UNIT 3

LAWS OF MOTION

Glimpse

1. **Force:** It may be defined as an agency (a push or pull) which changes or tends to change the state of rest or of uniform motion or the direction of a body. Force is a vector quantity.
2. **Inertia:** It is the inherent property of a material body by virtue of which it cannot change by itself, its state of rest or of uniform motion in a straight line. Inertia is of three types (i) inertia of rest (ii) inertia of motion (iii) inertia of direction.
3. Mass as the measure of inertia: If the body has more inertia i.e., it is more difficult to change its state of rest or of uniform motion.
4. **Momentum:** It is the quantity of motion in a body. It is equal the product of mass m and velocity v of the body.
5. **Newton's first law of motion:** It states that everybody continues in the state of rest or of uniform motion along a straight line, unless an external force is applied to change that state. This law defines forces.
6. **Newton's second law of motion:** It states that the rate of change of momentum of a body is directly proportional to the applied force and the change in momentum takes place in the direction of the applied force. This law gives a measure of the force.
7. **Newton's third law of motion:** It states that to every action, there is an equal and opposite reaction.
8. **Absolute units of force:** The SI unit of force is Newton (N) and CGS unit is dyne (dyn). $1N = 10^5$ dyne
9. **Gravitational unit of force:** The SI unit of force is kilogram weight (kg wt) or kilogram force (kg f) and the CGS unit is gram weight (g wt) or gram force (g f).

   1 kg wt = 9.8 N,

   1 g wt = 980 dyne
10. **Impulse of a force:** Impulse is the total effect of a large force which acts for a short time to produce a finite change in momentum. It is defined as the product of the force and the time for which it acts and equal to the total change in momentum. SI unit of impulse is N-s

    Impulse = Force X time duration

    = Total change in momentum.

11. **Law of conservation of linear momentum:** In the absence of any external force, vector sum of the linear moment of a system of particles remains constant.
12. **Rocket propulsion:** It is an example of momentum conservation in which the large backward momentum of the ejected gases imparts an equal forward momentum to the

rocket. Due to the decrease in mass of the rocket-fuel system, the acceleration of the rocket keeps on increasing.

13. **Concurrent forces:** The forces acting at the same point of a body are called concurrent forces.
14. **Equilibrium of concurrent forces:** A number of concurrent forces acting on a body are said to be in equilibrium if their vector sum is zero or if these forces can be completely represented by the sides of a closed polygon taken in the same order.
15. **Friction:** Whenever a body moves or tends to move over the surface of another body, a force comes into play which acts parallel to the surface of contact and opposes the relative motion. This opposing force is called friction.
16. **Static friction:** The force of friction which comes into play between two bodies before one body actually starts moving over the other is called static friction (f_S). Static friction is a self-adjusting force.
17. **Limiting friction:** The maximum force of static friction which comes into pay when a body just starts moving over the surface of another body is called limiting friction.
18. **Kinetic friction:** The force of friction which comes into play when a body is in steady motion over the surface of another body is called kinetic or dynamic friction (f_k) kinetic friction is less than limiting friction.
19. **Laws of limiting factor:**

    (i) The force of limiting friction depends upon the nature of the two surfaces in contact and their state of roughness.

    (ii) The force of limiting friction acts tangential to the two surfaces in a contact and in a direction opposite to that of the applied force.

    (iii) The force of limiting friction between any two surfaces is independent of the shape or area of the surfaces in contact so long as the normal reaction remains the same.

    (iv) The force of limiting friction between two given surfaces is directly proportional to the normal reaction between the two surfaces. Where the constant of proportionality is called the coefficient of limiting friction.
20. **Co- efficient of static friction.** It is defined as the ratio of liming force of friction to the normal reaction between the two surfaces in contact.
21. **Co- efficient of kinetic friction.** It is defined as the ratio of kinetic force of friction to the normal reaction between the two surfaces in contact.
22. **Methods of reducing friction**

(a) By polishing the surfaces

(b) Lubricating the surfaces

(c) By proving the streamlined or conical shape to the fast moving objects

(d) By converting sliding friction into rolling friction.

23. **Angle of friction:** It is the angle which the resultant of the limiting friction and the normal reaction makes with the normal reaction.
24. **Angle of repose:** It is the minimum angle that an inclined plane makes with the horizontal when a body placed on it just begin to slide down.
25. Rolling friction is less than sliding friction.
26. Wider tyres of a vehicle spread the weight of the vehicle over a large surface area and hence decrease the wear and tear of the tyres.
27. **Centripetal force:** It is the force required to make a body move along a circular path with a uniform speed. It always acts along the radius and towards the centre of the circular path. The centripetal force required to move a body of mass m along a circular r with speed v is given by mv^2/r.
28. **Centrifugal force.** It is a fictitious force acting radially outwards on a particle moving in a circle and is equal in magnitude to the centripetal force.