Class XI: Physics
Chapter 4: Laws of Motion

Chapter Notes

Key Learning:

1. Galileo extrapolated simple observations on motion of bodies on inclined planes, and arrived at the law of inertia. Newton's first law of motion is the same law as the law of inertia. According to it an object acted upon by no net force, will remain at rest or continue to move with a constant velocity and zero acceleration.

2. The tendency of an object to remain at rest or continue to move at a constant velocity is called inertia.

3. The frame of reference in which Newton first law is valid is called inertial frame of reference.

4. The frame of reference in which Newton first law is not valid is known as Non inertial frame of reference. These are accelerating reference frames.

5. Momentum (p) of an object is a vector quantity and is defined as the product of its mass (*m)* and velocity (v), i.e., p = mv.

6. Newton second law: The rate of change of momentum of an object is equal to the net external force and takes place in the direction in which the net force acts.

7. The net external force on an object is equal to its mass times the acceleration, i.e., F = ma

8. Impulse is the product of average force and time and equals change in momentum.

9. Newton's third law of motion states whenever object1 exerts a force on object2, then object2 must exert a force on object1 which is equal in magnitude and opposite in direction or to every action force, there is always an equal and opposite reaction force

10. Action and reaction act on different bodies and so they cannot cancel each other.

11. Law of Conservation of Momentum: The total momentum of an isolated system of particles is conserved. The law follows from the second and third law of motion.

12. If an object is at equilibrium, net resultant force acting on it is zero.

13. Normal reaction is the contact force perpendicular to the surface in contact.

14. Tension force is the restoring force in the rigid inextensible string or rope when being pulled down.

15. Centripetal force is always directed along the radius towards the centre.

16. A free body diagram is a diagram showing the chosen body by itself, free of its surroundings.

17. Two points for which one should be careful about while drawing Free Body diagrams are:

i. Include all the forces acting on the body
ii. Do not include any force that the chosen body exerts on any other body.

18. Free body equations represent the two equations of motion framed along two perpendicular axes.

19. Maximum value of Static friction

$$f_{s,max} \propto R$$

$$f_{s,max} = \mu_s . R$$

Here $f_{s,max}$ is the limiting value of the static friction, R is the normal reaction and μ_s is the coefficient of static friction.

20. Static friction increases with the applied force till it reaches a maximum value of $F_{s,max}$.

21. Kinetic friction

$$f_k \propto R$$

$$f_k = \mu_k . R$$

Here f_k is the limiting value of the static friction, R is the normal reaction and μ_k is the coefficient of kinetic friction.

22. The force required to start a motion is more than the force required to maintain a constant motion in a body.

23. Horizontal component of contact force equals force of friction.

24. Limiting value of static friction is greater than kinetic friction.

25. Force required to initiate the motion in a body should be greater than then the force required to maintain the motion with uniform velocity.

26. The direction of frictional force is always directed in the direction opposite to the relative motion between the two surfaces.

Top Formulae:

1. Momentum (p) = mass (m) x velocity (v)

2. Net external force $F = \frac{dp}{dt} = ma$

3. Impulse = Force x time duration

   = Change in momentum

4. According to Newton's third law of motion

   Force on A by B = - Force on B by A

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

5. According to conservation of linear momentum

Total initial momentum of an isolated system= Total final momentum of an isolated system

$$\vec{P}'_A + \vec{P}'_B = \vec{P}_A + \vec{P}_B$$

6. Equilibrium under three concurrent forces requires

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$$

7. Maximum value of Static friction

$$f_{s,max} = \mu_s . R$$

8. Kinetic friction

$$f_k = \mu_k . R$$

9. In Circular Motion

$$f_c = \frac{mv^2}{R}$$

10. Maximum permissible speed limit for car to take a turn along a rough road:

$v=\sqrt{(\mu_s rg)}$ along the unbanked road

$$v_{max} = \left(Rg \frac{\mu_s + tan\theta}{1 - \mu_s tan\theta} \right)^{\frac{1}{2}}$$

along the banked road.