

FRICTION

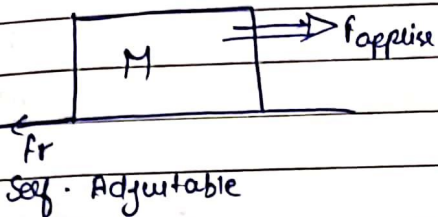


Friction



FRICTION

Let 100 N force is required to move this block.

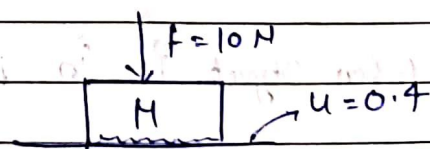


	friction	Applied	
Self-Adjustable			
Max. value = f_{limiting}	0	0	Rest static friction
	10 N	10 N	
	50 N	50 N	
	70 N	70 N	
	90 N	90 N	
	98 N	98 N	
	99 N	99 N	Object is moving.
Kinetic friction.	98 N	100 N	
	98 N	150 N	
	98 N	200 N	

Friction force is also a Contact force which acts parallel to Contact surface, which oppose relative motion or tendency of relative motion w.r.t Contact surface, in tangential direction.

Necessary Condition to act friction :-

- ① Contact
- ② Interlocking (μ)



- ③ Tendency or relative motion w.r.t Contact surface parallel to Contact force. friction from oppose motion.

No. tendency of relative motion.

friction = 0

IF $N = 0$ then friction must be zero = True

IF $f_s = 0$ then normal must be zero = False.

Static friction force $\Rightarrow$

Self adjustable force

always equal to applied force

Only when tendency of motion
object is at rest ($f_{net} = 0$)

friction = applied force which is creating
tendency of motion

Limiting friction force $\Rightarrow$

Maximum static friction

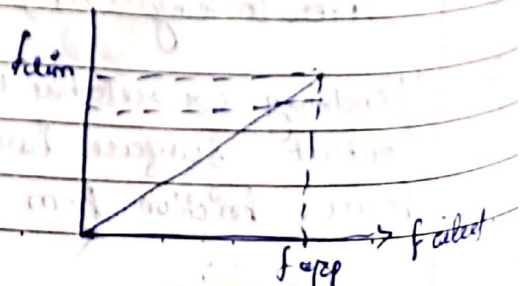
when object about to move

$f_{\text{limiting}} = \text{friction } f_l = \text{Ext force required}$
to move the object

Kinetic friction (Sliding friction) $\Rightarrow$

when object is in motion w.r.t contact force

$$f_{\text{static}} = f_{\text{applied}}$$



$$f_{\text{limiting}} = \mu_s N = \mu_s M$$

$$f_{\text{kinematic}} = \mu_k M$$

$$\mu_k < \mu_s$$

friction is a Necessity :-

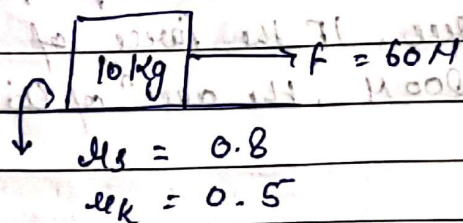
Without friction

- We cannot walk
- A bicycle, a vehicle, a train etc. cannot be started or stopped.
- It would be impossible to climb a tree or pole, to fix a nail, to write with a pen etc.

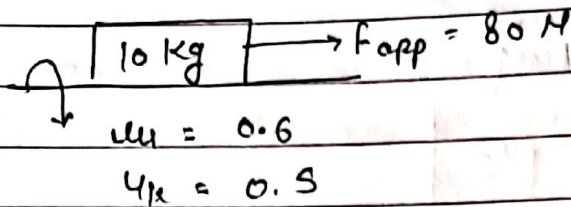
friction is an evil :-

- Wear and tear of tyres on the road is due to friction
- Wear and tear of the machinery parts is due to friction
- Heat produced by friction causes damage to the machine. Extra power is needed to overcome friction.

Ques Find acceleration and friction b/w block and accelerab,



Ques



Ques

which of the following is self adjusting force static friction.

Ques

Maximum force of friction is called limiting friction.

Ques

The limiting friction b/w two bodies in contact is independent of

- ① Nature of the surface in contact
- ② The area of surface in contact ✓
- ③ Normal reaction b/w the surface
- ④ The material of the bodies

Ques

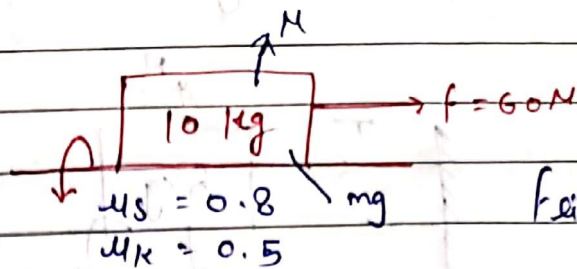
Which is a suitable method to decrease friction?

- ① Polishing
- ② Lubrication
- ③ Ball bearing
- ④ All ✓

Ques

A child weighing 25 kg slides down a rope hanging from a branch of a tall tree. If the force of friction acting against him is 200 N, the accelⁿ of child = $g = 10 \text{ m/s}^2$

Q. Find acceleration and friction b/w blocks



Step - 1

→ Find limiting friction

$$f_{\text{limiting}} = \mu_s N$$

$$= \mu_s mg$$

$$= \frac{8}{10} \times 10 \times 10$$

Step - 2

→ Compare it with applied force

$$f = 80 \text{ N}$$

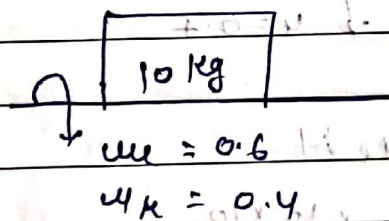
(act) $a = 0$

→ $f_{\text{limiting}} > f_{\text{applied}}$ (rest $f_{\text{applied}} = f_{\text{static}}$)

$$f_{\text{static}} = 60 \text{ N}$$

- $f_{\text{limiting}} < f_{\text{applied}}$ (Moving friction $= \mu_k N$)

Q. Find accⁿ / friction.



$$f_{\text{limiting}} = \mu_s N$$

$$= \mu_s mg$$

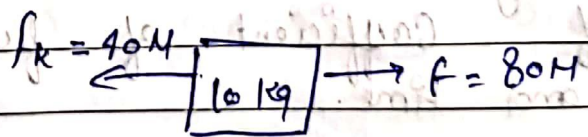
$$= \frac{6}{10} \times 10 \times 10$$

Object is in Motion.

$$f_{\text{kinetic}} = \mu_k N = \frac{4}{10} \times 10 \times 10$$

$$= 40 \text{ N}$$

$$f_{\text{lim}} = 60 \text{ N}$$

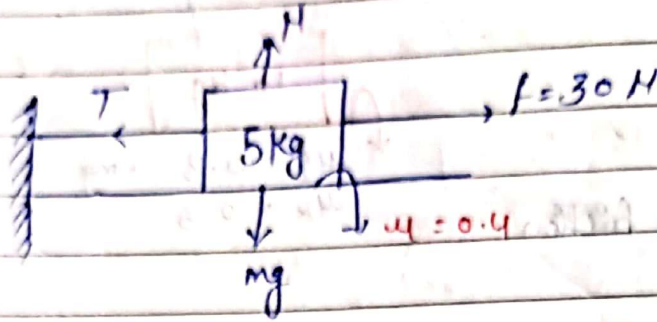


$$f_{\text{lim}} < f_{\text{applied}}$$

$$a = \frac{80 - 40}{10} = 4 \text{ m/s}^2$$

$$f_{\text{kinetic}} = 40 \text{ N}$$

Find tension in string.

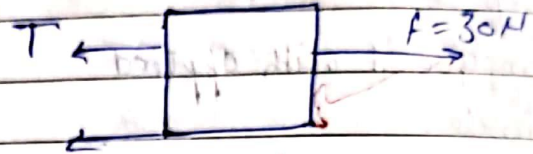


$$f_{\text{limiting}} = \mu N$$

$$= \frac{4}{10} \times 5 \times 10$$

$$= 20 \text{ N}$$

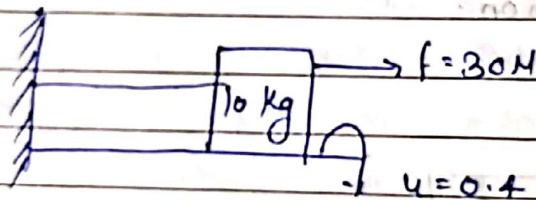
(Applied > limiting)



$$f_{\text{limit}} = 20 \text{ N}$$

$$T = 10 \text{ N}$$

Ques



Find tension in string.

$$f_{\text{limiting}} = \mu N$$

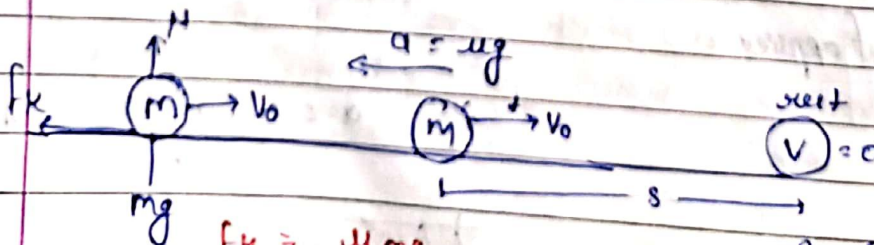
$$= \frac{4}{10} \times 10 \times 10$$

$$= 40 \text{ N}$$

B₂

Ques

Object is thrown with Velocity V_0 on rough surface of Coefficient of friction μ . Then stopping distance and time.



$$f_k = \mu mg$$

$$ma = -\mu mg$$

$$a = -\mu g$$

$$v^2 - u^2 = 2as$$

$$0 - V_0^2 = 2(-\mu g)s$$

$$s = \frac{V_0^2}{2\mu g}$$

don't use this

Ques A heavy box is slid across a rough floor with an initial speed of 4 m/s . It stops moving after 8 seconds. If the average resisting force of friction is 10 N the mass of the box (in kg) is.

(a) 40
(b) 20 ✓
(c) 5
(d) 2.5

$m \rightarrow V = 4 \text{ m/s}, t = 8 \text{ sec}, V = 0$

$$V = u + at \quad (f_{\text{avg}}) = -10 \text{ N}$$

$$0 = 4 + a \cdot 8$$

$$8a = -4$$

$$a = -\frac{1}{2} \text{ m/s}^2$$

$$ma = -10$$

$$m \left(-\frac{1}{2}\right) = 10$$

$$\boxed{m = 20 \text{ kg}}$$

Ques An object of mass 1 kg moving on a horizontal surface with initial velocity 8 m/s comes to rest after 10 s . If one wants to keep the object moving on the same surface with velocity 8 m/s the force required is.

(a) 0.4 N
(b) 0.8 N
(c) 0.2 N
(d) zero

$1 \text{ kg} \rightarrow V = 8 \text{ m/s}$

$$F_r = ma = 1 \times \frac{(-8)}{10} = -0.8 \text{ N}$$

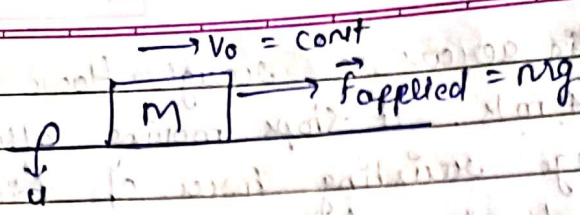
$$V = u + at$$

$$0 = 8 + a \cdot 10$$

$$10a = -8$$

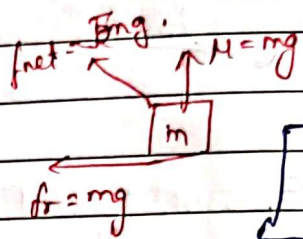
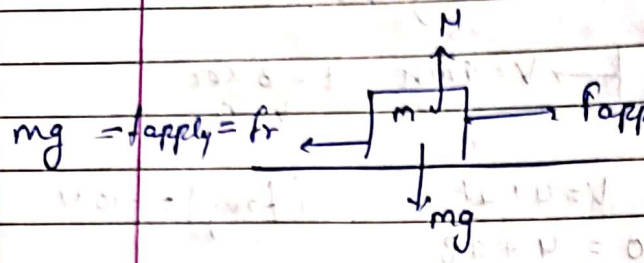
$$a = \frac{-8}{10} \text{ m/s}^2 \quad \boxed{a = 0.8 \text{ m/s}^2}$$

Ques Object is moving with constant velocity as shown in fig. Then find contact force b/w ground and block



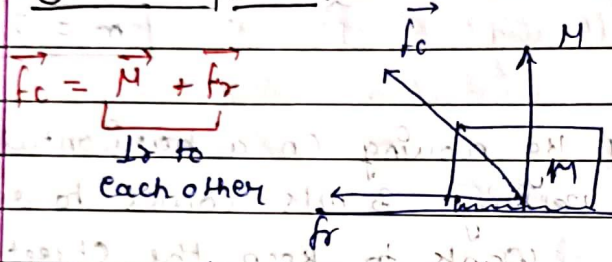
$\Sigma f_x = 0$
 $f = mg$ — (i)

$\Sigma f_y = 0$
 $N = mg$ — (ii)



$f_{net} = 2mg$

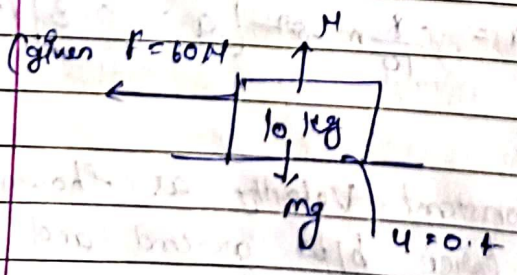
Contact force!



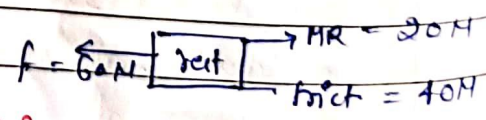
$|\vec{f}_c| = \sqrt{(N)^2 + (f_r)^2}$

Friction always opposes relative motion or tendency of relative motion.

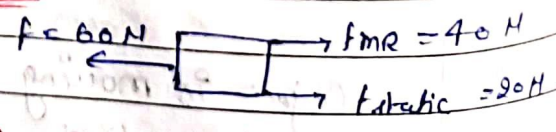
Find force applied by MR so that object will not slide



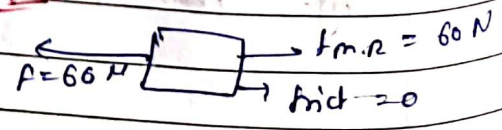
Case - 1



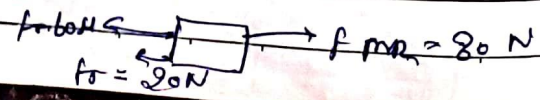
Case - 2



Case - 3



Case - 4



Ques

$f = 86 \text{ N}$ (given)

$f_{m.R} = ??$

5 kg

$\mu = 0.8$

Find force applied by M.R so that M move = ??

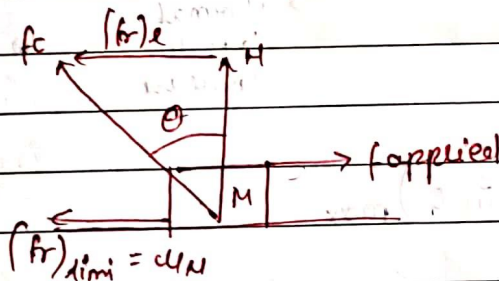
$$\begin{aligned} \text{Limiting} &= \mu N \\ &= \frac{8}{10} \times 5 \times 10 \\ &= 40 \text{ N} \end{aligned}$$

$$(f_{m.R})_{\min} = 40 \text{ N}$$

$$(f_{m.R})_{\min} = 120 \text{ N}$$

Angle of friction

Angle b/w normal reaction and Contact force when object is just about to move on horizontal surface



$$\tan \theta = \frac{f_r}{N} = \frac{\mu N}{N}$$

$$\tan \theta = \mu$$

$$\theta = \tan^{-1}(\mu)$$

→ Angle of friction

Ques

If angle of friction is 53° then find Coefficient of friction ??

$$\mu = \tan 53^\circ$$

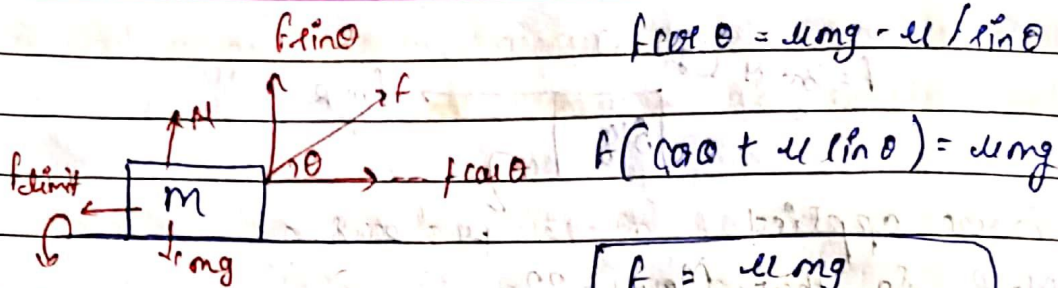
$$\mu = \frac{4}{3}$$

$$\mu = 1.33$$

Ans

Ques

Find minimum force required to move this object on rough surface



$$f \cos \theta = \mu mg - \mu f \sin \theta$$

$$f(\cos \theta + \mu \sin \theta) = \mu mg$$

$$f = \frac{\mu mg}{\cos \theta + \mu \sin \theta}$$

$$\Sigma f_y = 0$$

$$N + f \sin \theta = mg$$

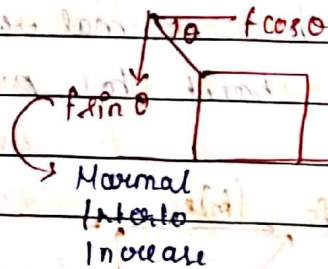
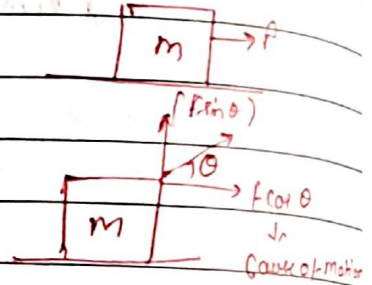
$$N = mg - f \sin \theta \quad \text{--- (1)}$$

$$\Sigma f_x = 0$$

$$f \cos \theta = f_s = \mu N$$

$$f \cos \theta = \mu (mg - f \sin \theta)$$

$$f = \frac{\mu mg}{\cos \theta + \mu \sin \theta}$$



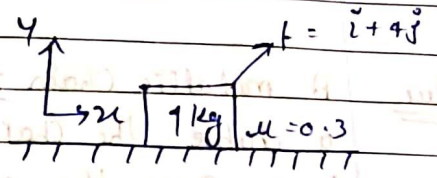
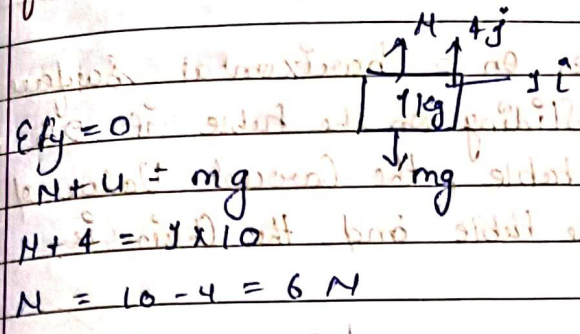
$$f_{\min} = \frac{\mu mg}{(1 \cos \theta + \mu \sin \theta)_{\max}}$$

$$f_{\min} = \frac{\mu mg}{\sqrt{1 + \mu^2}}$$

Ques In the figure shown horizontal force F_1 is applied on a block but the block does not slide. then as the magnitude of vertical force F_2 is increased from zero the block begins to slide. The correct statement is

- (1) The magnitude of normal reaction on block increase
- (2) static friction force acting on the block increase
- (3) Maximum value of static frictional force decrease
- (4) All of these

A force $\vec{P} = \hat{i} + 4\hat{j}$ acts on the block shown. The force of friction acting on the block is.



$$F_y = 0$$

$$N + 4 = mg$$

$$N + 4 = 1 \times 10$$

$$N = 10 - 4 = 6 \text{ N}$$

$$f_{\text{lim}} = \mu N = \frac{3}{10} \times 6 = \frac{18}{10}$$

$$= 1.8 \text{ N}$$

Ques In the figure shown, the Coefficient of static friction b/w the block A of mass 20 kg and horizontal table is 0.2. What should be the minimum mass of hanging block just beyond which blocks start moving?

- ① 2 kg
- ② 3 kg
- ③ 4 kg ✓
- ④ 5 kg

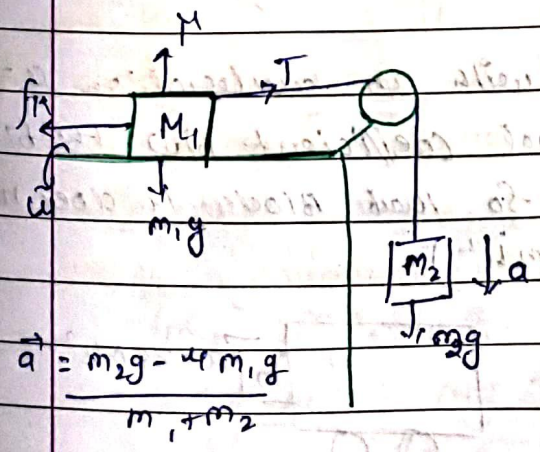
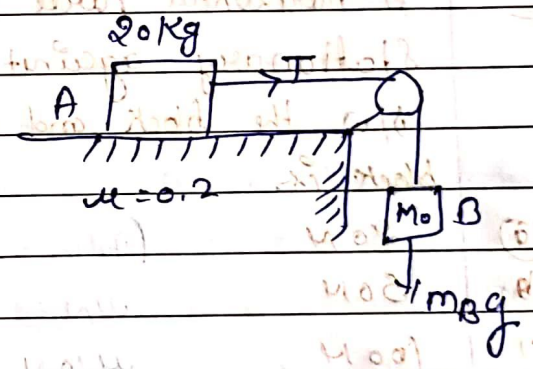
$$f_s = T$$

$$\mu N = m_B g$$

$$\mu mg = m_B g$$

$$0.2 \times 20 = m_B$$

$$m_B = 4$$



$$a = \frac{m_2 g - \mu m_1 g}{m_1 + m_2}$$

If acceleration in object is sliding.

$$m_2 g - T = m_2 a$$

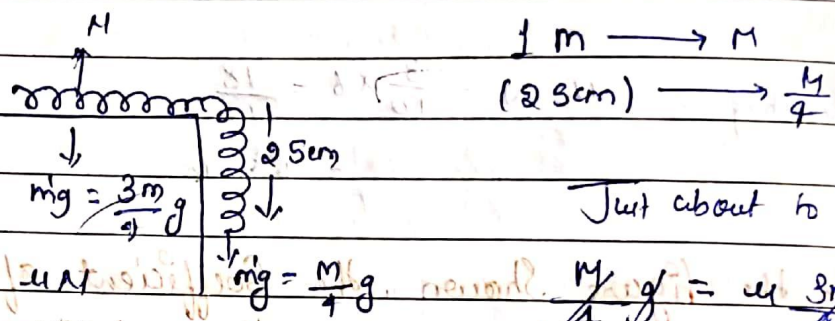
$$T - f_k = m_1 a$$

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

$$\vec{a} = \frac{m_2 g + f_{rk}}{m_1 + m_2} = \frac{m_2 g - \mu m_1 g}{m_1 + m_2}$$

Que A metallic chain 1m long lies on a horizontal surface of a table. The chain starts sliding on the table if 25 cm hangs over the edge of a table. The correct value of the coefficient of friction b/w the table and the chain is.

- (a) 1/3 ✓
- (b) 2/3
- (c) 1/4
- (d) 1/5



Just about to move

$$f_{\text{limiting}} = \mu N$$

$$f_{\text{limiting}} = \mu \frac{3m}{4} g$$

$$\frac{m}{4} g = \mu \frac{3m}{4} g$$

$$\mu_3 = 1$$

$$\boxed{\mu = \frac{1}{3}}$$

Que A horizontal force 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction b/w the block and the wall is 0.2. The weight of the block is.

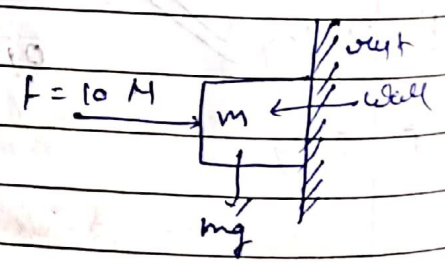
- (a) 20 N
- (b) 50 N
- (c) 100 N
- (d) 2 N ✓

$$f_{\text{static}} = (mg)$$

$$\mu N = mg$$

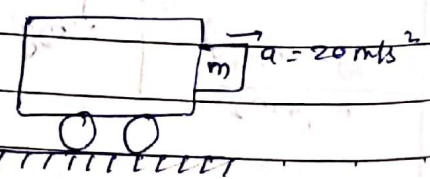
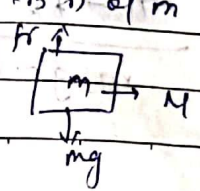
$$\mu 10 N = (mg)$$

$$\frac{2}{10} 10 = (\text{Weight})$$



Que A vehicle is moving on a road with an acceleration $a = 20 \text{ m/s}^2$ as shown in figure. The frictional coefficient b/w the block of mass (m) and the vehicle so that block is does not fall downwards is ($g = 10 \text{ m/s}^2$).

- ① 0.4
- ② 0.5 ✓
- ③ 2
- ④ 0.7



$$N = ma \quad \text{--- ①}$$

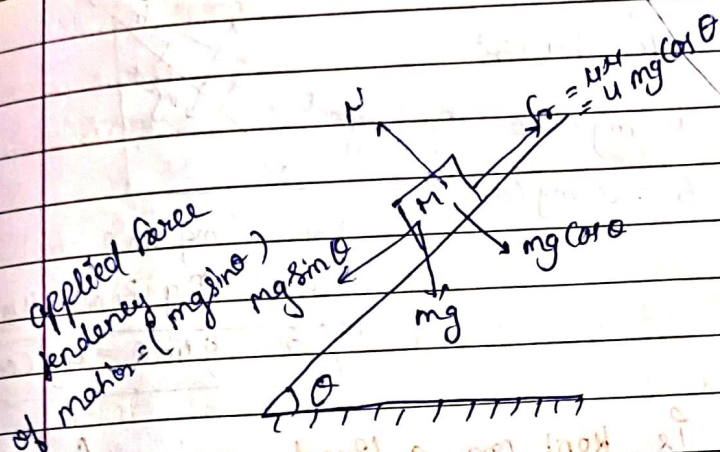
$$f_x = mg \quad \text{--- ②}$$

$$\mu N = mg$$

$$\mu ma = mg$$

$$\mu = \frac{g}{a} = \frac{10}{20} = 0.5$$

Friction of Inclined Plane



$$(f_{\text{net}}) = 0$$

↑ r to Inclined

$$N = mg \cos \theta$$

$$f_{\text{limiting}} = \mu N = \mu mg \cos \theta$$

as $\theta \uparrow$ $f_{\text{limiting}} \downarrow$

Friction force On Inclined Plane ! $\rightarrow$

Angle of repose (θ) $\Rightarrow$ It is the maximum angle of inclination inclined plane with horizontal such that the block kept on it remains at rest

Angle of repose (θ) $\rightarrow$ minimum angle at which object is just about to slide

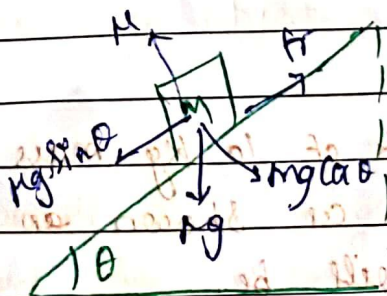
Just about to motion

limiting = applied

$$\mu N = mg \sin \theta$$

$$\mu mg \cos \theta = mg \sin \theta$$

$$\boxed{\mu = \tan \theta}$$



$$\boxed{\mu = \tan \theta}$$

$\rightarrow$ Just about to motion

Case-1 = object is placed on Inclined Plane

$$f_{\text{static}} > f_{\text{applies}}$$

$$\mu mg \cos \theta > mg \sin \theta$$

$$\mu > \tan \theta$$

object is at rest

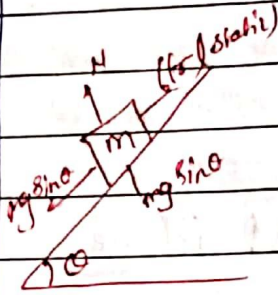
$$f_{\text{net}} = 0 \quad (N = mg \cos \theta)$$

$$f_{\text{static}} = mg \sin \theta$$

$$f_{\text{contact}} = \sqrt{N^2 + f_r^2}$$

$$\sqrt{(mg \cos \theta)^2 + (mg \sin \theta)^2}$$

$$f_{\text{conf}} = mg$$



$$\vec{f}_c = \sqrt{N^2 + f_r^2}$$

$$N = mg \cos \theta$$

$$f_r = \mu mg \cos \theta$$

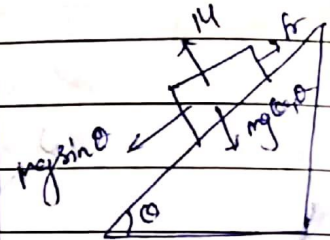
Case-2

$$\mu < \tan \theta$$

object is moving downwards

$$f_{\text{friction}} = \mu N$$

$$= \mu mg \cos \theta \quad (1)$$



$$ma = (mg \sin \theta - f_r)$$

$$ma = mg \sin \theta - \mu mg \cos \theta$$

$$a = g \sin \theta - \mu g \cos \theta$$

Ques A block of mass 10 kg is kept on a fixed rough ($\mu = 0.8$) inclined plane of angle of inclination 30° , the frictional force acting on the block is.

① 50 N ✓

② $50\sqrt{3}$ N

③ 52 N

④ 54 N

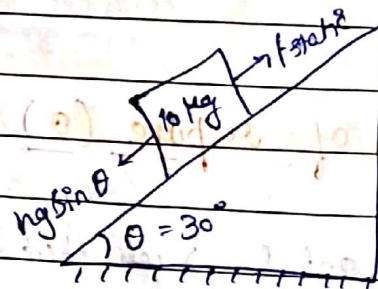
$$(f_{\text{static}}) = f_{\text{applies}}$$

$$mg \sin \theta$$

$$10 \times 10 \times \sin 30^\circ$$

$$100 \times \frac{1}{2}$$

$$50 \text{ N}$$



$$\mu = 0.8$$

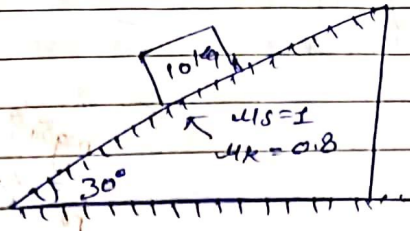
$$\tan \theta = \tan 30^\circ = \frac{1}{\sqrt{3}} = \frac{1}{1.71}$$

$$= 0.58$$

$$\mu > \tan \theta$$

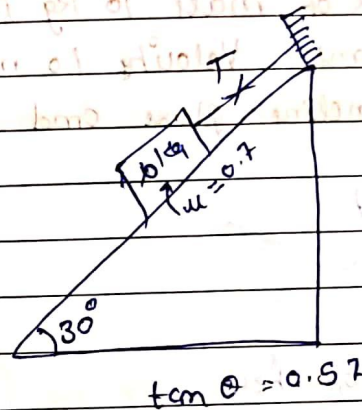
Ques A block of 10 kg mass is placed on a rough inclined surface as shown in figure. the acceleration of the block will be.

- ① Zero
② g
③ $\frac{g}{2}$
④ $\frac{\sqrt{3}g}{2}$



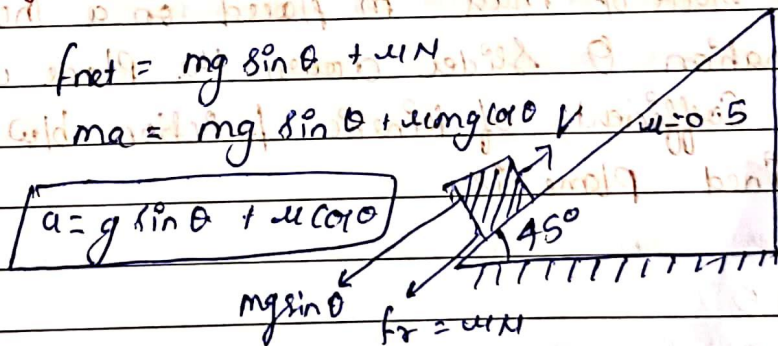
Ques the tension T in the string shown in figure is.

- ① Zero
② 50 N
③ 35 V 3 N
④ $(\sqrt{3}-1) 50 \text{ N}$



Ques A block of mass 1 kg is projected from the lowest point up along the inclined plane. If $g = 10 \text{ ms}^{-2}$, the retardation experienced by the block is

- ① $\frac{15}{\sqrt{2}} \text{ ms}^{-2}$
② $\frac{5}{\sqrt{2}} \text{ ms}^{-2}$
③ $\frac{10}{\sqrt{2}} \text{ ms}^{-2}$
④ zero



Ques A block (mass = $M \text{ kg}$) is placed on a rough inclined plane. A force F is applied parallel to the inclined (as shown in figure) such that it just starts moving upward. the value of F is.

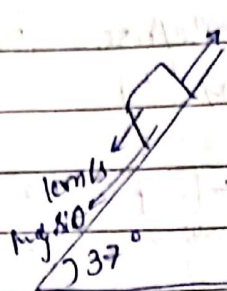
Ques A block of mass 10 kg is moving on inclined plane with constant velocity 10 m/s. The coefficient of kinetic friction b/w inclined plane and block is

① 0.57

② 0.75 ✓

③ 0.5

④ None



$$mg \sin \theta = \mu mg \cos \theta$$

$$\frac{\sin \theta}{\cos \theta} = \mu$$

$$\mu = \tan \theta$$

$$\mu = \frac{3}{4}$$

Ques A block of mass m placed on an inclined plane of angle of inclination θ slides down the plane with constant speed. The coefficient of kinetic friction b/w block and inclined plane is.

① $\sin \theta$

② $\cos \theta$

③ $\tan \theta$

④ $\tan^{-1} \theta$

$$\cos \theta = \theta$$

$$\mu > \tan \theta$$

$$\mu < \tan \theta$$

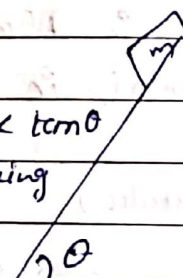
$$(\mu = \tan \theta)$$

$$\mu < \tan \theta$$

$$\text{moving}$$

$$\text{Just about move}$$

$$f_r = mg \sin \theta$$



Ques A block of mass 10 kg is released on rough inclined plane. Block starts descending with acceleration 2 m/s^2 . Kinetic friction force acting on block is (take $g = 10 \text{ m/s}^2$)

① 10 N

② 30 N ✓

③ 80

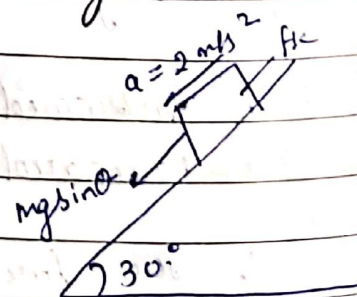
④ $50\sqrt{3} \text{ N}$

$$ma = mg(\sin \theta) - f_k$$

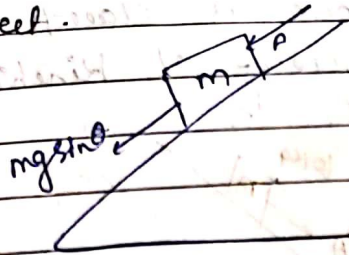
$$10 \times 2 = 10 \times 10 \times \frac{1}{2} - f_k$$

$$20 = 50 - f_k$$

$$f_k = 50 - 20 = 30 \text{ N}$$



Q. If ($\mu > 0$). Find minimum force required to move this object.

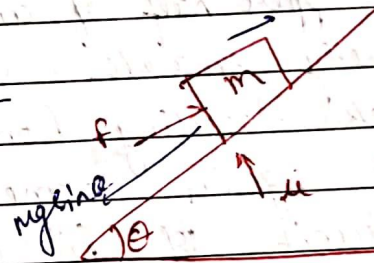


along inclined plane.
force just about to move

$$F_{\min} = \mu mg \cos \theta - mg \sin \theta$$

Q. A Block (mass = mg) is placed on a rough inclined plane. A force F is applied parallel to the inclined (as shown in figure) such that it just start moving upward. The value of F is.

- ① $mg \sin \theta + \mu mg \cos \theta$
- ② $mg \sin \theta + \mu mg \cos \theta$
- ③ $mg \sin \theta$
- ④ $\mu mg \cos \theta$

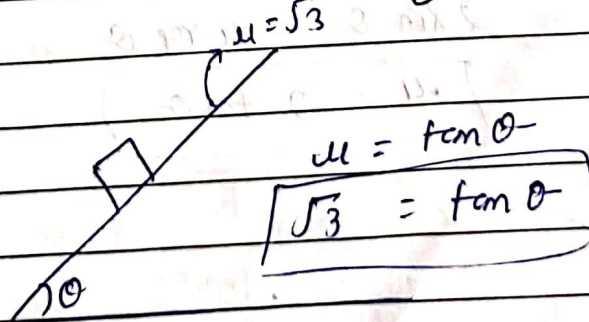


$$F = F_{\text{net}} + mg \sin \theta$$

$$(\mu mg \cos \theta + mg \sin \theta)$$

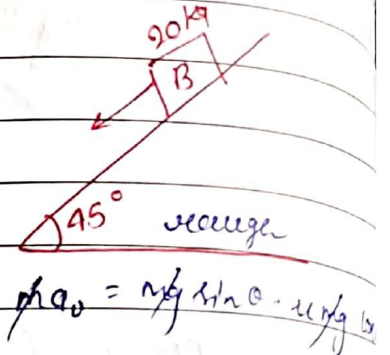
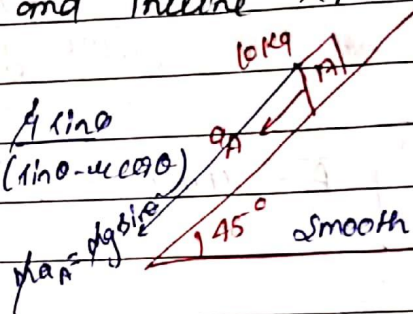
Q. A Cubical block rest on a plane of $\mu = \sqrt{3}$. The angle through which the plane is inclined to the horizontal so that the block just slides down will be

- ① 30°
- ② 45°
- ③ 60° ✓
- ④ 75°



Q. The section of acceleration of Block A placed on smooth incline with block B placed on rough incline is 2:1. The coefficient of kinetic friction b/w Block B and incline is.

- ① 0.5
 ② 0.75
 ③ 0.57
 ④ None



$$2 = \sin \theta$$

$$\sin \theta - \mu \cos \theta$$

$$1 - \mu = \frac{1}{2} \Rightarrow 1 - \frac{1}{2} = \mu \Rightarrow \mu = \frac{1}{2}$$

Q. The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom. If the coefficient of friction b/w the block and lower half of the plane is given by.

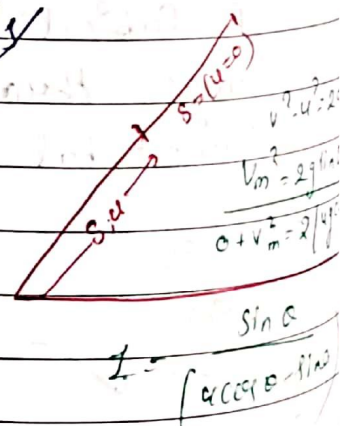
① $\mu = \frac{2}{\tan \theta}$ rest to rest

② $\mu = 2 \tan \theta$ $g \sin \theta = (\mu g \cos \theta - g \sin \theta)$

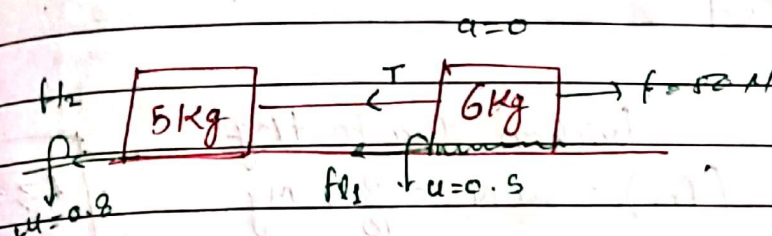
③ $\mu = \tan \theta$ $\sin \theta = \mu \cos \theta - \sin \theta$

④ $\mu = \frac{1}{\tan \theta}$ $2 \sin \theta = \mu \cos \theta$

$$\mu = 2 \tan \theta$$



Q1 Find acceleration and tension in the string



$$f_{\text{limiting}} = \mu N$$

$$= \frac{5}{10} \times 60$$

$$f_{\text{lim}} = 30 \text{ N}$$

$$f_{\text{lim}} = 40 \text{ N}$$

$$50 = \frac{8}{10} \times 5 \times 10$$

$$= 40 \text{ N}$$

Free motion -

$$f_{\text{applied}} > f_{\text{L1}} + f_{\text{L2}}$$

In question

$$f_{\text{L1}} + f_{\text{L2}} = 70 \text{ N}$$

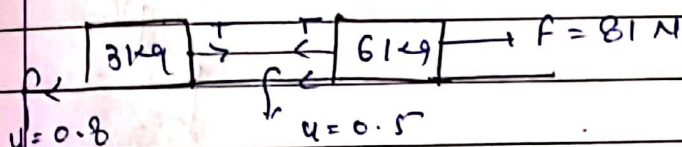
$$f_{\text{applied}} = 50 \text{ N}$$

$$\text{net}$$

$$a = 0$$

Q2 Find accⁿ and tension in string

Solⁿ



$$f_{\text{L1}} = 30 \text{ N}$$

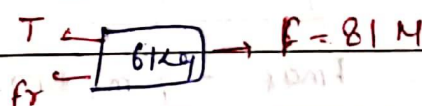
$$f_{\text{L2}} = 40 \text{ N}$$

$$f_{\text{L1}} + f_{\text{L2}} = 70 \text{ N}$$

$$F = f_{\text{L1}} + f_{\text{L2}} \quad (S+G) \rightarrow F = 81 \text{ N}$$

$$a = \frac{f_{\text{net}}}{m} = \frac{11}{11} = 1 \text{ m/s}^2$$

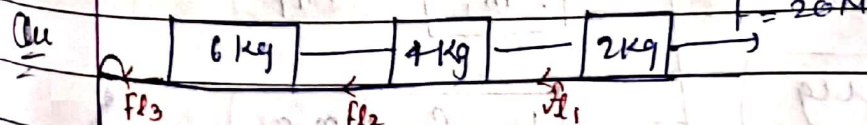
F.B.D of 6 kg - will move



$$\Sigma (f_{\text{L1}} + T) = mg$$

$$81 - (30 + T) = 6 \times 1$$

$$81 - 36 = T \Rightarrow T = 45$$

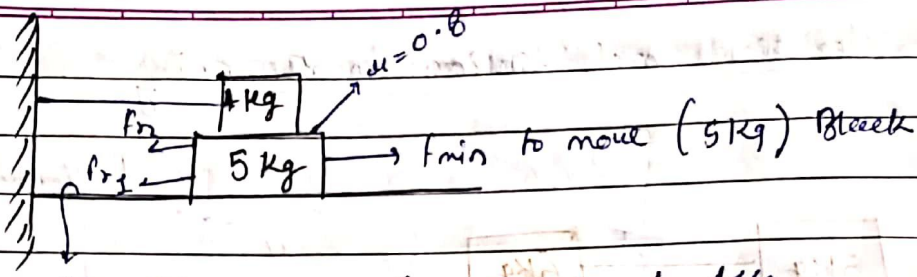


$\mu = 0.2$ for all, then find tension

btw 4 kg and 6 kg.

$$f_{\text{L2}} + f_{\text{L2}} + f_{\text{L3}} =$$

$$T = 8 \text{ N}$$



friction due to 4 kg
 $(F_{r2}) = \mu N = \frac{8}{10} \times mg$

$$= \frac{8}{10} \times 4 \times 10$$

$$= 32 \text{ N}$$

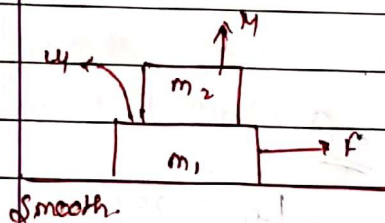
$$F \geq 45 + 32$$

$$77 \text{ N}$$

then object
will be ~~move~~
move

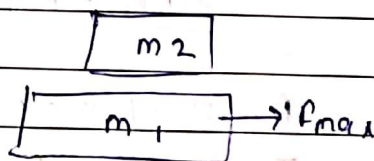
Ques

The rough block system on smooth horizontal surface. Find maximum force acting on lower block so that they will move together.



Smooth

(just about to slip.)



$$F_{\max} = (m_1 + m_2) \mu g$$

$$F_{\max} = m_2 a_{\max}$$

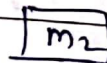
$$\mu N = m_2 a$$

$$\mu m_1 g = m_2 a_{\max}$$

$$a_{\max} = \mu g$$

Case-3

$$F_{\text{applied}} > (m_1 + m_2) \mu g$$



$$\mu m_2 g = m_2 a_2$$

$$a_2 = \mu g$$



$$F - F_r = m_1 a_1$$

$$a (\text{साव. - रसाव.}) = \frac{F}{(m_1 + m_2)}$$

Case-1

$$a < a_{\max}$$

(They will together)

$f_r \rightarrow$ Static

$$a_{\max} = \mu g$$

$\hookrightarrow$ Does not depend on m_1 & m_2

$$a > a_{\max}$$

They will slip

$f_r >$ kinetic

Case-2

$$a = a_{\max} = \mu g$$

They about to slip

$f_r \rightarrow$ limiting

Ques

Two block A and B of masses 5 kg and 3 kg respectively rest on a smooth horizontal surface with B over A. The coefficient of friction b/w A and B is 0.5. The maximum horizontal force (in N) that can be applied to A. So that there will be motion of A and B without relative slipping is.

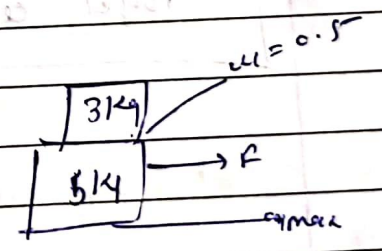
- ① 1.5
- ② 2.5
- ③ 4 ✓
- ④ 5

$$a_{\max} = \mu g = \frac{5}{10} \times 10$$

$$a_{\max} = \frac{F}{m_1 + m_2}$$

$$1.5 = \frac{F}{8}$$

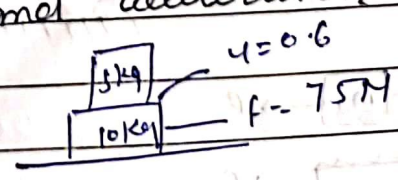
$$F = 40$$



Ques

Find friction b/w the block and acceleration of the block

$$a = \frac{75}{15} = 5 \text{ m/s}^2$$



$$a_{\max} = \mu g$$

$$0.6 \times 10 = 6 \text{ m/s}^2$$

They will move together

$$a_{10\text{kg}} = a_{5\text{kg}} = 5 \text{ m/s}^2$$

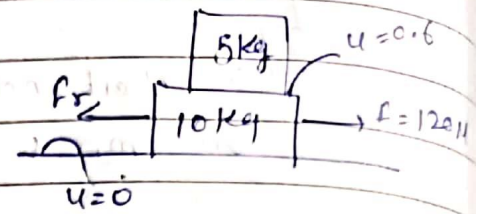
$$5 \text{ kg } \rightarrow f_r = m a = 5 \times 5 = 25$$

Ques Find friction b/w the block acceleration of the block

$$a_{max} = \mu g = \frac{6}{10} \times 10 = 6 \text{ m/s}^2$$

$$a = \frac{120}{15} = 8 \text{ m/s}^2$$

They will not move together



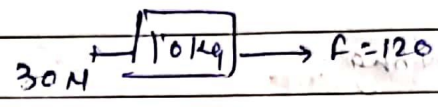
$$f_{r, \text{on}} = m a_{max}$$

$$\mu N = m a_{max}$$

$$\frac{6}{10} \times 10 \times 5 = 30 \text{ N}$$

$$a_{max} = 6 \text{ m/s}^2$$

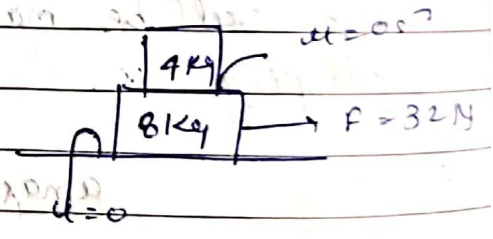
$$f_r = m a = 5 \times 6 = 30 \text{ N}$$



$$a = \frac{120 - 30}{10} = \frac{90}{10}$$

Find friction and accel of Blocks = ??

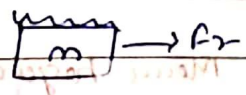
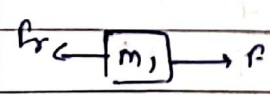
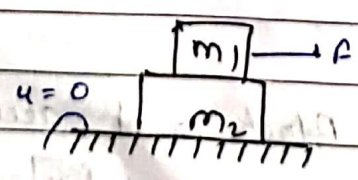
Q assumed are moving together $a = \left(\frac{32}{12} \right) = 2.6 \text{ m/s}^2$



They will together

$$a_{\text{together}} = a_{\text{together}} = 2.6 \text{ m/s}^2$$

$$f_r = m a = (4 \times 2.6) \text{ N}$$



They are about to slip

a_{max} so that they move together

$$f_{r, \text{limit}} = m_2 a_{max}$$

If they are moving together (accel = a)

$$F - f_r = m_1 a$$

$$f_r = (m_1 + m_2) a$$

$$F_{r, \text{limit}} = m_2 a_{max}$$

$$\mu m_1 g = m_2 a_{max}$$

$$a = \frac{\mu m_1 g}{m_2}$$

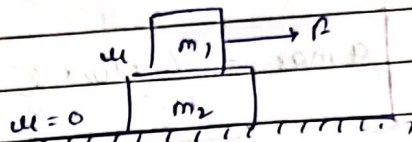
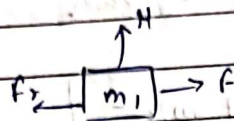
Ques In the given arrangement, the maximum value of F for which there is no relative motion b/w the blocks,

① $\mu m_1 g$

② $\mu (m_1 + m_2) g$

③ $\mu m_1 g \left(\frac{m_1}{m_2} + 1 \right)$

④ zero



$f_r = \mu N = \mu m_1 g$

$m_2 \text{ } a_{\max} : \mu m_1 g$

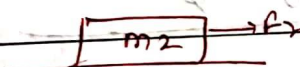
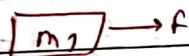
$f_{\max} = (m_1 + m_2) a_{\max}$

$(m_1 + m_2) \frac{\mu m_1 g}{m_2}$

$a_{\max} = \left(\frac{\mu m_1 g}{m_2} \right)$

$\left(\frac{m_1}{m_2} + 1 \right) \mu m_1 g$

MR



$a = \frac{F}{m_1 + m_2}$ (if they are moving together)

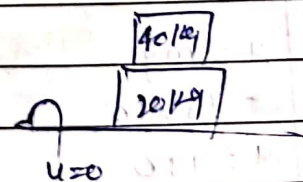
$a_{\max} = \mu g \left(\frac{m_1}{m_2} + 1 \right) > \text{Move Together}$

Ques Find friction force and acc of block

a (if they are moving together) $= \frac{120}{60} = 2 \text{ m/s}^2$

$a_{\max} = \frac{5 \times 16}{20} = \frac{40}{20} = 2$

$a_{\max} = 2 \text{ m/s}^2$



They will move together

$f_r = Ma = 20 \times 2 = 40 \text{ N}$

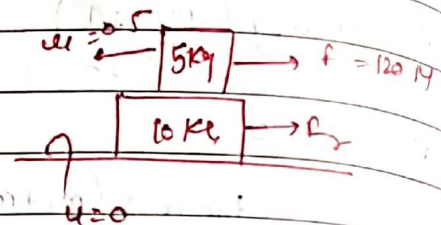
Ques Find friction force and accⁿ of block

* If they are moving together $= \frac{120}{15} = 8 \text{ m/s}^2$

$$a_{\max} = \frac{2 \times 10 \times \mu}{10} = 4 \text{ m/s}^2$$

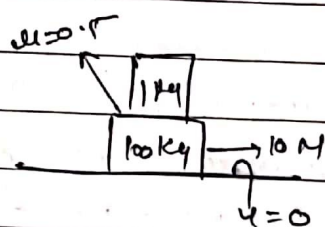
they will not move together

$$\begin{aligned} 10 \text{ kg} & \rightarrow a_{\max} = 4 \text{ m/s}^2 \\ f_r &= ma \\ 10 \times a &= 40 \text{ N} \end{aligned}$$



$$\begin{aligned} 40 \text{ N} & \leftarrow 5 \text{ kg} \rightarrow 120 \text{ N} \\ a &= \frac{120 - 40}{5} \\ a &= 16 \text{ m/s}^2 \end{aligned}$$

Ques Find friction of '1 kg'



$$a_{\max} = \mu g = \frac{5}{10} \times 10 = 5$$

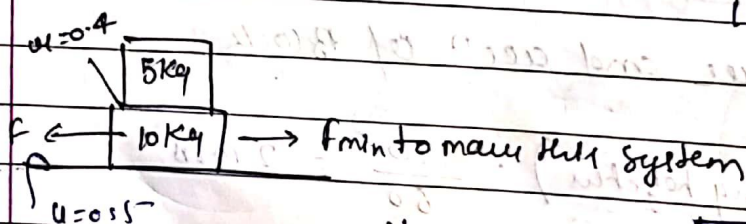
$$a = \frac{10}{101} = 0.1 \text{ m/s}^2$$

move together

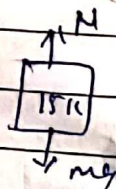
$$f_r = ma$$

$$1 \times 0.1 = 0.1 \text{ N}$$

Ques



$$\begin{aligned} N &= mg \\ &= 15 \times 10 \\ N &= 150 \end{aligned}$$

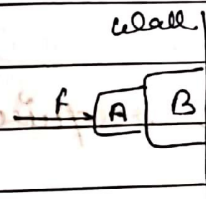


$$f_{\min} = 75 \text{ N}$$

$$f_{\text{limit}} \text{ at } \mu = \frac{5}{10} \times 150 = 75 \text{ N}$$

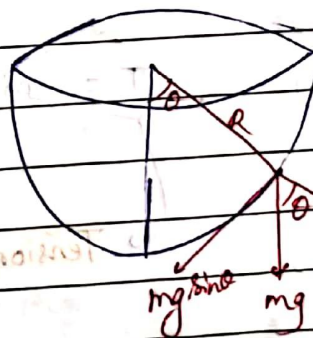
Figure show two blocks A and B pushed against the wall with force F . the wall is smooth but the surface in contact of A and B are rough. which of the following is true for the system of blocks to be at rest against wall.

- ① F should be equal to weight of A and B
- ② " " " less than wt of A and B
- ③ " " " more than wt of A and B
- ④ System cannot be in equilibrium (at rest)



Ques An insect crawls up a hemispherical surface. the coefficient of friction betw the insect and the surface is $\frac{1}{3}$. If the line joining the centre of the hemispherical surface to the insect makes an angle α with the vertical. the maximum possible value of α is given by.

- ① $\cos \alpha = 3$ ✓
- ② $\tan \alpha = 3$
- ③ $\sec \alpha = 3$
- ④ $\cos \alpha = \frac{1}{3}$

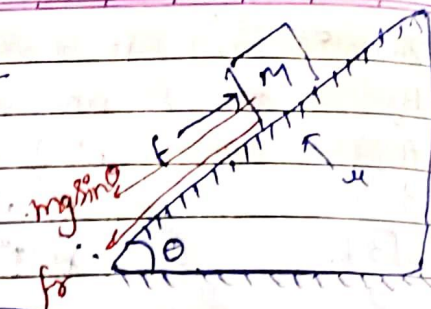


$$mg \sin \theta = \mu mg \cos \theta$$

$$\tan \theta = \mu$$

$$\tan \theta = \frac{1}{3}$$

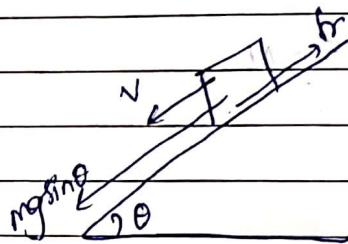
- ① $mg \sin \theta - \mu mg \cos \theta$
 ② $mg \sin \theta + \mu mg \cos \theta$ ✓
 ③ $mg \sin \theta$
 ④ $\mu mg \cos \theta$



$$f = mg \sin \theta + (f_s) \mu$$

Que Block of mass 10 kg is moving on inclined plane with constant velocity 10 m/s. The coefficient of kinetic friction b/w inclined plane and block is.

- ① 0.57
 ② 0.75 ✓
 ③ 0.5
 ④ None of these



$$mg \sin \theta = \mu mg \cos \theta$$

$$\frac{\sin \theta}{\cos \theta} = \mu$$

$$\mu = \tan \theta$$

$$= \frac{3}{4}$$

Que A block of mass m placed on a inclined plane of inclination θ slides down the plane with constant speed. The coefficient of kinetic friction b/w block and inclined plane is.

- ① $\sin \theta$
 ② $\cos \theta$
 ③ $\tan \theta$ ✓
 ④ $\tan^{-1} \theta$

Q. A block of mass 10 kg is released on rough inclined plane. Block starts descending with acceleration 2 m/s^2 . Kinetic friction force acting on block is (take $g = 10 \text{ m/s}^2$)

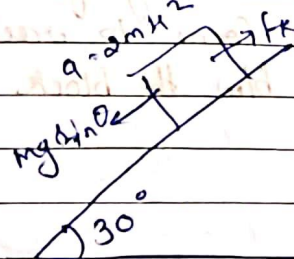
- (1) 10 N
 (2) 30 N ✓
 (3) 50
 (4) $50\sqrt{3} \text{ N}$

$$mg = mg(\sin \theta) + f_k$$

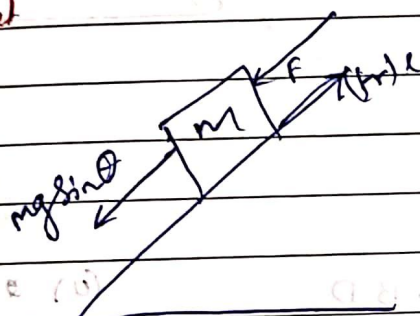
$$10 \times 10 = 10 \times 10 \times \frac{1}{2} + f_k$$

$$20 = 50 + f_k$$

$$f_k = 50 - 20 = 30 \text{ N}$$



Q. If ($\mu > 0$) find minimum force required to move this object



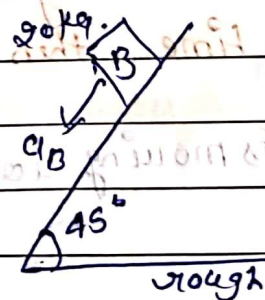
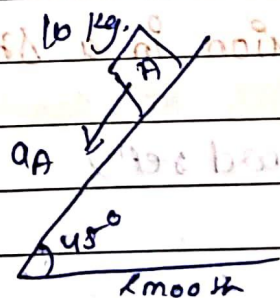
along inclined plane for just about to move

$$mg \sin \theta + f = (F \cos \theta) = \mu N$$

$$f = \mu mg \cos \theta - mg \sin \theta$$

Q. The ratio of acceleration of blocks A placed on smooth incline with Block B placed on Rough incline is $2:1$. The coefficient of kinetic friction b/w Block B and incline is:

- (1) 0.5 ✓
 (2) 0.75
 (3) 0.57
 (4) None of these



$$\frac{a_A}{a_B} = \frac{2}{1} = \frac{g \sin \theta}{g(\sin \theta - \mu \cos \theta)}$$

$$a_A = g \sin \theta - \mu g \cos \theta$$

$$2 = \frac{\sin \theta}{\sin \theta - \mu \cos \theta} = 1 - \mu = \frac{1}{2} \Rightarrow 1 - \frac{1}{2} = \mu \Rightarrow \mu = \frac{1}{2}$$

Ques The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom. If the coefficient of friction b/w the block and lower half of the plane is given by,

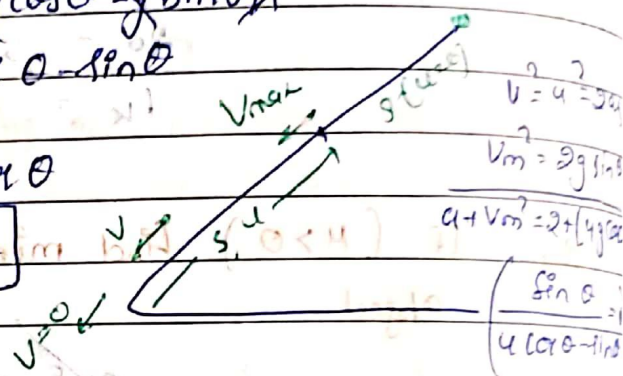
① $\mu = \frac{2}{\tan \theta}$ $g \sin \theta = (\mu g \cos \theta - g \sin \theta)$

② $\mu = 2 \tan \theta$ $\sin \theta = \mu \cos \theta - \sin \theta$

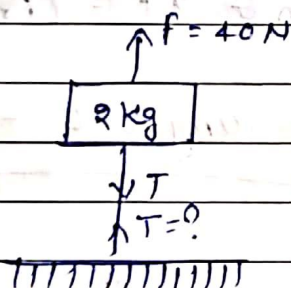
③ $\mu = \tan \theta$

④ $\mu = \frac{1}{\tan \theta}$ $2 \sin \theta = \mu \cos \theta$

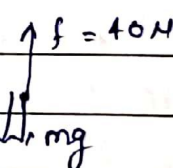
$\mu = 2 \tan \theta$



Ques Find tension in string



f. B. D



$T + mg = F$

$T = (40 - 20) = 20 \text{ N}$

(a) 20 kg

(b) 40 kg

(c) 60 kg

(d) 10 kg

Ques lift is retarding downward with 4 m/s^2 & will stop after some time, then tension in a string will be.

(lift is moving downward)

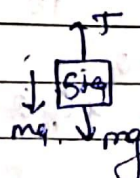


$T = ma + mg$

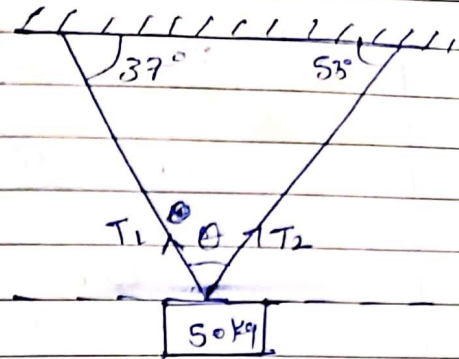
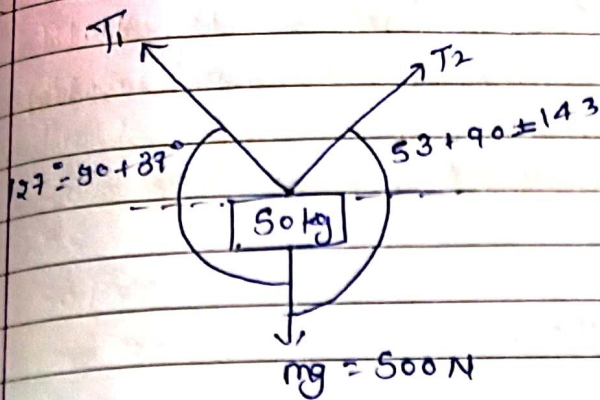
$= m(a + g)$

$= 5(4 + 10) = 70 \text{ N}$

f. B. D of 5 kg w.r.t. Retaal



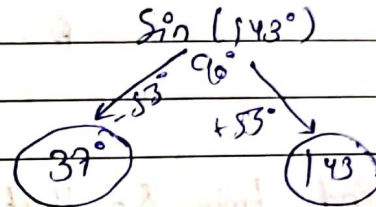
Q. Find T_1 & T_2 .



$$\frac{T_1}{\sin 143^\circ} = \frac{mg}{\sin 90^\circ}$$

$$T_1 = \frac{\sin 143^\circ \times 500}{1}$$

$$\frac{3}{5} \times 500 = 300 \text{ N}$$

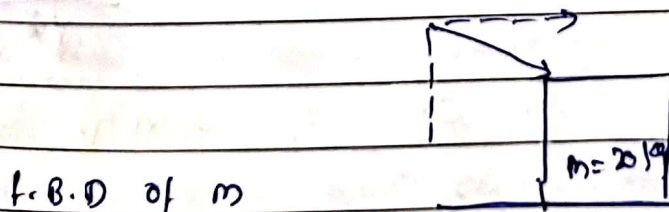


retardation means -ve accⁿ $\rightarrow$ false

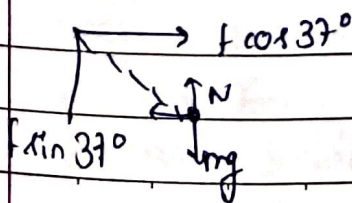
$\rightarrow$ does not mean -ve accⁿ

$\rightarrow$ acc opposite to velocity (motion)

Q. Find F so that block can slide on rough surface.



f.b.d of m



$$\Sigma F_y = 0$$

$$N = F \sin 37^\circ + mg$$

$$F \cos 37^\circ = f_r = \mu N$$

$$F \cos 37^\circ = \mu (F \sin 37^\circ + mg)$$

$$f \times \frac{4}{5} = \frac{4}{10} \left(f \frac{3}{5} + 200 \right)$$

$$2f = \frac{3f}{5} + 200$$

$$2f - \frac{3f}{5} = 200$$

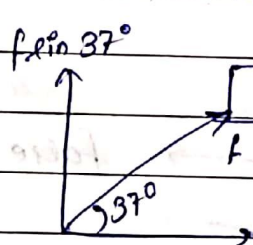
$$\frac{10f - 3f}{5} = 200$$

$$7f = 1000$$

$$f = \left(\frac{1000}{7} \right) \text{ N}$$

Ques find $f_{\min}$ so that block will be at rest.

I.B.D of Block



$$\begin{cases} \Sigma F_x = 0 \\ f \cos 37 = N \end{cases}$$

$$\Sigma F_y = 0$$

$$f \sin 37^\circ + (N)_x = mg$$

$$f \sin 37 + 4N = mg$$

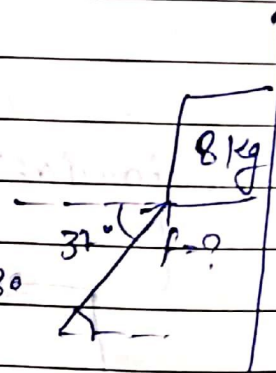
$$f \frac{3}{5} + \frac{4}{10} f \times \frac{4}{5} = 80$$

$$f \left(\frac{3}{5} + \frac{16}{50} \right) = 80$$

$$f \left(\frac{30+16}{50} \right) = 80$$

$$f = \frac{80 \times 50}{46}$$

$$\frac{4000}{46} \text{ N}$$



Ques A suitcase is gently dropped on a conveyor belt moving at 3 m/s , if the coefficient of friction b/w the belt and the suitcase is 0.5 find the displacement of suitcase relative to conveyor belt before slipping b/w the two is stopped ($g = 10\text{ m/s}^2$)

(a) 2.7 m

(b) 1.8 m

(c) 0.9 m ✓

(d) 1.2 m

$a = \mu g$

$v^2 - u^2 = 2as$

$(3)^2 - 0 = 2 \times 0.5 \times s$

$s = \frac{9}{2 \times \frac{1}{2} \times 10}$

$s = 0.9\text{ m}$

Ques Ram Lal is walking along east then direction of friction on Ram Lal is ??

- (a) East (static)
- (b) West
- (c) North
- (d) South

Ques When a bicycle is in motion, the force of friction exerted by the ground on the two wheels is such that it acts

- (a) in the backward direction on the front wheel and in the forward direction on the rear wheel.
- (b) in the forward direction on the front wheel and in the backward direction on the rear wheel.
- (c) in the backward direction on both front and rear wheels.
- (d) in the forward direction on both the front and rear wheels.

Circular Dynamics :- Study of Cause of Circular motion

→ Object is moving with constant speed in straight line without net external force ($F_{net} = 0$) → True

(ii) Object is moving with constant speed on circular path without net external force (UCM) → false

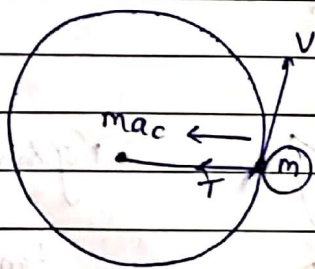
direction is changing here =

accelerated body

hence there must be a force which will provide required accⁿ = $\frac{v^2}{R}$

Centripetal force :-

It is not a force. Centripetal force just a name given to the requirement of force to move the object on circular path. This requirement can be fulfilled by any real force.



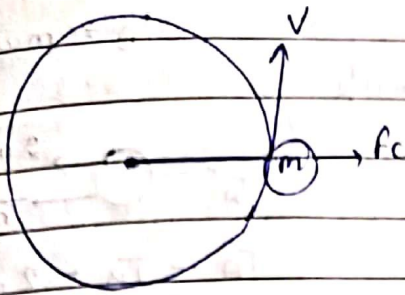
$$F_{net} = m a_c$$

$$T = m \left(\frac{v^2}{R} \right) = \text{net force towards centre}$$

Tension force is - Playing a role of Centripetal force.

Centrifugal force :-

Centrifugal force is a pseudo force from non Inertial frame (frame moving on circular path)



→ Non Inertial Observer

→ Pseudoforce (opposite dirⁿ of R.L)

→ Object is at rest w.r.t R.L

$m \rightarrow F_c = ma_c = \frac{mv^2}{R}$

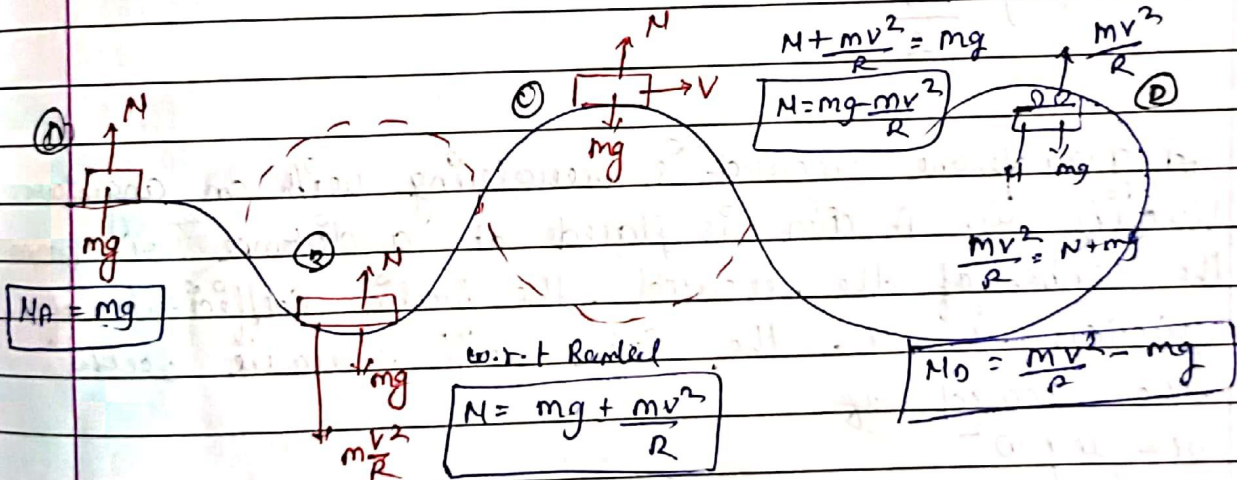
$T_c = \frac{mv^2}{R}$

Centripetal force (ground)

$F_{\text{net}} = 0$

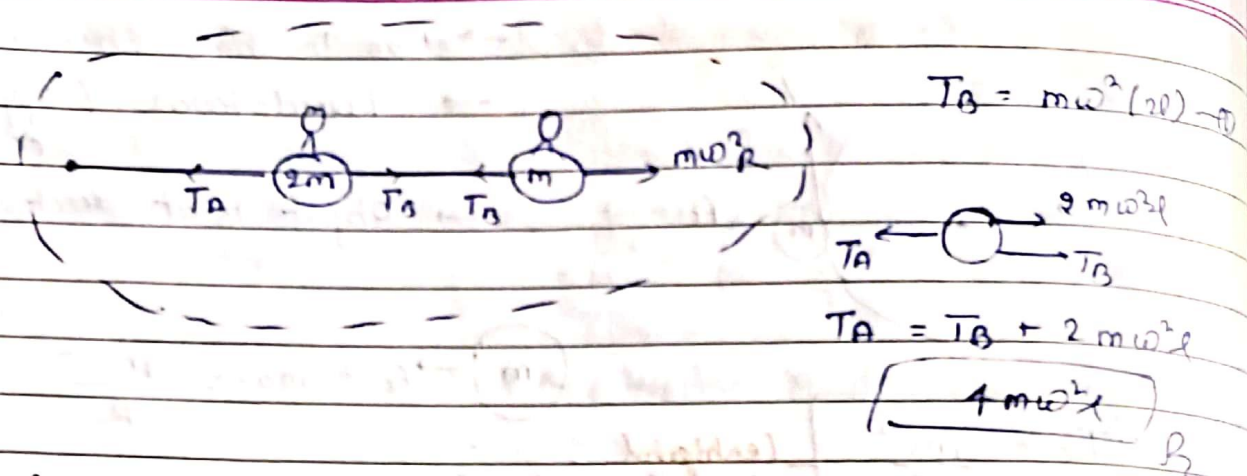
$T = \frac{mv^2}{R}$

Can Centripetal force and Centrifugal force balance each other ?? — No

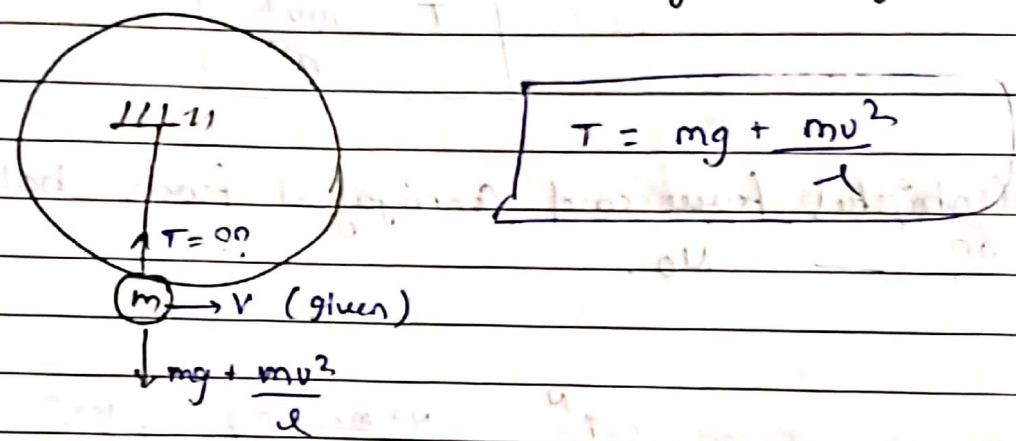


Find Centripetal at B from ground

$F_c = N - mg$
 $\left(\frac{mv^2}{R}\right) = N - mg$

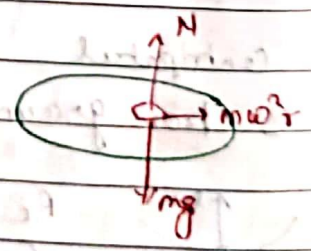


Ques Find Centrifugal force acting on object



Ques A gramophone record is revolving with an angular velocity ω . A coin is placed at a distance r from the centre of the record. The static coefficient of friction is μ . The coin will revolve with the record if.

- ✓ 1. $\mu \geq \mu g \omega^2$
2. $r < \frac{\omega^2}{\mu g}$ f.B.d Disc w.r.t Ramtal
3. $r < \frac{\mu g}{\omega^2}$
4. $r \geq \frac{\mu g}{\omega^2}$
- f.B.d (static) $\mu N \geq m\omega^2 r$
- No for Condition $\frac{\mu g}{\omega^2} \geq r$



Q. A boy is sitting on the horizontal platform of a rotating wheel at a distance of 5 m from the centre. The wheel begins to rotate and when the angular speed exceeds 1 rad/s, the boy just slips. The coefficient of friction b/w the boy and the wheel is $(g = 10 \text{ m/s}^2)$

① 0.5 ✓ $\omega = 1 \text{ rad/s}$

② 0.32

③ 0.71

④ 0.2

$$\mu mg = m\omega^2 r$$

$$\mu = \frac{\omega^2 r}{g} \Rightarrow \frac{1 \times 5}{10} = \frac{1}{2} \text{ B}$$

Bending of Cyclist

① — $N \cos \theta = mg$

② — $N \sin \theta = \frac{mv^2}{R}$

② / ①

$$\frac{N \sin \theta}{N \cos \theta} = \frac{mv^2}{Rmg}$$

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

$$V_m = \sqrt{Rg \tan \theta}$$

Q. A Cyclist riding the bicycle at a speed of $14\sqrt{3}$ m/s takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. What is his inclination to the vertical?

① 30°

② 45°

③ 60° ✓

④ 75°

$$V = \sqrt{Rg \tan \theta}$$

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

$$\frac{14 \times 14 \times 3}{10 \times 20\sqrt{3}} = \tan \theta$$

$$\tan \theta = \frac{3}{\sqrt{3}} = \sqrt{3}$$

$$v = 14\sqrt{3}$$

$$R = 20\sqrt{3}$$