14/08/2018

Page No.:
Date:

Laws of Motion.

For motion of an object

↓ required

Force

↓

To push or pull in convenient direction.

Inertia-

Object will maintain either his rest position or in uniform motion. Then this properties of an object is called Inertia.

⇒ **Newton's first law of motion**

Every object will maintain his rest position ~~of~~ or in uniform motion whenever no external force is applied over it.

OR.

object will maintain inertia of rest or inertia of motion whenever no external force applied over it.

Momentum $P = MV = kg\,ms^{-1} = [MLT^{-1}]$

⇒ **Newton's second law of motion-**

Rate of change of momentum in respect to time.

$$F \propto \frac{dp}{dt}$$

$$\frac{dp}{dt} = kF \qquad k = \text{constant} = 1$$

$$\frac{P_2 - P_1}{t} = F$$

$$\frac{m(v-u)}{t} = F \qquad \left(\because a = \frac{v-u}{t}\right)$$

$$ma = F$$

Second law also states that force is equal to mass × acceleration.

Page No.:
Date:

$$F = ma$$

$$(\hat{i}F_x + \hat{j}F_y + \hat{k}F_z) = m(\hat{i}a_x + \hat{j}a_y + \hat{x}a_z)$$

The S.I unit of force = Newton
The C.G.S unit of force = Dyne

$$F = ma$$

$$1N = 1 kg \times 1 m/sec^2$$

$$1 Dyne = 1 gm \times 1 cm/sec^2$$

$$1N = 10^5 dyne.$$

- The gravitational unit of force = $1 kg \times 9.8 m/sec^2$
$= 1 kgf$
$= 9.8 N$

$$1 gf = 980 cm/sec^2$$
$$= 980 dyne$$

⇒ Concept of Inertial mass.

$$F = ma$$

$$m = \frac{F}{a}$$

⇒ Accelerated motion is due to a force —
Force change the speed of moving object.

Applied force can be measured by force law.

$$F \propto l$$

Impulse — Average force applied for small time interval called Impulse (I)

$$I = Force \times \Delta t = Ns$$

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

$$Ft = m(v-u)$$

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

Date:

⇒ Application of Impulse.

Catching of a ball by a ~~cricket~~ fielder

Comfortable in cars or vehicles.

Imp ⇒ Newton's second law is the Real law of motion.

From Newton's second law

$$F = ma$$

In absence of external force

$$ma = \text{constant}$$

$$a = \text{constant}$$

$$v = u + at$$

$$\boxed{v = u}$$

Object starts with initial velocity u then its velocity is constant then final velocity is also u. It shows newton's first law of motion.

⇒ Newton's third law followed from Newton's second law.

$$F_{AB} = \frac{dP}{dt}$$

$$F_{BA} = \frac{dP_2}{dt}$$

$$F_{AB} + F_{BA} = \frac{dP_1}{dt} + \frac{dP_2}{dt}$$

In absence of force

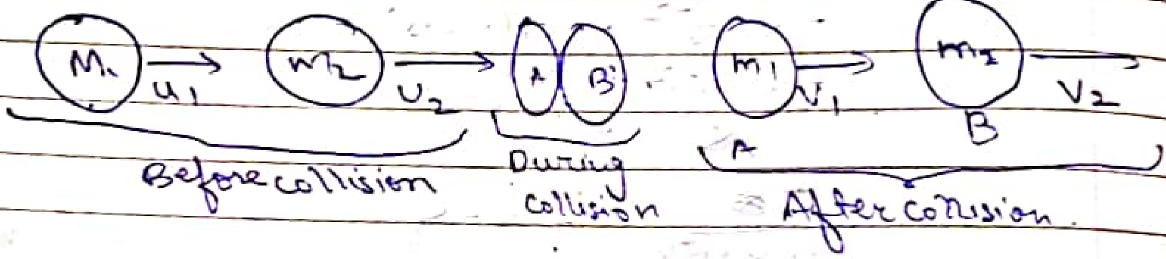
$$F_{AB} + F_{BA} = 0$$

$$\boxed{F_{AB} = -F_{BA}}$$

This expression shows newtons third law of motion.

→ Principle of Conservation of linear momentum.

In absence of external force total momentum of a system is constant called principle of conservation of linear momentum.



$m_1u_1 + m_2u_2$

$= m_1v_1 = m_2v_2$

$$F_{AB} = \frac{m_1(v_1 - u_1)}{t}$$

$$F_{AB} = \frac{m_2(v_2 - v_1)}{t}$$

$$F_{AB} + F_{BA} = 0$$

$$\frac{m_1(v_1 - u_1)}{t} = -\frac{m_2(v_2 - u_2)}{t}.$$

$$m_1v_1 - m_1u_1 = -m_2v_2 + m_2u_2$$

$$\boxed{m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2}$$

so, momentum before collision is equal to momentum after collision.

→ From 2nd law of motion Newton.

$$F_{ext} = \frac{dP_1}{dt} + \frac{dP_2}{dt} + \frac{dP_3}{dt} + \text{-------}$$

In absence of external force.

$$0 = \frac{d}{dt}(P_1 + P_2 + P_3 + \text{----})$$

$$P_1 + P_2 + P_3 + \text{------} \rightarrow 0 = \text{constant}.$$

⇒ Application for conservation of momentum.
When bullet is fired from the gun then gun gets recoil / gives a kick in backward direction.

Mass of Gun = M
Recoil velocity of gun = v
mass of Bullet = m
Velocity of Bullet = V

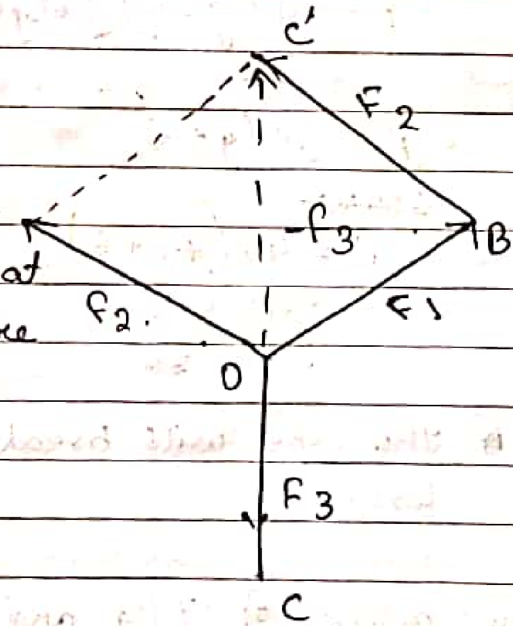
Momentum before firing = Momentum after firing

$$M \times 0 + m \times 0 = Mv + mV$$

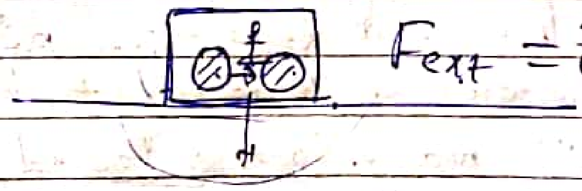
$$Mv = -mV$$

$$v = -\frac{m}{M} V$$

* Concurrent force



If number of forces acting at fixed point then they are called concurrent force.



$F_{ext} = 0$

$P_1 = P_2$

$m_s a = 0$

$m\left(\frac{V-u}{t}\right) = 0$

$m(V-u) = 0 \times t$

$mV - mu = 0$

$P_f - P_i = 0$

$P_f = P_i$

Q A monkey of mass 40 kg flying on a rope which can strend a maximum tension of 600 N. In which of the following cases will the rope break. The monkey.

a) Climbs up with an acceleration of 6 m/s².
b) Climbs down with an acceleration of 4 m/s²
c) Climbs up with a speed of 5 m/s.
d) falls down the rope nearly freely under gravity.

a) Mass = 40 kg.

~~mg + a~~

$F = m(g+a)$] object goes up

$F = M(g-a)$] object goes down

158
40
000
632
6320
3

$F = m(g+a)$

~~600N =~~

$F = 40(9.8+6)$

$= 40 \times 15.8$

$= 632.$

- The rope will break because the force on the rope is less.

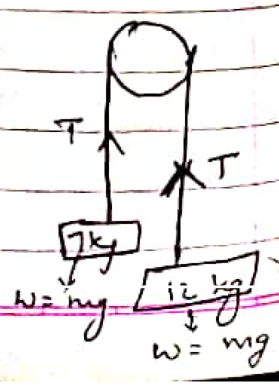
Q. Two masses of 7 kg and 12 kg are connected at the two ends of a light unextansible string that passes over a frictionless pulley. Find the acceleration of mass and the tension in the string when the masses are released.

$\cancel{T} - m_1 g = m_1 a$

$m_2 g - \cancel{T} = m_2 a$

$g(m_2 - m_1) = a(m_1 + m_2)$

$a = \dfrac{g(m_2 - m_1)}{(m_1 + m_2)}$



Q. A 30 kg shell is flying at 48 m/s. When it explodes it one part of 18 kg ~~Stopp~~ stops. While the remaining part flying on. Find the velocity of later.

$$m_1 v_1 = m_2 v_2$$

$$30 \times 48 = 12 \times V$$

$$V = \frac{30 \times 48}{12} = 120 \text{ m/sec}$$

FRICTION

It is a phenomenon in which one object slides over another object then in between contact of two surfaces force developed which oppose the motion of an object.

It is of two types.
i) Static   ii) Kinetic

Laws of Friction.

i) The value of limiting friction depends upon the nature of two surface of contact and their state of roughness.

ii) The force of friction is tangencial to the two surfaces in contact and act opposite to the direction in which the body could start moving on applying force.

iii) The value of limiting force of friction is directly proportion to normal reaction.

$$F \propto R$$

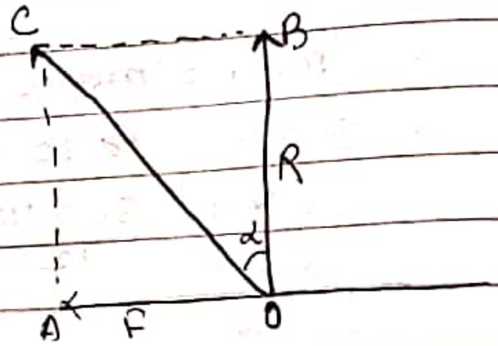
$$F = \mu R$$

μ = const. called coefficient of friction

$$\mu = \frac{F}{R}$$

iv) The value of limiting friction for any two given surface is independent of shape or area of surface in contact.

Angle of friction



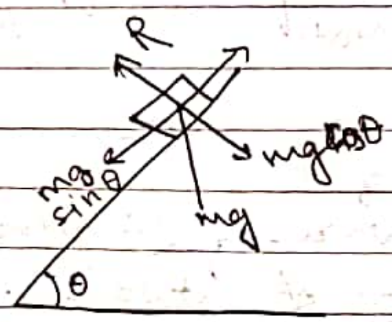
Resultant of F and R makes an angle with normal reaction is called angle of friction.

In ΔOCB

$$\tan\alpha = \frac{F}{R} = \mu$$

Hence, coefficient of friction numerically equal to tangent of angle of friction.

Angle of Repose

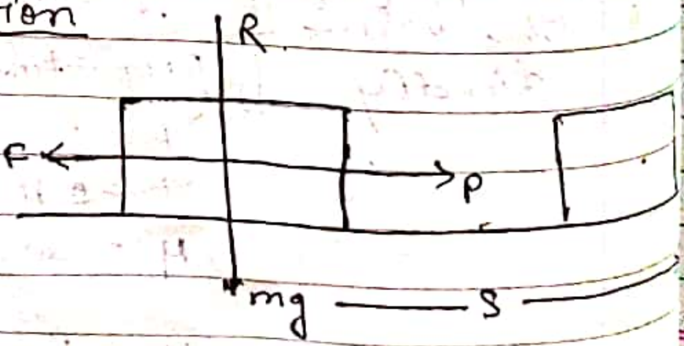


$$\mu = \frac{F}{R} = \frac{\cancel{mg}\sin\theta}{\cancel{mg}\cos\theta} = \tan\theta = \tan\alpha$$

$$\boxed{\theta = \alpha}$$

For particular angle of inclined plane with horizontal object start to slide that particular angle is called angle of repose.

Work done against friction



P → is applied force.

Page No.:
Date:

$$\mu_k = \frac{F}{R}$$

$$F = \mu_k R = \mu_k \cdot mg = P$$

$$\boxed{W.d = P.S = \mu_k mg.S}$$

* Rolling friction.

When one objects rolls over another object then, between contact of two surface, force develop, named as friction force oppose the motion and phenomenon called rolling friction.

Cause of rolling friction

Inclimbing up the hump infront of the wheel encounter some opposite force against the motion are called cause of rolling friction.

* Friction is necessary evil. →

i) Due to friction nails and screw hold the bolt together.
ii) By belt power can be transmitted from electric motor to machine.
iii) It helps to walk or to drive car.
iv) Application of brakes in ~~~~ vehicle due to friction.

• Due to friction work can be done by the machine and that work done converts in heat energy which destroy the machinery part.

$$\boxed{\mu = \frac{F}{R}}$$

a = centripetal acceleration $= \frac{v^2}{r}$

$v = \omega r$
↓
omega

* Method to reduce friction –
  - Polishing
  - Lubrication
  - Proper selection of material.
  - Rolling friction
  - Stream lining

* Dynamics of circular motion.

When object moves in circular path around the fixed axis then two types of forces developed.

i) Centripetal forces which acts towards the centre.

ii) Centrifugal force which acts away from the centre.

In case of centripetal and centrifugal.

$$F = m\frac{v^2}{r}$$

$$= \frac{m\omega^2 \cancel{r^2}}{\cancel{r}}$$

$$= m\omega^2 r$$

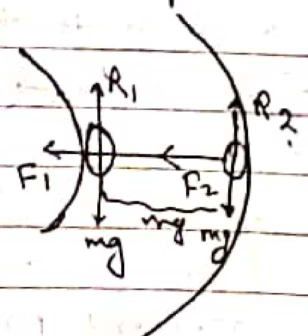
$$\boxed{\omega = \frac{2\pi}{T}}$$

$$= \frac{m4\pi^2 r}{T^2}$$

$$= 4\pi^2 r f^2 \qquad F = ma$$

$$= 4m\pi^2 f^2 r$$

A vehicle taking a circular path on a level road



$$\mu = \frac{F}{R}$$

$$F = \mu R$$

$$F_1 + F_2 = \frac{mv^2}{r}$$

$$\mu R_1 + \mu R_2 = \frac{mv^2}{r}$$

$$\mu(R_1 + R_2) = \frac{mv^2}{r}$$

$$\mu \cancel{m} g = \frac{\cancel{m} v^2}{r}$$

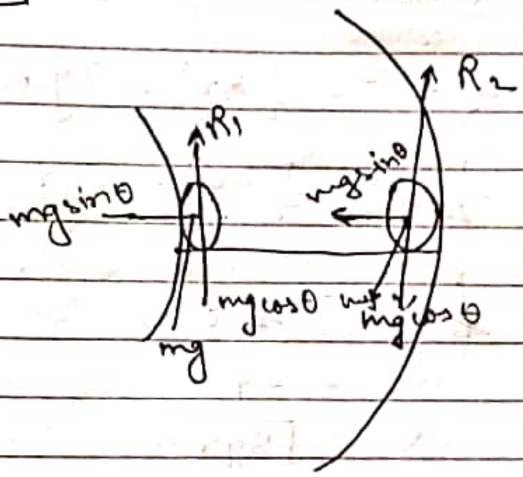
$$\boxed{\mu = \frac{v^2}{rg}}$$

• Blanked Road.

~~R cos~~

$R\cos\theta = mg$

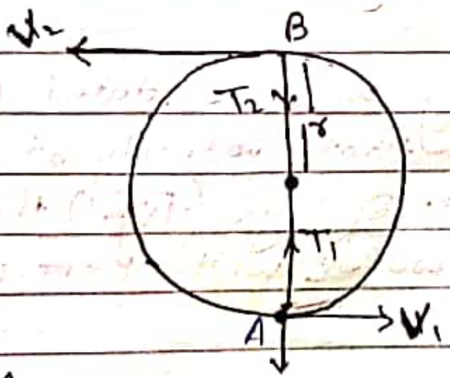
$R\sin\theta = \frac{mv^2}{r}$



$$\frac{\cancel{R}\sin\theta}{\cancel{R}\cos\theta} = \frac{\cancel{m}v^2}{r\cancel{m}g}$$

$$\boxed{\tan\theta = \frac{u^2}{rg}}$$

* Motion in a virtical circle.



At point A.

$$T_1 - mg = \frac{mv_1^2}{r}$$

At point B

$$T_2 + mg = \frac{mv_2^2}{r}$$

$T_2 = 0$

$$\cancel{m}g = \frac{\cancel{m}v_2^2}{r}$$

$$u_2^2 = rg$$

According to the principle of conservation of energy.
Total energy at point A = Total energy at point B.

K.E at point A = (KE + P.E) at point B.

$$\frac{1}{2}mv_1^2 = \frac{1}{2}mv_2^2 + mg(2r)$$

$$\frac{1}{2}v_1^2 = \frac{1}{2}v_2^2 + 2gr$$

$$\frac{1}{2}v_1^2 = \frac{1}{2}rg + 2gr$$

$$\frac{1}{\cancel{2}}v_1^2 = \frac{5}{\cancel{2}}gr$$

$$v_1^2 = 5gr$$

$$v_1 = \sqrt{5gr}$$

$$T_1 - mg = \frac{m}{\cancel{r}}5g\cancel{r}$$

$$T_1 = 5mg + mg = 6mg$$

* If a bucket containing water is rotated along a vertical circle such that velocity at the lowest point is square root of 5gr ($\sqrt{5gr}$) that is equal or greater so the water will not split.