CHAPTER – 1

MEASUREMENTS AND FORCE

1. Define the unit of a physical quantity.

   The standard used for the measurement of a physical quantity is called its unit.

2. Differentiate between fundamental quantity and derived quantity.

   Physical quantities which are independent of other quantities are called fundamental quantities. Quantities derived from fundamental quantities are called derived quantities.

3. What are the seven fundamental quantities and their units in SI system.

FUNDAMENTAL QUANTITY	UNIT
Length	meter
Mass	kilogram
Time	second
Electric current	ampere
Temperature	kelvin
Amount of substance	mole
Luminous intensity	candela

4. Explain different types of errors in measurements.

   The difference between true value and the measured value of quantity is known as errors of measurement. Errors in measurement can be classified into two categories. They are systematic errors and random errors.

1. Systematic Errors

Systematic errors in measurements can be due to instrumental errors, incorrect experimental technique and personal errors.

1. Instrumental errors: These errors arise from the imperfect design or calibration of instruments, zero error of instruments etc.

2. Error due to incorrect experimental technique: These kinds of errors occur due to inaccurate experimental procedure as well as external factors.

3. Personal errors: Such errors arise due to personal bias, lack of proper setting of the apparatus or individual's carelessness in taking observations.

This type of errors can be minimized by using better instruments, improving experimental techniques and avoiding personal bias.

2. Random Errors

Random errors come from unpredictable changes in experimental conditions. The magnitude and direction of these errors varies randomly with each measurement. The random errors can be reduced by taking a greater number of measurements. These errors can be removed by averaging.

5. Distinguish between absolute error, relative error and percentage error.

Absolute error

Absolute error of a measurement is the difference between the individual measurement and arithmetic mean of that quantity.

Relative error

The ratio of mean absolute error to the mean value of the physical quantity measured is called the relative error.

$$\text{Relative error} = \frac{\Delta a_{mean}}{a_{mean}}$$

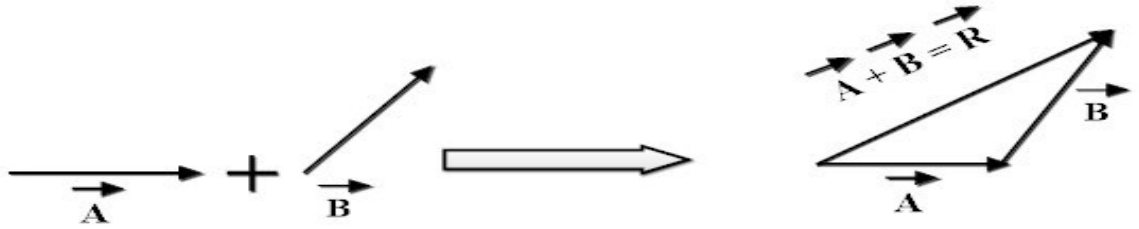
Percentage error

The relative error of a physical quantity expressed in percentage is called percentage error.

$$\text{Percentage error} = \frac{\Delta a_{mean}}{a_{mean}} \times 100\ \%$$

6. State and explain triangular law of vector addition.

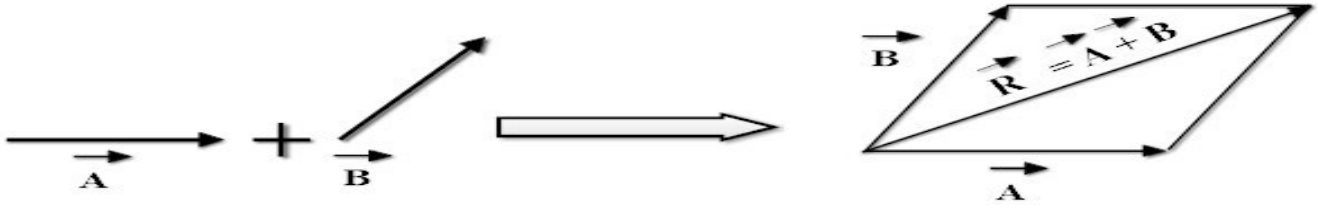
The triangular law of vector addition states that if two vectors are represented by the adjacent sides of a triangle taken in order, then the resultant vector is represented both in magnitude and direction by the third side of the triangle taken in the reverse order.



Let $\vec{A}$ and $\vec{B}$ are two non-parallel vectors. To find the vector sum using the triangle method, place the vectors such that the tail of one vector coincides with the head of the other vector. Complete the triangle by drawing the third side. The third side gives resultant vector $\vec{B}$.

7. State and explain Parallelogram law of vector addition.

The parallelogram law of vector addition states that if two vectors are represented both in magnitude and direction by the two sides of a parallelogram drawn from a point, then the resultant vector is represented both in magnitude and direction by the diagonal of the parallelogram passing through the point.



8. Explain the term resolution of a vector.

The process of splitting a given vector into two or more vectors along different directions is called resolution of a vector. The vectors obtained by the resolution of the given vector are called component vectors.

9. State Newton's first law of motion and explain inertia.

Newton's first law of motion states that everybody continues in its state of rest or of uniform motion along a straight line unless compelled by some external force to change that state.

Inertia is the resistance of a body to any change in its state of rest or uniform motion along a straight line.

A person standing in a stationary bus fall backward when the bus suddenly starts. This is because the lower part of his body moves forward with the bus but the upper part of his body remains in rest due to inertia of rest, which results in the backward fall.

A person trying to get down from a moving bus, falls forward. The lower part suddenly comes to rest on touching the ground, but he upper part of his body remains in motion due to inertia of motion and the person falls forward.

10. Define force from first law of motion.

Force can be defined as any agency which can change the state of rest or of uniform motion of a body.

11. State and explain Newton's second law of motion.

Newton's second law of motion states that the rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of the force.

Consider a body of mass '*m*' moving with a velocity '*u*'. If under the action of a force '*F'*, the velocity changes to '*v*', its momentum also changes from mu to mv. According to Newton's second law of motion,

$$\text{force} \propto \frac{\text{change in momentum}}{\text{time}}$$

$$\text{force} \propto \frac{\text{final momentum} - \text{initial momentum}}{\text{time}}$$

$$F \propto \frac{\text{mv} - \text{mu}}{\text{t}}$$

$$F \propto \frac{\text{m(v} - \text{u)}}{\text{t}}$$

since $a = \frac{(\text{v}-\text{u})}{\text{t}}$ is the acceleration of the body,

$$F \propto ma$$

$$F = k\,ma$$

where k is the constant of proportionality. Thus, force is proportional to the product of mass and acceleration. By suitably defining the SI unit of force, we can take k =1. Thus,

$$F = ma$$

12. With the help of an example explain Newton's third law of motion.

Newton's third law of motion states that to every action, there is always an equal and opposite reaction When a man jumps off a boat to the shore, he exerts a force on the boat. The boat exerts an equal and opposite force on the man which makes the jump possible. The boat moves backward due to the force exerted by the man.

.

13. Explain the recoil of gun. Derive an expression for the recoil velocity of gun.

The total momentum of the gun and bullet before firing is zero. After firing the bullet moves with a velocity producing a momentum in the forward direction. To balance the momentum change, the gun moves backward with a velocity, such that the total momentum is zero.

Let M_g and m_b are masses of the gun and bullet respectively. Suppose, a bullet is fired from the gun with a velocity v_b and the gun recoils with a velocity V_g.

$Total\ momenta\ before\ firing = 0$

$Total\ momenta\ after\ firing = M_g V_g + m_b v_b$

By law of conservation of momentum, the total momenta after firing must be equal to total momenta before firing.

$$M_g V_g + m_b v_b = 0$$

$$M_g V_g = - m_b v_b$$

$$V_g = - \frac{m_b v_b}{M_g}$$

14. Explain the propulsion of a rocket using the law of conservation of momentum.

The initial total momentum of the rocket on its launching pad is zero. After the rocket is launched, the fuel is continuously burned and hot gases are ejected out in the downward direction with high velocity. This creates a momentum change in the downward direction. To balance it, the remaining mass of the rocket moves in the upward direction.

15. What is impulse. Show that change impulse is equal to change in momentum.

A large force acting for a short interval of time is called an impulsive force. Impulse (I) is defined as the product of force and time for which the force acts.

$impulse = force \times time$

$I = F \times t$

From Newton's second law of motion, we have

$$F = ma = m\frac{(v-u)}{t}$$

$$\therefore \quad I = m\frac{(v-u)}{t} \times t$$

$I = m\,(v-u)$

$I = mv - mu$

$impluse = change\ in\ momentum$