St. Lawrence High School

A Jesuit Christian Minority Institution

Study Material – 4

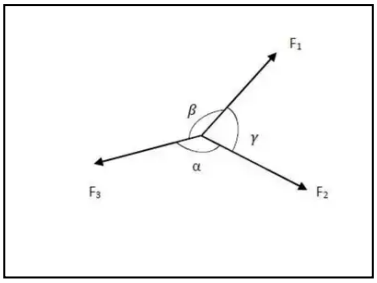
Term : 1st

Class – XI | Subject – Physics

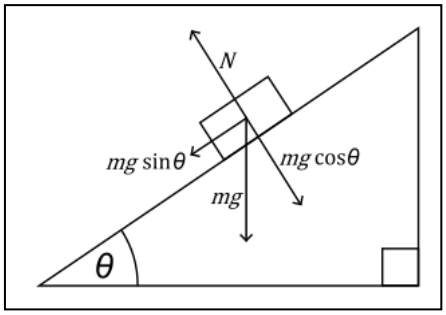
Chapter – Laws of motion, Friction and Circular motion | Date – 22.08.20

❖ Laws of motion:

- 1st Law – is the law of inertia that defines force.
- 2nd Law – is the law of momentum. It gives the mathematical and scientific measurement of force as $force = mass \times acceleration$
  Or , F = m . a
  Or, $F = m\frac{dv}{dt} = \frac{d(mv)}{dt} = \frac{dp}{dt}$ [where p = mv = momentum]
- 3rd Law – gives the idea and direction of reaction force.
- Conservation of linear momentum – states that, at the absence of net zero amount of external force on a system, the total linear momentum of the system will be conserved.
  i.e. $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ when $F_{ext} = 0$
  - Impulse of a force - is defined as the product of the force and its time of impact. For variable force, impulse $= \int F.dt$
    Therefore, the area of F-t graph will signify the impulse of the force.
  - Lami's theorem – If a point object is at rest under three concurrent forces of magnitudes $f_1, f_2 and\ f_3$ making $\alpha, \beta\ and\ \gamma$ angles with one another as shown in the figure, then $\frac{f_1}{\sin\alpha} = \frac{f_2}{\sin\beta} = \frac{f_3}{\sin\gamma}$



  - Free Body Diagram (FBD) – it is a problem solving technique that helps us to consider a part of a system as one independent system when all the different forces on that part are considered. Then ultimately we can apply 2nd law to define the motion of that system i.e. $F_{net} = m.a$
  - A body placed on a smooth inclined plane of angle of inclination θ, (as shown in the figure), the component of weight normal and parallel to inclined plane will be $mg\cos\theta\ and\ mg\sin\theta$ respectively. Then the acceleration down the inclined plane will be $g\sin\theta$.



❖ Friction :

- Nature of frictional force –
  1. It always opposes the applied force
  2. It does not depend on the area of contact and the relative velocity of the surfaces. It only depends on the normal reaction.
  3. It is self adjusting in nature up to a certain maximum value called the limiting force of friction.
  4. Limiting force of friction is a little higher than the kinetic force of friction.
- Angle of friction $\theta = \tan^{-1}(\mu)$
- Angle of repose $\varphi = \tan^{-1}(\mu)$

❖ Circular Motion:

- Circular motion can be of two types – uniform and non uniform.
- Uniform circular motion is a special kind of circular motion of a body where the linear speed of the body in the circular path remains constant, but it possesses acceleration due to the change in direction of the velocity vector. The angular velocity here is constant and the angular acceleration is zero.
- For non uniform circular motion, the speed changes hence angular velocity is not constant and the angular acceleration is also nonzero.
- Angular velocity or angular frequency $\omega = \frac{d\theta}{dt}$
- Angular acceleration $\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2}$
- If T be the fixed time period of rotation , then$T = \frac{2\pi}{\omega}$
- For a body in circular motion, the velocity is directed tangentially always, the acceleration will have two components – one is radially inward a_r and another is tangential a_t, called radial and cross radial components of acceleration.
  a_t is directed along the linear velocity if the particle is speeding up and opposite if it is slowing down.
- $\alpha \; and \; \omega$ are along the same direction if the particle is speeding up and opposite if it is slowing down.
- The angular displacement θ, initial angular velocity ω_0, angular acceleration α and time duration of rotation t follows the following equations –

$$\omega = \omega_0 + \alpha t$$
$$\omega^2 = \omega_0^2 + 2\alpha\theta$$
$$\theta = \omega t + \frac{1}{2}\alpha t^2$$

Name of the teacher – Soumitra Maity