CONCEPT MAP

Laws of Motion

Newton's laws are a set of statements and definitions that we believe to be true because the results they predict are found to be in very exact agreement with experiment over a wide range of conditions.

Frictional force act along the surface between two bodies whenever one moves or tries to move over the other, and in a direction so as to oppose relative motion on the surfaces.

First Law

If the net external force on a body is zero, its acceleration is zero. Acceleration can be non-zero only if there is a net external force on the body.

Inertia
It is the property of a body to resist the change of its state of rest or uniform motion.

Types of inertia
- Inertia of rest
- Inertia of motion
- Inertia of direction

Second Law

The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts. *i.e.*,

$$\vec{F}_{ext} = \frac{d\vec{p}}{dt}$$

Weight
$\vec{W} = m\vec{g}$

Force
$\vec{F} = m\vec{a}$

Fundamental forces
- Gravitational force
- Electromagnetic force
- Nuclear force
- Weak force

Impulse
It is the change in momentum.
Impulse = Force × time duration
or $\vec{F}t = m\vec{v} - m\vec{u}$

Derived forces
- Tension force
- Normal force
- Spring force

Momentum
It is the product of mass and velocity.
$\vec{p} = m \times \vec{v}$

Conservation of linear momentum
If the net external force on a system of particles is zero, the vector sum of the linear momentum of all the particles remain conserved.

$$\vec{F}_{net} = \frac{d\vec{p}}{dt} = 0 \Rightarrow \vec{P} = \text{constant}$$

Third Law

To every action, there is always an equal and opposite reaction. *i.e.*,

$$\vec{F}_{12} = -\vec{F}_{21}$$

Centripetal force Rotational force acting on a body performing uniform circular motion *i.e.*,

$$F_C = \frac{mv^2}{r}$$

Bending θ of a cyclist from vertical is given by

$$\tan\theta = \frac{v^2}{rg}$$

Maximum permissible speed to avoid slipping on banked circular road is

$$V_{max} = \left[\frac{rg(\mu_s + \tan\theta)}{1 - \mu_s \tan\theta}\right]^{1/2}$$

Sliding friction
The force of friction which comes into play when one body slides or tends to slide on the surface of another body is known as sliding friction.

Rolling friction
The force of friction which comes into play when one body rolls or tends to roll on the surface of another body is known as rolling friction.

Types of sliding friction
- Static friction
- Limiting friction
- Kinetic friction

Experiment shows that when a body is at rest, the frictional force to be overcome before it moves, called limiting friction, is greater than that which acts once it is moving, called sliding, kinetic or dynamic friction.

Laws of friction
- The limiting frictional force f is directly proportional to the normal force R exerted by the surface on the body *i.e.*, $f \propto R$ or $f = \mu_s R$ where μ_s is coefficient of static friction.
- The dynamic frictional force f' is directly proportional to the normal force, R, *i.e.*, $f' \propto R$ or $f' = \mu_K R$ where μ_K is coefficient of kinetic friction and it is reasonably independent of the speed of motion.
- The frictional force does not depend on the area of contact of the surfaces if the normal reaction is constant.

Symbols Used

- F = force
- m = mass of the body
- a = acceleration of the body
- g = acceleration due to gravity
- u = initial velocity
- v = final velocity
- p = momentum
- t = time duration
- N = normal reaction