Since the book is at rest, the resultant force on the book must be zero, i.e.
3. Let a person throw a ball on the wall, the bounces back it is due to the reason that the ball exerts a certain force on the wall. This is known as the action of the ball on the wall. The wall also exerts a force known as the reaction of the wall on the ball which is equal in magnitude and so the ball bounces back.

**MASS AND WEIGHT**

**MASS: -**

The quantity of matter contained in a body is called the mass of that body.

**UNIT: -**

The S.I unit of mass is

**FORMULA: -**

It is denoted by and can be calculated as

**WEIGHT: -**

The force with which the earth attracts a body towards its centre is called weight.

**UNIT: -**

Since weight is also a force therefore its unit is same as force i.e. Newton.

**FORMULA: -**

The weight of a body can be calculated as ,

**DIFFERENCE BETWEEN MASS & WEIGHT**

|  |  |
| --- | --- |
| **MASS** | **WEIGHT** |
| **Definition:**  The quantity of matter contained in a body is called mass of that body. | **Definition:**  The force with which the earth attracts a body towards its centre is called weight. |
| **Scalar Quantity:**  Mass is a scalar quantity. | **Vector Quantity:**  Weight is vector quantity. |
| **Unit:**  Its S.I unit is kilogram | **Unit:**  Its S.I unit is Newton. |
| **Formula:**  Mass can be given as | **Formula:**  Weight can be calculated as |
| **Constant Quantity:**  The mass of a body remains constant everywhere. | **Variable Quantity:**  The weight of a body is not constant its value changes at different places. |
| **Physical Balance:**  Mass can be determined by ordinary physical balance. | **Spring Balance:**  Weight is measured with the help of spring balance. |

**MOMENTUM**

**DEFINITION: -**

The quantity of motion present in a body is called momentum. Momentum can also be defined as the product of mass and velocity of a moving body. It is denoted by .

**MATHEMATICALLY: -**

Where,

**UNIT: -**

Therefore the unit of momentum is

**LAW OF CONSERVATION OF MOMENTUM**

**STATEMENT: -**

The momentum of an isolated system (Isolated system is that system which is not affected by an external force) always remains constant or conserved.

**MATHEMATICAL EXPRESSION: -**

**EXPLANATION:**

1. Consider two balls of masses moving with velocities respectively.
2. If then the body moves towards and then collide with it and the final velocities after collision of becomes respectively.

According to law of conservation of momentum.

i.e.

**APPLICATIONS: -**

* If a balloon is blown up and released it flies round the room. During the flight, air escapes from the balloon in one direction while it moves in the opposite direction. This is due to law of Conservation of momentum of the system of air & balloon.
* The recoil of a gun when a bullet is fixed from it is due to the conservation of momentum of the system consisting of gun & bullet.

**FORCE OF FRICTION**

**DEFINITION: -**

When a body slides over the surface of another body an opposing force is setup to resist the motion. This opposing force is called “Force of Friction” or “Simply Friction”.

**EXPLANATION: -**

Consider a wooden block placed on the table. There are two forces acting on it.

1. Weight of the block acting vertically downward.
2. Reaction of the table acting vertically upward called Normal Reaction denoted by .

It is found experimentally that the limiting frictional force is proportional to the total weight pressing the block against the table or normal reaction .

**MATHEMATICALLY: -**

Where

**CO-EFFICIENT OF FRICTION**

“The ratio of the limiting Friction to the normal reaction between two surfaces in contact with each other is called Co-efficient of Friction.”

Its value depends upon the nature of the two surfaces in contact.

* If the surface is horizontal then the normal reaction is equal to the weight of the block as shown in fig,

Putting the value in eq. (ii)

Eq. (ii) ⇒

**FACTORS ON WHICH FRICTION DEPENDS: -**

Following are the factors on which frictional force depends.

1. Friction force is directly proportional to the normal reaction of the surface .
2. Friction depends upon the nature of the two surfaces in contact with each other.

**TYPES OF FRICTION**

1. **STATIC FRICTION:**

When a body is at rest over the surface of another body the friction between them is said to be Static Friction. The maximum value of static friction is limiting Friction.

1. **SLIDING FRICTION:**

When a body slides over the surface of another body the friction between is said to be Sliding Friction.

1. **ROLLING FRICTION:**

When a body rolls over the surface of another body, the friction between them is said to be Rolling Friction. Rolling friction is less than sliding friction.

1. **KINETIC FRICTION:**

The friction during motion is called Kinetic friction. This friction is slightly less than the limiting friction.

**ADVANTAGES OF FRICTION: -**

1. Due to friction we can stop the moving objects (by applying brakes).
2. We walk on earth due to the friction we push the ground in backward direction and ground gives the reaction in forward direction. This is possible due to friction.
3. Friction is also necessary for living beings e.g. If there were not enough friction in the joints, we would find it very difficult to stand up right.
4. The threading on the car tyres is done to provide necessary frictional force between the tyre and the road to enable the car to move smoothly.

**DISADVANTAGES OF FRICTION: -**

1. Friction produces heat in various parts of the machines, due to which some useful energy is wasted as heat energy.
2. Friction cause ware and tare in various moving parts of machines.

**METHODS OF REDUCING FRICTION: -**

1. The various moving parts of machines are properly lubricated with lubricating oils.
2. In machines various moving parts are replaced by ball bearings.
3. Where sliding is unavoidable, a layer of greasing material is used between the sliding surfaces.
4. The front portions of the fast moving objects e.g. aero planes is made oblong in order to decrease air friction.

**CONCLUSIONS: -**

1. The force of friction always acts parallel to the surfaces in contact and opposite to the direction of motion.
2. The friction is due to the roughness of the material surfaces in contact.
3. The maximum force of friction which stops the motion of the body is called limiting friction.
4. The graph between applied force and frictional force is given as
5. This graph represents that an increase in the applied force increases the force of friction.
6. When the body is set into motion the value of friction becomes constant.

**TENSION IN A STRING**

**DEFINITION: -**

Tension is a reactive force exerted by a string on a body to which it is attached.

**EXPLANATION: -**

Consider a person holding a block of weight by means of a string, the weight of the block pulls it downwards, while the string pulls it upward with an equal force. The force exerted on the figures, the force experienced by the hand and the upward force acting on the block is due to the force developed in the string. This force is called Tension in the string. The S.I unit of Tension is newton .

* **Motion of Bodies Connected by a String Passing over Frictionless Pulley: -**

**Case I: When both the bodies move vertically.**

Consider two bodies having unequal masses and connected by a string passing over a frictionless pulley.

Suppose is greater than . Hence body will move down with an acceleration while body will move up with the same acceleration.

Let be the tension in the string.

Consider the motion of body . Two forces are acting on the body .

1. Weight of the body acting downwards=
2. Tension in the string acting upwards

Since body is moving down so is greater than .

The net force acting vertically downwards on

According to Newton’s Second law of motion the net force is given as

Comparing eqs. (1) and (2)

Consider the motion of body . Two forces are acting on it.

1. Weight of the body acting downwards =
2. Tension in the string acting upwards

Since body is moving upwards so tension in the string is greater than weight of the body.

The net force on body is given by

Applying Newton’s Second Law of motion

Comparing eqs. (3) and (4)

Adding eqs. (A) & (B)

Divide eq. (A) by (B)

**Case II: When one body moves vertically and the other horizontally.**

Consider two bodies of masses connected to the ends of the string passing over a frictionless pulley.

The body moves vertically downward with an acceleration and the body moves on a smooth horizontal table towards the pulley with same acceleration.

Consider the motion of body . Two forces are acting on it.

1. Weight of the body acting downwards = .
2. Tension in the string which is acting upward

Since body is moving down so . The net force is given as

Apply Newton’s Second Law of motion

Comparing eqs. (1) and (2)

Now consider the motion of body . Three forces are acting on it.

1. Tension acting horizontally.
2. Weight acting vertically downward.
3. The normal reaction of the smooth surface which acts vertically upward.

Since the weight and normal reaction are equal and opposite they cancel the each other. The only force acting is the Tension.

According to second law of motion,

Comparing (3) and (4)

Add eqs. (A) and (B)

Substitute the value of in e.q. to get

e.q. ⇒

**CHAPTER # 5**

**VECTORS**

**SCALARS: -**

Those physical quantities which are completely specified by magnitude only are called scalar quantities or simple scalars.

They can be added, subtracted and multiplied by simple arithmetic methods.

**EXAMPLES: -**

Length, mass, time, temperature, area, volume, density, speed, distance, energy etc. are few examples of scalars.

**VECTORS: -**

Those physical quantities which are completely specified by magnitude and direction both are known as vector quantities or simply vectors.

**EXAMPLES: -**

Force, acceleration, Displacement, velocity, momentum, torque, electric and magnetic field are the few examples of vectors.

**METHODS OF VECTOR ADDITION**

The vector quantities acting along different directions cannot be added, subtracted, multiplied by simple arithmetic methods. They are added, subtracted and multiplied by geometric or trigonometric methods. Some of the methods of vector addition are.

1. Head to Tail rule or Graphical Method.
2. Rectangular Method.
3. Parallelogram Method.

**REPRESENTATION OF VECTORS: -**

A vector is represented by an arrow drawn parallel to the direction of the vector. The length of the arrow indicates the magnitude of the vector and the arrow head gives its direction.

Vectors are represented by a straight line according to.

* some reference axis .
* some suitable scale.

**RESULTANT VECTOR: -**

The resultant vector of two or more than two vectors is a vector that has the same effect as the combined effect of the vectors to be added.

**OR**

The resultant vector of two or more than two vectors is the vector sum of all the vectors.

**ADDITION OF VECTORS: -**

The process by which we get the resultant of two or more than two vectors is called Addition of vectors.

**HEAD TO TAIL RULE (GRAPHICAL METHOD): -**

The easiest method to find the magnitude and direction of the resultant vector is graphical method.

If are the two vectors, then their resultant can be given as,

The resultant vector of two vectors is determined by drawing representative lines of these vectors in such a way that the head of the one coincides with the tail of the other. The representative line obtained by joining the tail of the first vector to the head of second vector represents resultant vector. This method of adding vectors is known as Head to Tail rule of vector addition.

**STEPS OF PROCEDURE: -**

1. First we choose a system of some reference axes.
2. Draw the first vector with a suitable scale keeping in view its magnitude and direction.
3. Draw the second vector using the same scale by placing the ‘Tail’ of the second vector on the ‘Head’ of the first vector.
4. Join the ‘Head’ of the second vector to the ‘Tail’ of first vector.
5. The straight line which is directed from the ‘Tail’ of the first vector to the ‘Head’ of the last vector represents the resultant vector, whose magnitude and direction can be measured.

This method of addition of vectors is known as Head to Tail rule of vector addition or Graphical method.

**NEGATIVE VECTOR: -**

The vector of a vector which is same in magnitude but opposite in the direction is called negative vector. E.g.

**SUBTRACTION OF VECTOR: -**

Subtraction of the vector from vector is defined as “the addition of the negative vector to the vector . ”

**EXPLANATION: -**

1. let and are two vectors as shown.
2. it is required to find
3. for this purpose negative of is obtained as shown.
4. Add vector to vector to obtain the resultant.

**MULTIPLICATION OF A VECTOR BY A NUMBER: -**

When a vector is multiplied by a number it remains a vector quantity.

Let the number say be positive than the new vector has magnitude times of the original vector and its direction remains the same.

* If a vector is represented by a directed line segment of length vectors and will be represented by directed line segments of length and respectively.

**NOTE: -**

The lines representing these vectors are parallel to one another and their arrow heads pointing in the same direction.

* If the vector is multiplied by a negative number say , the new vector has a magnitude times the original vector and its direction is opposite to .

The vectors are shown.

**NOTE: -**

The negative sign reverses the direction of the arrowhead.

**RESOLUTION OF VECTOR: -**

**DEFINITION: -**

The process of splitting up a single vector into its or more than two components is known as Resolution of vector.

**COMPONENT VECTORS: -**

The vectors, whose vector sum is equal to a given vector, are called the component vectors of that vector.

**RECTANGULAR COMPONENTS: -**

The components of the vector which are mutually perpendicular to each other are termed as rectangular components.

**EXPLANATION: -**

Consider a vector which makes an angle with the positive x-axis as shown.

Its rectangular components (i.e. x-component and y-component) may be found as,

1. A perpendicular is drawn to the x-axis from the head of the vector to obtain the x-component .
2. Similarly a perpendicular is drawn to the y-axis from the head of the vector to obtain the y-component .

**MAGNITUDE OF COMPONENTS: -**

Consider the right angled triangle in the scalar form.

In the above triangle:

This is the horizontal component of vector .

This is the vertical component of the vector .

**ADDITION OF RECTANGULAR COMPONENTS OF VETOR: -**

Consider rectangular components which are represented by line segments respectively.

Add these two components by Head to Tail rule of vector addition.

Consider the right angled triangle

Using the Pythagoras Theorem

The direction of the resultant vector can be determined by the trigonometric ratio.

**CHAPTER # 6**

**EQUILIBRIUM**

**STATICS: -**

The study of forces acting on stationary bodies in equilibrium is called statics.

**EQUILIBRIUM: -**

A body at rest or moving with uniform velocity along a straight line is said to be in Equilibrium.

In both cases the body does not possess any acceleration. Hence all the bodies in equilibrium do not possess any acceleration.

**PARALLEL FORCES: -**

When a number of forces act on a body and if their directions are parallel, they are called Parallel forces.

Parallel forces may be like or unlike.

**LIKE PARALLEL FORCES: -**

If two parallel forces have the same direction, they are called Like parallel forces.

**UNLIKE PARALLEL FORCES: -**

If two parallel forces have the opposite directions, they are called unlike parallel forces.

**Resultant Of Two Like Parallel Forces**

Consider two like parallel forces and acting on a body at and as shown.

Suppose is the resultant forces of and then

It means that the Resultant force of two like parallel forces is a force whose magnitude is equal to the sum of the magnitudes of the two forces and the direction is the same as either of the forces.

**Resultant Of Two Unlike Parallel Forces**

Consider two Unlike Parallel Forces and acting on a body at and as shown.

Here is greater than . Suppose is the resultant force of and . Thus,

It means that the resultant of two unlike parallel forces is a force whose magnitude is equal to the difference of the magnitudes of the two forces and the direction is the same as that of the greater force.

**TYPES OF EQUILIBRIUM: -**

There are two types of Equilibrium.

1. Static Equilibrium.
2. Dynamic Equilibrium.

**STATIC EQUILIBRIUM**

A body at rest is said to be in Static Equilibrium.

**EXAMPLES OF STATIC EQUILIBRIUM: -**

A box lying on a table. Bridges, Buildings.

Consider a spherical ball of weight suspended from the ceiling by a string as shown. The ball is in Static Equilibrium.

There are two forces acting on the ball. The force of gravity acting downward and the upward pull of the string known as Tension . These two forces balance each other, so the ball is at rest.

**DYNAMIC EQUILIBRIUM**

“A body moving with uniform velocity along a straight line is said to be in Dynamic Equilibrium.”

**EXAMPLES OF DYNAMIC EQUILIBRIUM: -**

A Paratrooper falling with uniform velocity is an example of Dynamic Equilibrium. When the parachute opens an upward force due to reaction of air acts on the parachute. The force of gravity acting vertically downward is balanced by the air reaction acting vertically upward. Hence the paratrooper falls down with uniform velocity.

Another example of dynamic Equilibrium is a car moving with uniform velocity along a road. The force of engine is acting in the forward direction while the force of friction between the road and the tyres is acting backward. If these two forces balance each other than the car will move with uniform velocity.

**NOTE: -**

For a body to be in equilibrium no unbalanced force should act on the body. The downward forces must balance the upward forces and the leftward forces must balance rightward. It means that the resultant of all the forces must be zero.

**STATES OF EQUILIBRIUM: -**

There are three states of Equilibrium of a body.

1. Stable Equilibrium
2. Unstable Equilibrium
3. Neutral equilibrium

**STABLE EQUILIBRIUM**

A body is said to be in Stable Equilibrium if it comes back to its original position when it is slightly displaced.

**OR**

If the centre of gravity of a body is raised on a slight jerk than the body is said to be in the state of Stable Equilibrium.

**EXAMPLES OF STABLE EQUILIBRIUM**

Book lying on a table is an example of Stable Equilibrium. If the book is lifted from one edge and then allowed to fall then it will come back to its original position.

**UNSTABLE EQUILIBRIUM**

A body is said to be in Unstable Equilibrium if it does not come back to its original position when it is slightly displaced.

**OR**

If the centre of gravity of a body is lowered on a slight jerk than the body is said to be in the state of Unstable Equilibrium.

**EXAMPLES OF UNSTABLE EQUILIBRIUM**

Vertically standing pencil is an example of Unstable Equilibrium. If it is slightly disturbed from its position it will not come back to its original position.

**NEUTRAL EQUILIBRIUM: -**

A body is said to be in Neutral Equilibrium if it does not come back to its original position but occupies a new position similar to its original position when it is slightly displaced.

**OR**

If the centre of gravity of a body is neither raised nor lowered on a slight jerk than the body is said to be in the state of Neutral Equilibrium.

**EXAMPLES OF NEUTRAL EQUILIBRIUM**

Rolling ball is an example of Neutral Equilibrium. If the ball is slightly pushed it will not come back to its original position but occupies a new position similar to original position.

**CENTRE OF GRAVITY**

The Centre of Gravity is the point at which the whole weight of the body appears to act. It may be inside or outside the body.

**COUPLE**

Two forces which are equal in magnitude opposite in direction, parallel to each other and having different lines of action are called a Couple.

Consider two equal, unlike parallel forces, each of magnitude , acting at And as shown.

The Torques or moments of two forces are given by.

Both these moments have the same direction i.e. counter clockwise, so the total moment of the two forces is equal to the sum of the two moments.

Therefore, Moment of the couple is equal to the product of one of the forces and the perpendicular distance between the lines of action of two forces. This perpendicular distance between the two forces is called ARM OF THE COUPLE.

**NOTE: -**

Whenever a couple acts on a body, there is only rotation.

A couple cannot be balanced by a single force. It can be balanced by an equal and opposite couple.

**AXIS OF ROTATION: -**

The fixed line or axis about which the body can rotate is called its axis of rotation. A force acting on such a body (which can only rotate) can only produce rotation.

**EXAMPLE: -**

When we apply a force on the door, it can rotate, as it can move as a whole along a straight line.

**TORQUE OR MOMENT OF A FORCE**

The ability of force to rotate a body about its axis of rotation is called Torque or moment of force.

**EXPRESSION: -**

where,

**FACTORS ON WHICH TORQUE DEPENDS**

The Torque acting on a body depends on

1. the magnitude of the applied forces.
2. the moment arm.

**MOMENT ARM: -**

The perpendicular distance from the axis of rotation to the line of action of the force is called the moment arm of the force.

**NOTE: -**

Anticlockwise Torques are taken positive.

Clockwise Torque are taken negative.

**FIRST CONDITION OF EQUILIBRIUM**

**STATEMENT: -**

The first condition of Equilibrium states

“If a body is in equilibrium then the vector sum of all forces acting on the body must be equal to zero.”

**EXPRESSION: -**

The first condition can be written as

i.e.

The linear acceleration of a body in equilibrium is zero.

In 2-Dimensions the first condition of Equilibrium can be written as.

i.e.

If a body is in equilibrium, then the summation of the x-components and y-components of all the forces acting on the body must be equal to zero.

**EXPLANATION: -**

**EXAMPLE # 1: -**

Consider a body suspended with the help of string, two forces acts upon it, one is the weight of the body acting vertically downwards and other is the Tension in the string acting vertically upwards. If the body is in equilibrium then,

Since there is no force along x-axis

i.e.

**EXAMPLE # 2: -**

If the body is in equilibrium than the weight is equal to the normal reaction and the leftward Force is equal to the rightward Force

i.e.

**SECOND CONDITION OF EQUILIBRIUM: -**

**STATEMENT: -**

“For a body to remain in equilibrium, the positive torques producing counter clockwise (anticlockwise) rotation must be balanced by equal magnitude negative torques producing clockwise rotation. This is the second condition of Equilibrium.”

**OR**

“If the algebraic sum of all the torques acting on a body is equal to zero then the body is said to be in the state of Equilibrium.”

**MATHEMATICAL EXPRESSION: -**

The second condition of Equilibrium can be written as.

i.e.

The angular acceleration of a body in equilibrium is zero.

**EXPLANATION: -**

Consider a rigid uniform bar supported at its middle point 0. Suppose , , , , and are the torques or moments produced by forces , , , , and respectively as shown.

, , and are clockwise moments.

, , and are anticlockwise moments.

The bar is in Equilibrium under the action of all these forces. Therefore, the sum of all the torques will be zero i.e.

This is the principle of moments.

**IMPORTANT POINTS TO REMEMBER: -**

Anticlockwise moments / torque are positive.

Clockwise moments / Torques are negative.

All the forces and its components pointing towards positive direction are taken to be positive whereas the forces directed towards the negative are taken to be negative.

All the forces and components directed towards positive are taken to be positive whereas the forces directed towards the negative are taken to be negative.

When first condition of equilibrium is satisfied , the body is said to be in TRANSLATIONAL EQUILIBRIUM.

When the second condition of equilibrium is satisfied , the body is said to be in ROTATIONAL EQUILIBRIUM.

**CHAPTER # 7**

**CIRCULAR, MOTION AND GRAVITATION**

**LAW OF UNIVERSAL GRAVITATION**

**INTRODUCTION: -**

The law of Universal Gravitation was discovered by Sir Isaac Newton in the year 1686. This law is true not only for the heavenly bodies but also for any two bodies in the universe.

**STATEMENT: -**

“Everybody in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.”

**DERIVATION: -**

Consider two bodies and of masses and respectively. Let be the distance between their centres as shown in the figure. According to Newton’s Law of Gravitation the force of attraction exerted by body on is same in magnitude but opposite in direction to the force exerted by the body on

The magnitude of force of attraction between them is given as,

Combining (i) and (ii) then,

Where is a constant of proportionality known as Gravitational constant and its value is

**GRAVITATIONAL CONSTANT**

According to Newton’s Law of Gravitation

If and

then,

Therefore can be defined as

“ is the force which exist between two bodies of masses each which are at a distance of from each other.”

**UNIT OF G: -**

**DETERMINATION OF G: -**

The value of was determined experimentally by Henry Cavendish in 1798 with air instrument called Cavendish Balance.

The Cavendish balance consist of two small sphere of mass mounted at opposite ends of a light horizontal rod of length which is suspended at its centre by a fine vertical fibre.

When two large spheres of mass arc brought near to small sphere at distance , the gravitational force of attraction between the spheres produce torque, which twists the fibre. The twist in fibre is proportional to the magnitude of Torque.

According to Newton’s law of Gravitation the gravitational force between the spheres is given as

This force produces torque which is given

The Torque produces a twist which is proportional to the magnitude of torque.

where is constant of proportionality substituting all the known values, the value of can be calculated.

**NOTE:-** this experiment is performed in a closed room to prevent change in temperature & circulation of air.

**MASS OF EARTH**

**DERIVATION: -**

The mass of the earth can be determined with the help of Law of Universal Gravitation.

Consider a body of mass be placed on the surface of the earth. Let be the mass of the Earth and be the distance between the centres of the body and earth.

The Earth attract the bodies towards its centre and the force with which the earth attracts a body towards its centre is given by the Law of Universal Gravitation.

As we know the gravitational force exerted on the body by the earth is equal to the weight of the body.

Comparing eq (1) and (2)

where,

Put the values in eq. (3)

eq. (3)

The mass of the earth is

**VARIATION OF ‘g’ WITH ALTITUDE**

Consider a body of mass of the surface of earth.

As we know that the gravitational force of attraction between the body and the earth is equal to the weight of the body.

The gravitation force by Newton’s law gravitation is given as.

Comparing eq. (1) and (2)

Since and are constant. So the acceleration due to gravity depends the value of R.

From the above relation it is clear that the value of varies inversely to the square of the distance from the centre of earth. If the distance from the centre of earth is increased the value of will decreases and vice versa.

If the body is moved up to distance from earth surface the acceleration due to gravity at that point is

Divided eq. (A) and (B) we get,

Using Binomial Expansion formula

So,

The terms containing higher powers of are neglected.

The above eq. shows that greater the value of the smaller is the value of or in other words the value of decreases as we go up from the surface of earth.

**ORBITAL VELOCITY**

Consider a satellite of mass moving in an orbit of radius with velocity around the earth. The gravitational force of attraction between the satellite and earth provides necessary centripetal force.

Let be the mass of the earth than the gravitational force between the satellite and earth is given as,

The centripetal force is given by

Comparing Eq. (1) and (2)

If is the acceleration due to gravity at the position of satellite then,

Substitute the value in above eq.

Comparing Eqs. (A) and (B)

If the satellite is revolving very near to the surface of the earth.

then,

**CENTRIPETAL FORCE**

**DEFINITION: -**

The force which forces a body to move along a circular path is called centripetal force and its direction is towards the centre of the circle.

**OR**

The force which acts towards the centre along the radius of a circular path on which the body is moving with a uniform velocity is called Centripetal Force.

**DERIVATION: -**

Consider an object of mass moving in a circle of radius with constant speed

According to Newton’s 2nd law of motion.

Where is the centripetal acceleration produced by the centripetal force and

Substitute the value of in eq. (1)

**FACTORS ON WHICH CENTRIPETAL FORCE DEPENDS**

The Centripetal force is

**UNIFORM CIRCULAR MOTION: -**

“When a body moves in a circular path with constant speed it is said to be uniform circular motion.”

**OR**

“If a body moves in a circular path in such a way that it always covers equal distances in equal intervals of time then it is said to have uniform circular motion.”

The magnitude of the velocity is constant along its path. However, the direction of velocity changes. At any point on the circle the direction of velocity is tangent to the circle at that point.

**EXAMPLES OF CIRCULAR MOTION**

1. The movement of planets around the sun in fixed circular orbits.
2. In an atom the electron are moving constantly around the nucleus.

**NOTE: -**

The body possesses acceleration as the change in velocity in terms of direction is occurring.

**CENTRIPETAL ACCELERATION**

Consider a body of mass moving with constant speed around a circle of radius . The direction of velocity is tangent to the circular path at any point.

**EXPLANATION: -**

As the body moves along the circular path, there is a change in velocity in terms of direction i.e the direction of velocity is continuously changing, so it has an acceleration. According to Newton’s 2nd law of motion, a force must be acting on it. The magnitude of velocity remains constant so this force has no component in the direction of motion. Force is at right angle to the tangent to the circle and is directed towards the centre of circle called Centripetal force.

**DEFINITION:-**

The Centripetal force produces acceleration in its own direction called centripetal acceleration. The magnitude of centripetal acceleration is equal to the square of the speed divided by the radius of the circle. It is given as,

1. Directly proportional to the mass of object.
2. Directly proportional to the square of velocity.
3. Inversely proportional to the radius of circular path.

**EXAMPLES OF CENTRIPETAL FORCES: -**

1. The centripetal force required by natural planets to move constantly around a circle is provided by gravitational force.
2. The motion of electrons around the nucleus in an atom is possible due to centripetal force. This force is provided by electrostatic force of attraction between positively charged nucleus and negatively charged electrons.
3. If a stone is tied to a string is whirled in a circle, the required centripetal force to it is supplied by our hand. As a reaction, the stone exerts an equal force which is felt by our hand.

**CENTRIFUGAL FORCE**

**DEFINITION: -**

The reaction of centripetal force which is directed out of the circle is called centrifugal force.

**EXPRESSION: -**

The magnitude of centrifugal force is equal to the magnitude of centripetal force but its direction is opposition to that of centripetal force.

**EXAMPLES OF CENTRIFUGAL FORCE: -**

If a stone is tied with one end of the string, and it is moved around a circle then the force exerted on the string in outward direction is centrifugal force.

**DERIVATION OF CENTRIPETAL ACCELERATION: -**

The magnitude of centripetal acceleration of a body in a uniform circular motion is directly proportional to the square of the velocity and inversely proportional to the radius of the circle in which body is moving.

Combining (i) and (ii)

**CENTRIFUGE: -**

It is an appliance used to separate heavier particles from the lighter particles in a liquid.

The liquid is rotated in a cylindrical vessel at high speed with the help of an electric motor. The heavier particle moves away from the axis of rotation and the lighter particle moves hear the axis of rotation.

1. A cream separator is a type of centrifuge in which milk is rotated at high speed, the lighter cream particles collect near the axis while the skimmed milk moves away from the axis.
2. Sugar crystals are separated from molasses with the help of a centrifuge. When sugar solution is rotated in a cylindrical vessel the sugar crystal moves away from the axis of rotation and collected on the net around the vessel drum.
3. In washing machine dryer, the wet clothes are rotated at high speed. The water particles due to centrifugal force throws outward through the holes in the wall of outer vessel as the drum containing wet clothes rotates.

**CHAPTER # 8**

**WORK, POWER AND ENERGY**

**WORK**

**DEFINITION: -**

When a force acts on a body and moves it through some distance along the direction of force, then work is said to be done by the force.

The product of Force and displacement is called work.

**EXPRESSION: -**

If a Force acts on the body and displaces it through the distance then the work done by the force on the body is given as

**SCALAR QUANTITY: -**

Work is a scalar quantity.

**UNIT: -**

The S.I unit of work is

**JOULE: -**

When a force of one newton moves body through a distance of one metre in the direction of force then the work done is equal to one Joule.

**‘WORK’ WHEN THE FORCE MAKES AN ANGLE ‘’ WITH THE DIRECTION OD DISPLACEMENT**

When a force acts on a body at an angle with the direction of motion of the body as shown below.

The magnitude of force which displaces the body is

In this case work done is defined as,

“The product of the displacement and the component of force in the direction of displacement i.e. .”

**POSITIVE WORK (MAXIMUM WORK): -**

When the force acts in the direction of displacement, work done is said to be positive and maximum. Here

**ZERO WORK (MINIMUM WORK): -**

When the force acts at right to the displacement, work done is said to be zero. Here

**NEGATIVE WORK: -**

When the force is opposite to the displacement, work done is said to be negative displacement i.e.

**POWER: -**

The rate of doing work is called Power.

**OR**

The work done per unit time is called Power.

**EXPRESSION: -**

**UNIT: -**

The S.I unit of Power is

Since is a small unit, so power is commonly expressed in

In British Engg. System the unit of Power is horse power

**WATT: -**

The power is one watt when work is done at the rate of one joule per second.

**OR**

The power is said to be one watt when 1 Joule of work is done to move a body in one second.

**SCALAR QUANTITY: -**

Power is a scalar quantity.

**POWER AND VELOCITY: -**

When a constant Force acts on a body and displaces it through a distance in the direction of force in time then,

The rate of doing work i.e power developed is given as

Substitute the value of in eq. (ii)

As we know that the rate of change in displacement is called velocity.

Substitute in eq. (iii)

Hence,

**ANOTHER DEFINITION OF POWER: -**

“The product of force and velocity is called Power.”

**ENERGY**

**DEFINITION: -**

“Energy is defined as the ability of doing work.”

* When we do work on a body, we store an amount of energy equal to the work done in that body.

**FORMS OF ENERGY: -**

There are two forms of energy.

**Energy**

**Kinetic Energy**

**Potential Energy**

**Elastic Potential Energy**

**Gravitational** **Potential** **Energy**

**KINETIC ENERGY**

**DEFINITION: -**

The energy possessed by a body by virtue of its motion is called Kinetic Energy.

**EXPRESSION: -**

Consider a body of mass placed on a frictionless horizontal surface initially at rest. When a force is applied it covers a distance and its final velocity becomes

The work done in covering the displacement is

According to Newton’s Second Law of motion. When a force acts on a body, it produce an acceleration in the direction of force which is given as

Using the Second equation of motion.

i.e.

Here,

∴ the above equation becomes

Substitute the value of in eq. (i)

This work done is equal to the energy of the moving body which is called Kinetic Energy so,

**POTENTIAL ENERGY**

**DEFINITION: -**

The energy possessed by a body by virtue of its position (height) is called potential energy.

**KINDS OF POTENTIAL ENERGY: -**

There are different kinds of potential energy such as.

1. Gravitational Potential Energy.
2. Elastic Potential Energy.

**GRAVITATIONAL POTENTIAL ENERGY**

**DEFINITION: -**

The Potential Energy possessed by a body in the gravitational fields called Gravitational Potential Energy.

**OR**

The energy associated with a mass when lifted to a height in the earth’s gravitational field is called gravitational potential energy.

**EXPRESSION: -**

Consider a body of mass on the ground. When the body is lifted to a height by applying a force which is just equal to its weight some work has to be done against the force of gravity.

The force by which the body is lifted to a height is just equal to its weight which is given as,

Where is the mass of the body.

Work done is the product of force and displacement.

The distance through which the body is lifted is

Substitute the value of and in eq. (ii)

This work done on the body is stored in it as gravitational work (Gravitational P.E)

**ELASTIC POTENTIAL ENERGY**

**DEFINITION: -**

The energy stored in a compressed or stretched elastic material such as a spring is called Elastic Potential Energy.

**EXPRESSION: -**

Suppose a Force pushes a spring to compress it from its equilibrium position to some other position

The force is directly proportional to the amount of Compression.

i.e.

Where is the spring constant. Its value depends on the stiffness of the spring.

From the figure it is clear that:

The Compression force at is zero.

The Compression force at is

The average Compression force needed to compress the spring from to is

The work done in compressing the spring is

Substitute the value of in eq. (ii)

This work causes the Elastic Potential Energy.

**LAW OF CONSERVATION OF ENERGY**

“Energy can neither be created nor destroyed, it can be transformed from one from to another but the total amount of energy remains constant.”

**INTERCONVERSION OF K.E AND P.E: -**

Consider an object of mass lying at a height above the earth’s surface at point . The potential energy at this height is maximum and is equal to . The Kinetic energy at point is zero since the velocity is zero.

Now let the body fall down under the action of gravity. During this downward motion its height decreases continuously so its potential energy also decreases. At the same time during the downward motion, the velocity increases so the Kinetic Energy also increases. Hence the work done by it under the action of gravity is equal to its Kinetic Energy.

Thus when the body falls freely under gravity and when there is no opposing force there is a continuous decreases in its P.E and this decrease is equal to increase in K.E. When it reaches the surface of earth its P.E is zero and the whole of the energy Kinetic.

When the body strikes the ground its P.E is converted to K.E. If is the mass of the body and is the velocity then its K.E will be.

Where is the velocity with which the body reaches point

Using the second equation of motion.

where,

is the initial velocity at

is the final velocity at

Hence,

then

Therefore,

or in other words

**EXAMPLES OF INTERCONVERSION OF ENERGY: -**

There are many examples which indicate the transformation of energy from one form to another.

If we pass electric current through a thin wire in a bulb then it starts glowing producing heat and light. In this case electrical energy is changed into heat and light energy.

In a bus or car engine burning of fuel gives out chemical energy which makes the bus to move. Here chemical energy is changed into heat, sound and Kinetic Energy.

**OTHER FORMS OF ENERGIES: -**

There are many forms of energy.

1. Mechanical Energy
2. Chemical Energy
3. Electrical Energy
4. Heat Energy
5. Light Energy
6. Nuclear Energy
7. Solar Energy

**CHAPTER # 9**

**MACHINES**

**MACHINE: -**

A machine is a device that is used for doing work in a more convenient manner.

**OR**

A machine can also be defined as a device by means of which a force applied at one point can be used to overcome a resistance at some other point.

**PURPOSES OF MACHINE: -**

Machines are used for various purposes. They are as follows.

1. Transfer of force.
2. Enlargement of the effect of force.
3. Change in the speed of work.
4. Change in the direction of force.
5. **TRANSFER OF FORCE: -**

A machine can transfer force from one place to another.

For E.g.

1. While during a nail into a wall, the force of the hand is transferred to the nail with the help of hammer.
2. While during a cycle, we transfer the force of our feet to its wheel.
3. **ENLARGEMENT OF THE EFFECT OF FORCE:**

A machine can lift heavier loads by applying comparatively smaller force.

For E.g. Heavy vehicles can be lifted with the help of screw jack. The screw jack enlarges the magnitude of force of our hand.

1. **CHANGE IN THE SPEED OF WORK: -**

Machines are used to increase the speed of work. For E.g. we can travel larger distance in the same interval of time by using a bicycle then by foot.

Machines are also used to reduce the speed of work For Eg. Use of gears in a car.

1. **CHANGE IN THE DIRECTION OF FORCE: -**

Machines are used to change the direction of force.

For E.g. While lifting a bucket of water from a well we use a pulley and apply the force in the downward direction while the bucket moves in the upward direction.

**COMMON TERMS**

**EFFORT: -**

The force applied to a machine for doing work is called efforts. It is denoted by

**LOAD OR WEIGHT OR RESISTANCE: -**

The weight lifted or resistance overcome by the machine is called load. It is denoted by .

**INPUT: -**

The work done on a machine by the effort is called Input of the machine.

**OUTPUT: -**

The work done by the machine on the weight (load) is called as Output of the machine.

**EFFICIENCY: -**

The ratio between the useful work done by the machine (Output) to the work done on the machine (Input) is called Efficiency.

Efficiency is usually expressed in Percentage.

The efficiency of a real machine is always less than 1 but for an ideal machine it is equal to 1.

For an Ideal machine

i.e.

A machine whose Output is equal to Input is said to be an Ideal machine.

**MECHANICAL ADVANTAGE: -**

The ratio between the load lifted and the effort applied is called the mechanical advantage of a machine. It is denoted by .

It has no unit because it is the ratio between the similar quantities.

**LEVER**

**DEFINITION: -**

The rigid bar which can rotate about a fixed point is called a lever. The point about which it rotates is called Fulcrum. By applying the force at one end of the bar weight can be lifted on the other end.

A lever has two arms.

1. Force arm or Effort arm or Power arm
2. Weight arm or Load arm

**EFFORT ARM: -**

The distance between the force (effort) and the fulcrum is called force arm or effort arm.

**WEIGHT ARM: -**

The perpendicular distance between the weight (Load) and fulcrum is called weight arm or load arm.

**KINDS OF LEVER**

There are three different kinds of lever.

1. **LEVER OF THE FIRST KIND: -**

In the level of the first kind the fulcrum lies between the load and effort . Following fig. illustrates are idea.

**EXAMPLES: -**

1. See-Saw
2. Common balance
3. Pair of scissors
4. Crow bar
5. **LEVER OF THE SECOND KIND: -**

In the lever of the second kind, the weight is in between the fulcrum and effort .

**EXAMPLES: -**

1. Nut cracker
2. Punching machine
3. Door
4. Wheel barrow
5. Bottle opener.
6. **LEVER OF THE THRID KIND: -**

In the lever of the third kind, the efforts is situated between the fulcrum and weight .

**EXAMPLES: -**

1. Forceps
2. Human arm
3. Fire tongs

**PRINCIPLE OF LEVER: -**

In the above figure the effort tends to rotate the lever about the fulcrum in one direction and the weight tends to rotate it in the opposite direction.

Since the lever operates on the principle of moments. i.e. If the two torques are equal than the lever is said to be in equilibrium.

Therefore,

Therefore the Mechanical Advantage of lever is

**CONCLUSION: -**

From the above expression we conclude that the of Lever can be increased by increasing the length of the effort arm and by decreasing the length of the weight arm.

**INCLINED PLANE**

A rigid plane which is inclined to the horizontal at a certain angle is called an inclined plane.

**OR**

The surface which makes an angle with the horizontal is called an inclined plane.

**MECHANICAL ADVANTAGE: -**

The following figure shows a load being pulled along an inclined plane , inclined at an angle to the horizontal.

The weight of the load acts vertically downwards and the length of the surface of the inclined plane is . In order to raise this load to a vertical height , the effort has to move distance along the path .

For an ideal machine

But

Consider the

Thus,

**CONCLUSION: -**

From the above equation it is clear that smaller the value of angle , smaller will be and greater will be the mechanical advantage of an inclined plane.

**PULLEY**

A pulley is a wheel with a grooved rim. The wheel is supported in a frame which is called block. The wheel can rotate freely about an axle in the block. It can be suspended from a fixed beam by means of a hook. Following fig. illustrates the idea.

**FIXED PULLEY: -**

A fixed pulley is one with a fixed support which does not move with either the effort or the load such a pulley is used to raise the load.

**MECHANICAL ADVANTAGE: -**

A load is tied at one end of the rope passing over a pulley and the effort is applied at the other end.

If the weight of the rope and the frictional force are negligible, then the effort applied to the load will be equal to the load lifted .

Thus,

Mechanical Advantage of fixed pulley is 1

**MOVABLE PULLEY: -**

In a movable pulley, the block of the pulley is not fixed to a strong beam and therefore the pulley can move.

In movable pulley one end of the rope passing round the pulley is tied to a rigid support and effort is applied at other end as shown below.

The weight which is to be lifted is hung from the hook of the block. The tension produced in the rope is equal to the effort.

As both ends of the rope are pulling the weight upwards so the net effort acting on the weight is . If the weight of the rope and frictional force are neglected the in equilibrium position.

Thus the mechanical advantage of a movable pulley is 2.

**CONCLUSION: -**

This means double load can be lifted with the help of a single movable pulley as compared to effort.

**SCREW JACK**

A screw jack is a simple machine which is used to lift heavy loads by applying a small force. It is usually used to lift a car or heavy automobile when it is required.

**CONSTRUCTION: -**

It consists of a long screw rod passing through a threaded block and handle which is called Tommy bar to turn the threaded Block . Due to this it rises up and the heavy load is lifted. The distance between two consecutive threads of the screw is called pitch of the screw.

**MECHANICAL ADVANTAGE: -**

When the effort is applied to the Handle , the effort moves in a circle of radius (where is the length of Tommy Bar). Due to this rotation the block moves up.

When the handle is turned through one complete revolution, the effort moves through a distance and the load is raised to a height .

For Ideal Condition:

But,

Therefore,

**CONCLUSION: -**

The above expression shows that M.A of Screw Jack is directly proportional to the length of the Tommy bar (handle) and inversely proportional to the pitch of the screw.

The M.A of the screw jack is very large as the pitch of the screw is very small as compared to the length of the handle.

**WHEEL AND AXLE**

It is a very simple machine used to lift heavy loads for example pulling a bucket of water from a deep well.

**CONSTRUCTION: -**

It consists of two cylinders one of large radius and other of smaller radius wounted on the same shaft having a common axis of rotation. The cylinder with larger radius is called wheel while the cylinder with smaller radius is called axle. Following fig. illustrates the idea.

**MECHANICAL ADVANTAGE: -**

When the effort is applied at the end of the rope wound round the wheel and the load is tied to a rope wound round the axle in the opposite direction.

When the effort turns the wheel through one complete revolution, the axle also turns one revolution. The effort moves through a distance of and the load moves through a distance of . If the frictional force is neglected, then

For an Ideal Machine

Mechanical Advantage of Wheel and axle

**CONCLUSION: -**

The above expression shows that the M.A of wheel and axle is directly proportional to the Radius of the wheel and inversely proportional to the radius of the axle.

**CHAPTER # 10**

**PROPERTIES OF MATTER**

**MATTER: -**

Anything that exists physically is matter. Anything which has mass and occupy space is called matter e.g. air, water etc.

**STATE OF AMTTER: -**

There are three states or phases of matter.

1. Solid State
2. Liquid State
3. Gaseous State

**PROPERTIES OF SOLIDS: -**

1. **INTERMOLECULAR FORCE: -**

The force of attraction between the molecules of a solid is very strong.

1. **SHAPE AND VOLUME: -**

They have a definite shape and fixed volume.

1. **DENSITY ‘’: -**

Solids have a large density.

1. **MOLECULAR POSITION: -**

In solids the molecules or atoms are very close to each other. The distance between the molecules is very less as compared to solids and gases.

1. **MOVEMENT OF MOLECULES: -**

The molecules of a solid vibrate at their mean position and do not leave their place.

**PROPERTIES OF LIQUIDS: -**

1. **INTERMOLECULAR FORCE: -**

The force of attraction between the molecules of a liquid is lesser as compared to solids but greater as compared to gases..

1. **SHAPE AND VOLUME: -**

The liquids have a definite volume but no shape. They take the shape of the container in which they arc contained.

1. **DENSITY ‘’: -**

Density of liquids is less than solids but higher than gases.

1. **MOLECULAR POSITION: -**

The distance between the molecules of a liquid is greater as compared to solids but lesser as compared to gases.

1. **MOVEMENT OF MOLECULES: -**

The molecules of a liquid move from one place to another insider the liquid, but they do not cross the surface of the liquid.

**PROPERTIES OF GASES: -**

1. **INTERMOLECULAR FORCE: -**

The force between the molecules of gases is lesser as compared to solids and liquids.

1. **SHAPE AND VOLUME: -**

Gases have no definite shape and volume.

1. **DENSITY ‘’: -**

They have a low density.

1. **MOLECULAR POSITION: -**

The distance between the molecules of gases is greater as compared to solids and liquids.

1. **MOVEMENT OF MOLECULES: -**

The movement of the molecules is very haphazard and move in every direction.

**FOURTH STATE OF MATTER: -**

**PLASMA:**

Matter is also found in the fourth state called Plasma. This is an ionized state of matter concerned largely with ionized gases. “Plasma is any state of matter which contains enough force charged particles for its dynamical behavior to be governed by electromagnetic waves.”

**ELASTICITY**

The property of the body due to which it regains its original state (original shape) after the removal of the external force (deforming force) is called ELASTICITY.

**FOR EXAMPLE: -**

1. If a force is applied to a rubber band stretches and returns back to its original shape after the removal of the deforming force. Thus rubber band is an elastic body.
2. A wooden metre scale bands when a force is applied to it. After the removal of the force it straightens out. Thus a meter scale is an elastic body.

**DEFORMATION: -**

Any change in dimension (shape or size) a substance is called deformation.

**ELASTIC BODIES: -**

Those bodies which regain their original state after the removal of the deforming force are called elastic bodies.

**ELASTIC LIMIT: -**

The certain limit of the applied force up to which the elastic body will come back to its original shape when the force is removed. This limit is called Elastic Limit.

Elastic Limit differs from material to material. Beyond the elastic limit, the object will not come back to its original state after the removal of the force.

**STRESS**

**DEFINITION: -**

The internal force arising from the deformation of the body and acting per unit area of the body is called stress. It is denoted by

**OR**

Stress is the opposing force per unit area resisting any change in shape, length or volume due to application of an external force. It is denoted by

**EXPRESSION: -**

**UNIT: -**

The unit of stress in M.K.S system is or .

**STRAIN**

**DEFINITION: -**

The relative deformation produced in the body is called strain.

**OR**

The fractional deformation which is produced by stress is known as strain.

**OR**

The ratio of the change in length, volume or shape to the original length, volume or shape is called strain.

It is denoted by a Greek letter Epsilon

**MATHEMATICALLY**

i.e.

(in case of linear strain)

**UNIT: -**

It has no unit because it is the ratio between two similar quantities.

**KINDS OF STRAIN**

There are three kinds of strain

1. **LONGITUDINAL OR LINEAR STRAIN: -**

The strain due to change in length is called Longitudinal or Linear Strain.

1. **VOLUMETRIC STRAIN: -**

The strain due to change in volume is called Volumetric Strain.

1. **SHEARING STRAIN: -**

The strain due to change in shape is Shearing Strain.

**HOOKE’S LAW**

**STATEMENT: -**

For a elastic body the ratio of stress to strain is a constant.

**OR**

Within elastic limit, stress is directly proportional to strain.

**MATHEMATICAL EXPRESSION: -**

Where is the constant of proportionality.

**YOUNG’S MODULUS**

**DEFINITION: -**

For a elastic body, the ratio of the stress to the linear strain is constant and is called the modulus of elasticity or YOUNG’S MODULUS. It is denoted by .

**MATHEMATICAL EXPRESSION: -**

i.e.

Stress is the opposing force per unit area. If is the force and is the area then,

Strain is the relative deformation.

**UNIT: -**

The S.I unit of Young’s Modulus of Elasticity is which is same as the unit of stress.

**LIMIT OF HOOKE’S LAW**

Hooke’s law is obeyed up to a certain limit called the elastic limit the elastic limit body is permanently deformed.

**COMPARISON OF ELASTICITIES OF TWO SUBSTANCES: -**

Consider two elastic substances in the form of wires. They are identical i.e. having same length and area of cross-section.

Suppor are the strains produced in the two wires , respectively on applying the same stress to both of them. Let be the moduli of elasticity’s of the two bodies respectively.

Since the Young’s Modulus states.

Therefore,

and

Where,

Divided (i) and (ii)

If

then,

**CONCLUSION: -**

From the above expression we conclude that a body with smaller strain is more elastic than the body having a larger strain when the applied stress is same. Thus steel is more elastic than rubber.

In other words a body which is easily deformed is less elastic than the body which undergoes deformation with difficulty when the applied stress is same.

**APPLICATION OF HOOKE’S LAW**

**HOOKE’S LAW APPLIED TO A HELICAL SPRING:**

Suppose a helical spring is suspended vertically from a fixed support. A block is attached at its lower end as shown

In the above figure the force of gravity displaces the block in the downward direction. As a result the spring is stretched. After some time the block comes to rest and attains equilibrium.

There are two forces acting on the block.

1. The force of gravity acting downward.
2. The tension in the spring acting upward.

In equilibrium these two forces are equal and opposite.

According to Hooke’s Law

“Stress is directly proportional to strain.”

Here the stress is Tension denoted by and strain produced is extension denoted by .

So, Hooke’s Law can be stated as,

“Tension is proportional to extension.”

i.e.

Where is the constant of proportionality and is known as spring constant. Its unit is .

The negative sign shows that Tension and Extension are opposite to each other.

**PRESSURE**

**DEFINITION: -**

The perpendicular force per unit area acting on a surface is called pressure.

**OR**

Force per unit area acting normal to the surface is called pressure.

**MATHEMATICAL EXPRESSION: -**

i.e.

**UNIT: -**

The S.I unit of pressure is Pascal

**PASCAL: -**

One Pascal is defined as,

“It is the pressure when a force of acts normally on an area of ”

**ATMOSPHERIC PRESSURE: -**

The earth is surrounding by a thick layer of air called atmosphere. The pressure exerted by the weight of the atmosphere on the surface of the earth is called atmospheric pressure.

At sea level its value is . This standard pressure is called one atmosphere or one bar.

**DEMONSTRATION OF ATMOSPHERIC PRESSURE: -**

1. **COLLAPSING CAN EXPERIMENT: -**

The effect of the atmospheric pressure can be demonstrated by evacuating a tin using a vacuum pump. Before the air is pumped out, the pressure inside the tin is equal to the atmospheric pressure. When the air is partially removed, the pressure inside the tin is less than the atmospheric pressure and hence the tin collapses.

**MEGDEBURG-HEMISPHERE EXPERIMENT**

**INTRODUCTION: -**

Von Guericke demonstrated the existence of atmospheric pressure. His experiment is known as Magdeburg hemisphere experiment.

**EXPERIMENT: -**

Magdeburg took two hollow metallic hemispheres which were placed in contact. The air inside the hemispheres was pumped out by using a vacuum pump.

After the partial removal of the air from inside the hemispheres it was very difficult to separate them by pulling them apart because the pressure exerted by the atmosphere on the outer walls of the hemisphere was much greater than the pressure exerted by the air left inside the hemisphere.

**BAROMETER: -**

A device used for measuring the atmospheric pressure is called a barometer.

**PRESSURE OF LIQUIDS AND GASES**

**DERIVATION: -**

Consider a vessel / tank which is filled with liquid. Now in this tank imagine a cylinder whose area of cross-section is .

Let be the height of the cylinder and be the density of the liquid. The volume of the imaginary cylinder is calculated as,

But

So the mass of the liquid in the imaginary cylinder is

The weight of the liquid in the imaginary cylinder is given as,

The weight of the liquid is equal to the force acting normally on Area

**FACTORS ON WHICH PRESSURE DEPENDS**

1. It is directly proportional to depth .
2. It is directly proportional to the density of the liquid .
3. It is directly proportional to the acceleration due to gravity.

**VARIATION OF PRESSURE WITH DEPTH: -**

Following figure illustrates an idea regarding the direction in pressure with depth. The pressure of water at spouts and are shown. They are fitted at depths respectively.

Here,

**Variation of Pressure with Depth**

**PASCAL’S LAW**

**STATEMENT: -**

When a pressure is applied to a liquid, it is equally transmitted in all directions by the liquid.

**EXPLANATION: -**

As the force is applied to piston , it moves in ward and the other pistons move out ward through the same distance showing that the pressure has been transmitted equally in all directions inside the liquid. Following fig. illustrates the idea.

**APPLICATIONS OF PASCAL LAW**

1. **HYDRAULIC LIFT**

It is used to lift heavy loads for example cars, buses etc.

**CONSTRUCTION: -**

The hydraulic lift consists of two cylinders and of different areas and respectively with air tight pistons. Both the cylinders are filled with a liquid.

**WORKING: -**

A small force is applied at a piston of area . The piston moves in the downward direction.

According to Pascal law the pressure exerted on the piston of area is transmitted equally to the larger piston through the liquid.

As the area of the piston i.e. is much larger than that of . Therefore the force on the piston is much greater than that of the force on piston . Thus,

Due to this reason the larger piston moves upward and the can placed on it is lifted.

1. **HYDRAULIC BREAKES**

These brakes are used in automobiles.

**CONSTRUCTION: -**

The hydraulic brake system consists of the following parts.

1. Master cylinder joined by four tubes.
2. Four small cylinders called brake cylinders.
3. The master cylinder and brake cylinders containing oil are provided with pistons,

**WORKING: -**

On applying force to the brake pedal, the piston in the master cylinder moves inside and exerts a pressure on the oil. This pressure is transmitted to the oil in the brake cylinder through the tubes. This force acts on the brake shoe attached to a caliper.

On releasing the pressure on the pedal, the spring connecting the two brake shoes contracts and pulls them off from the rotor. Thus the wheel is force to rotate again.

1. **HYDRAULIC PRESS**

The hydraulic press is used for compressing soft materials. For example cotton into compact bales.

**CONSTRUCTION: -**

Hydraulic Press is very much similar to hydraulic lift. The piston of larger cross sectional area is provided with a rigid roof over it to lift an object. Both the cylinders are filled with a liquid.

**WORKING: -**

A small force is applied at piston . It moves downward. According to Pascal Law, this pressure is equally transmitted to the larger piston through the liquid.

As the area of the piston is larger than that of so it moves up with a greater force and compresses any material placed between the rigid roof and the piston.

**ARCHIMEDES PRINCIPLE**

**STATEMENT: -**

When a body is completely or partially immersed in a liquid, a force of thrust acts upon it which is equal to the weight of the displaced liquid.

**THRUST: -**

A body immersed in a liquid experiences a force in the upward direction due to which the weight of the body decreases. This upward force on the immersed body is known as **THRUST**.

**EXAMPLE: -**

Place the closed end of a test tube vertically on the surface of water and push it downwards one would feel some force acting upward on the test tube. This upward force on the test tube is called **up thrust**.

**ANACYTICAL TREATMENT OF ARCHIMEDES PRINCIPLE**

Consider a cylinder of length and area of cross-section immersed in a vessel filled with a liquid of density

Let,

Since the force acting on the liquid is given a

The Force on the top surface acts vertically downwards while the Force on the bottom surface acts vertically upwards.

Here is the atmospheric pressure.

The up thrust (net force acting on the cylinder in the upward direction) is equal to the difference in forces at top and bottom surface because the forces acting on the sides cancel each other.

Thus, is the uprush of a liquid on an object immersed in a liquid.

∴ The above equation becomes,

**CONCLUSION: -**

Thus we conclude that the up thrust of a liquid on an object immersed in it is equal to the weight of the liquid displaced by the object.

When an object is immersed in a liquid, it experiences an up thrust and has an apparent weight given as

This means an object loses some weight in a liquid.

**BUOYANCY AND LAW OF FLOATATION**

Buoyancy is the property of a liquid by virtue of which it exerts an upward force (up thrust) on a body which is wholly or partially immersed in the liquid. This upward force is called buoyant force.

When an object is immersed in a liquid, it is acted upon by two forces (weight of the body and the buoyant force acting vertically upward). The weight of the object is fixed but the buoyant force is not fixed. Its value is maximum when the object is completely immersed in the liquid.

**CONDITIONS OF FLOATING BODIES: -**

1. (a) If the maximum value of the Buoyant force is equal to the weight of the body.

i.e.

The body will float in the liquid in such a way that upper surface of the object will coincide with the surface of the liquid.

(b) If the object is partially immersed so that the existing buoyant force is one half of the maximum value.

i.e.

The object will float with half of its volume under the liquid.

This shows that if the existing buoyant force is small (as compared to mar. buoyant force) then, the portion of the object in the liquid will also be small.

1. If the existing buoyant force is grater than the weight of the object.

The object will float on the surface of liquid with no portion inside the liquid.

1. If the buoyant force is less than the weight of the object then the object will sink.

Following figure illustrates the idea.

**KINETIC MOLECULAR THEORY**

According to this theory,

1. Matter is composed of atoms and molecules.
2. The molecules are in a continuous state of motion either translational, rotational or vibrational and hence possessing translational, rotational or vibrational energies.
3. The molecules attract each other with a force which depends on the distance between them.
4. The Kinetic energy of the molecules is directly proportional to absolute temperature.

**FLUID FRICTION / VISCOSITY**

The liquids have the ability to flow because the molecule of liquid can slide over one another. Different liquids have different rate of flow. Some liquids like honey, Mobil oil flow slowly and are called viscous liquid while ether, gasoline etc. flow quickly and are called less viscous.

**DEFINITION: -**

The internal resistance in the flow of liquid is called viscosity.

**OR**

The property by which a liquid tends to oppose the relative motion between its different layers is called viscosity. It is denoted by eta .

**EXPLANATION: -**

Suppose a liquid flows in a smooth horizontal glass tube. The liquid is divided into different layers parallel to the fixed surface. The layer of liquid in contact with the surface (walls) remain stationary. The velocity of the layers increases with the distance from the fixed surface and the layer with the highest velocity is shown.

**DERIVATION: -**

Consider a layer at a distance from the stationary surface. Let be the area of the layer moving with velocity

The backward dragging force is directly proportional to area and velocity and inversely proportional to distance b/w layers.

Where is called the coefficient of Viscosity and is defined as,

“Force required to maintain of velocity difference between two layers of area and distance apart.”

Negative sign shows that the dragging force is opposite to the flow of liquid.

**UNIT OF VISCOSITY: -**

The unit of viscosity is Poise.

**SURFACE TENSION**

**DEFINITION: -**

The amount of energy that is required to increase the surface of a liquid by a unit area is called surface Tension.

**OR**

The property of a liquid by virtue of which the free surface of a liquid behaves like a stretched membrane tending to decrease the surface area is called surface Tension.

**OR**

Magnitude of force acting perpendicular to a unit length of a line in the surface is called surface Tension.

**EXPRESSION: -**

If is the force acting on a length then the surface Tension is given as,

**UNIT: -**

The S.I unit of surface Tension is

**EXPLANATION: -**

The forces acting on a molecule inside the body of the liquid are balanced in all directions by the neighboring molecules and hence the net force is zero.

Whereas the molecules at the surface of the liquid is not subjected to any upward force and hence they experience a more downward pull. This downward force is responsible for surface Tension. Due to this the free surface of the liquid behave like a stretched membrane.

**EXAMPLES OF SURFACE TENSION: -**

1. A steel needle dropped in water will sink because the density of steel is greater than that of water. If it is mode slightly oily and then placed on the surface of water it will float leaving a depression of water under it. The needle is not actually floating. It is the surface Tension of water which supports it and stops from sinking.
2. The water droplet falling from a top has a spherical shape due to surface tension. The surface tension minimizes the surface of the drop.