PRACHAND NEET

ONE SHOT

Physics

FRICTION
and Circular Motion

By – Brofessor Dr. Aayudh

Topics *to be covered*

1. Part 1 – Basic Maths And Vectors

(NLM revise)

2. Part 2 – Normally Dhakka Maro
3. Part 3 – Theory of friction
4. Part 4 – Cone of Friction
5. Part 5 – Block Hilega ki nahi

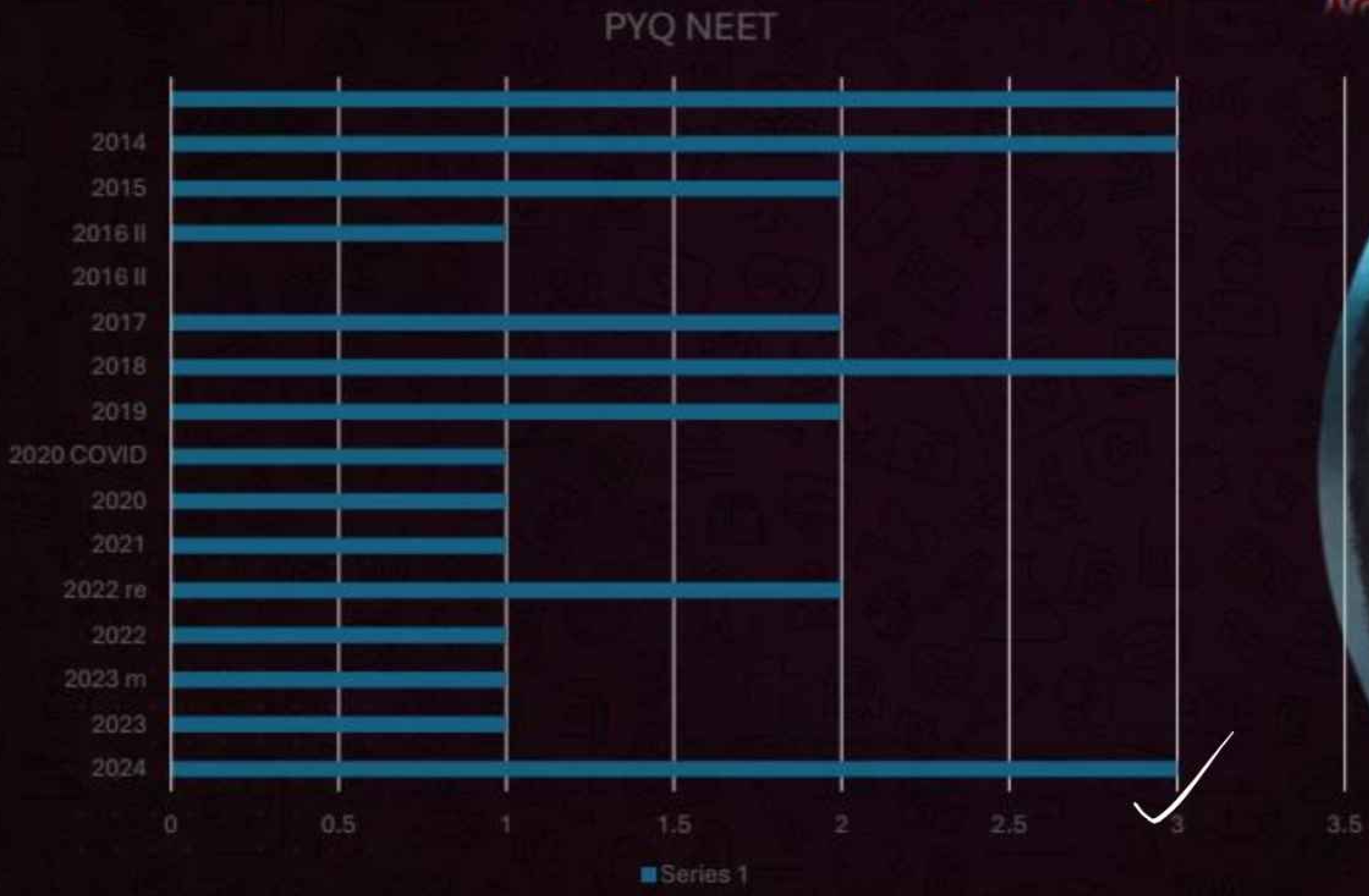

PRACHAND SERIES
TELEGRAM CHANNEL
@PW_YAKEENDROPPER
S#07
@BROFESSORARMY

NEET SYLLABUS

- Static and Kinetic friction
- Laws of friction
- Rolling friction

BROFESSOR ANALYSIS

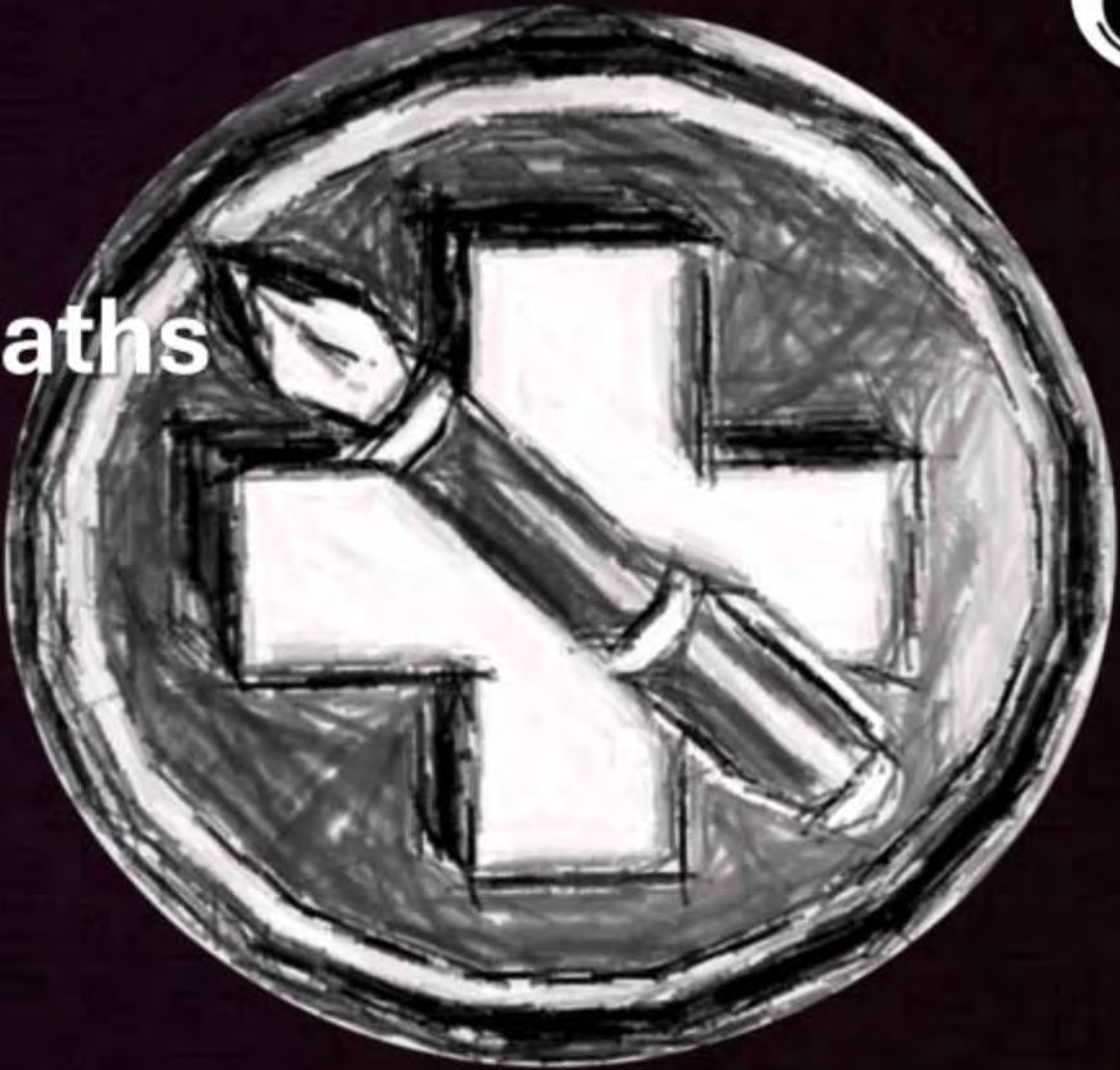
Difficulty Level : EASY
Difficulty Level : MEDIUM
Difficulty Level : HARD
Difficulty Level : YODHA



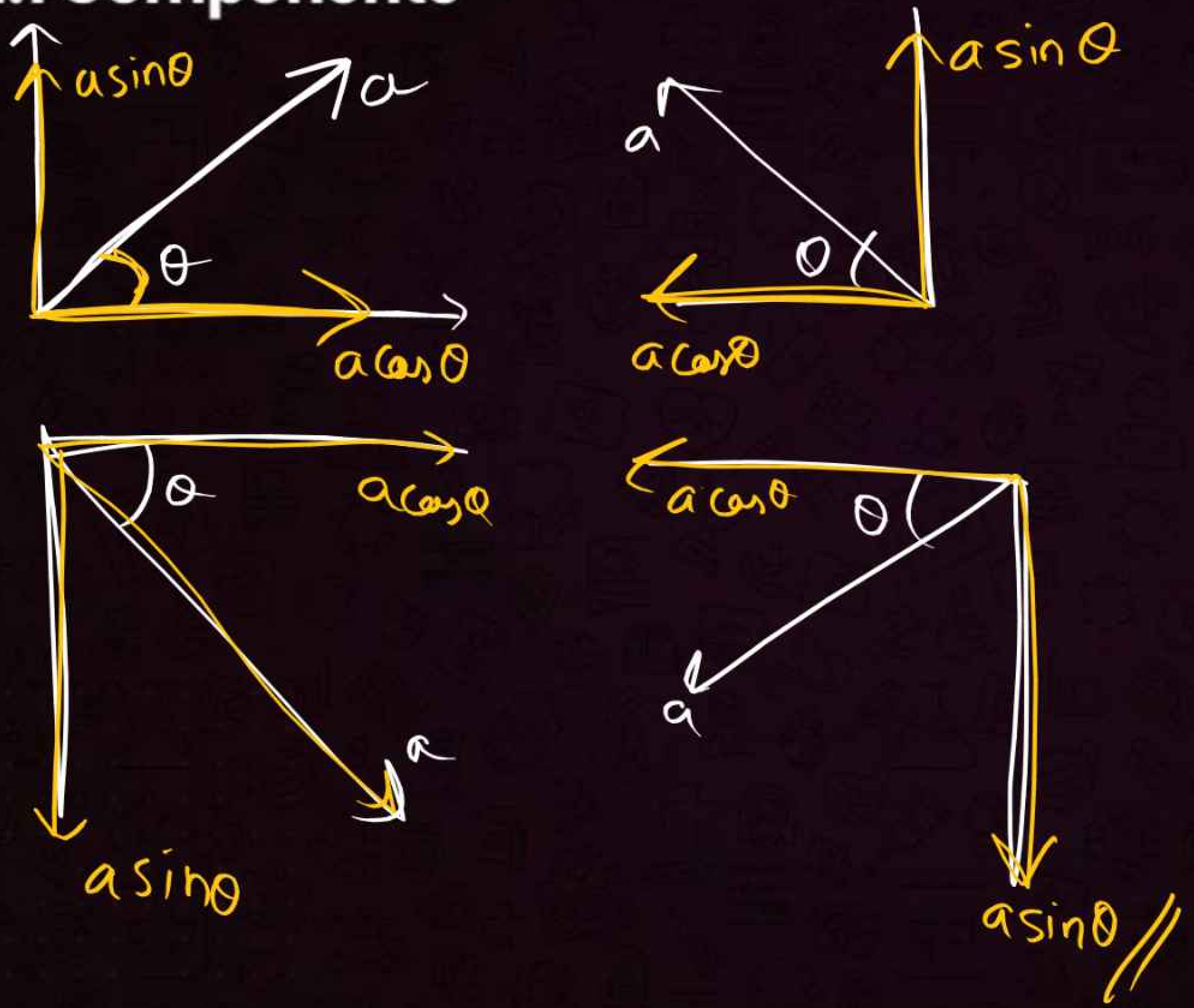
Topics *to be covered*

6. Part 6 – μ marna buri baat hai
7. Part 7 – Approaches in Friction (YODHA)
8. Part 8 – Friction in connected bodies
9. Part 9 – Multiple Block System
10. Part 10 – Theory based question and AR
11. Part 11 – PUPPY POINTS and Revision

Part 1 – Basic Maths And Vectors



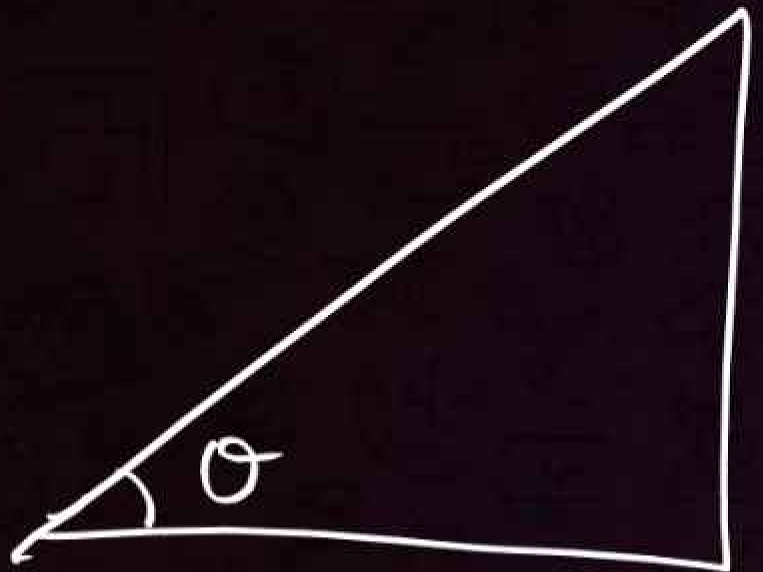
1.1 Components



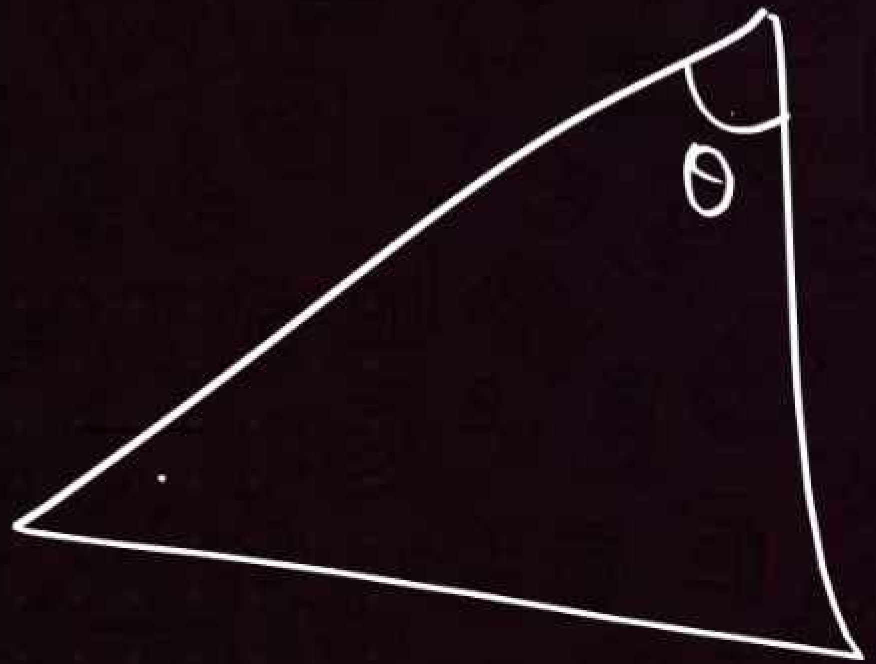
1.2 Jadugar SIN COS Complement

$\sin \longleftrightarrow \cos$

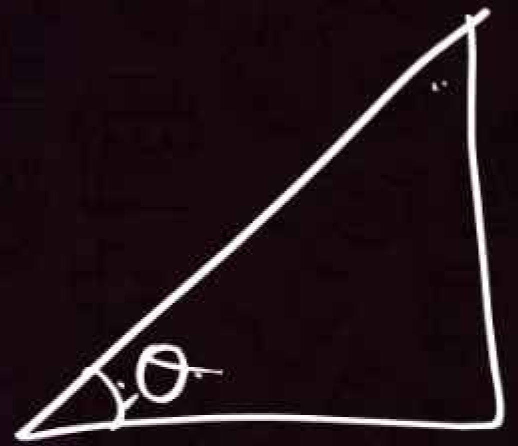
$\tan \longleftrightarrow \cot$



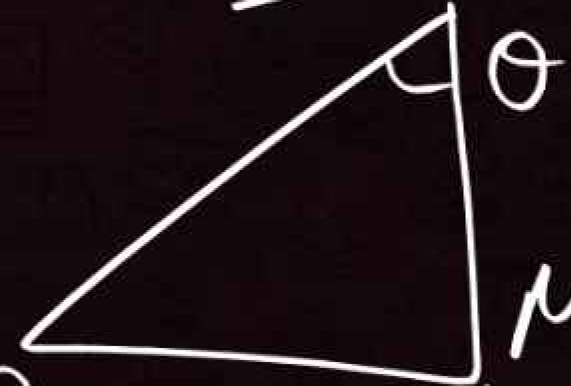
$$s = \frac{v^2}{2(g\sin\theta - \mu\cos\theta)}$$



$$s = \frac{v^2}{2(g\cos\theta - \mu\sin\theta)}$$



$\mu = 2\tan\theta$

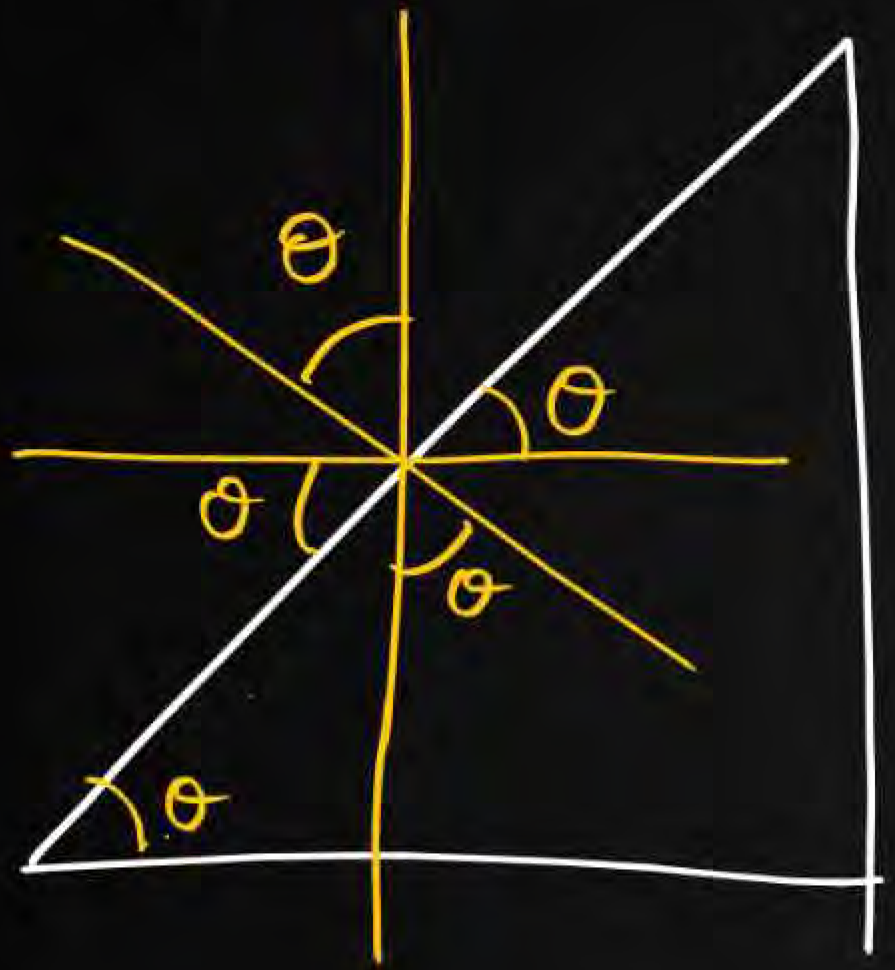


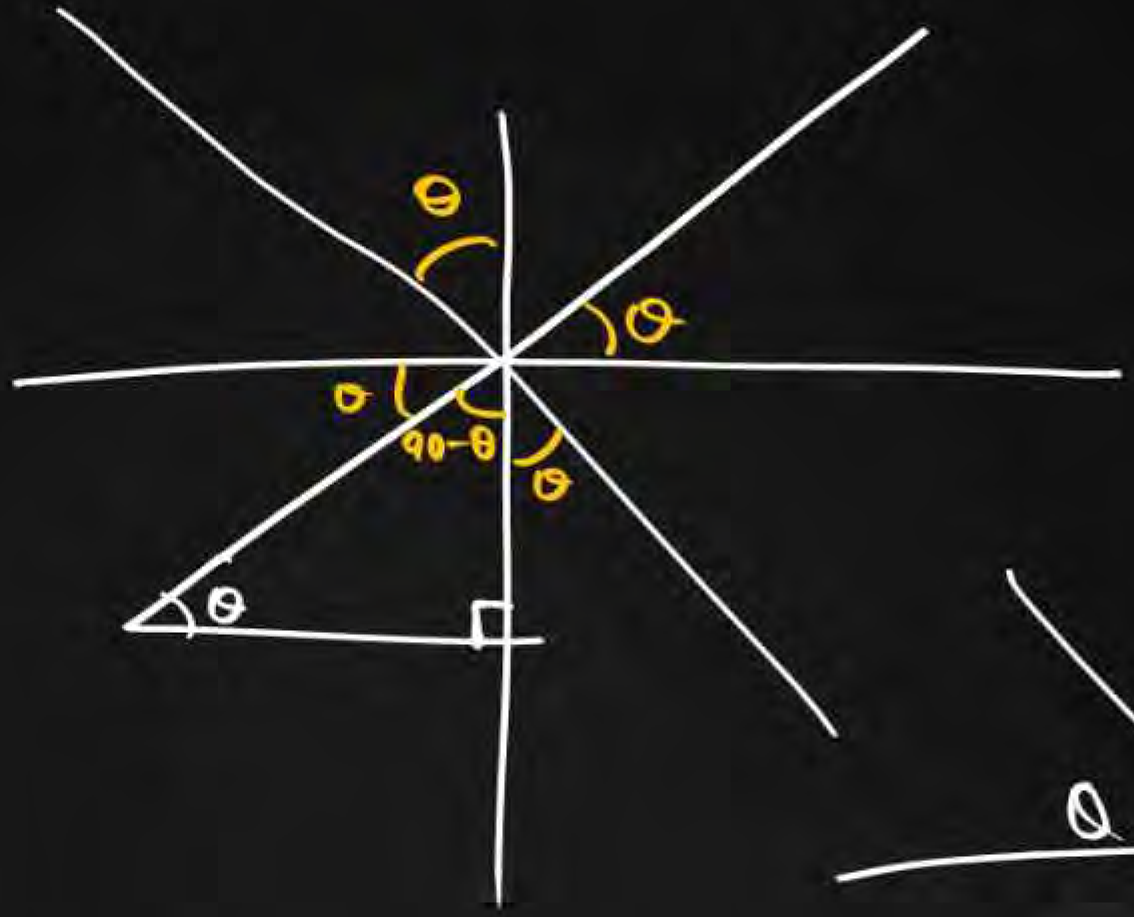
$\mu =$

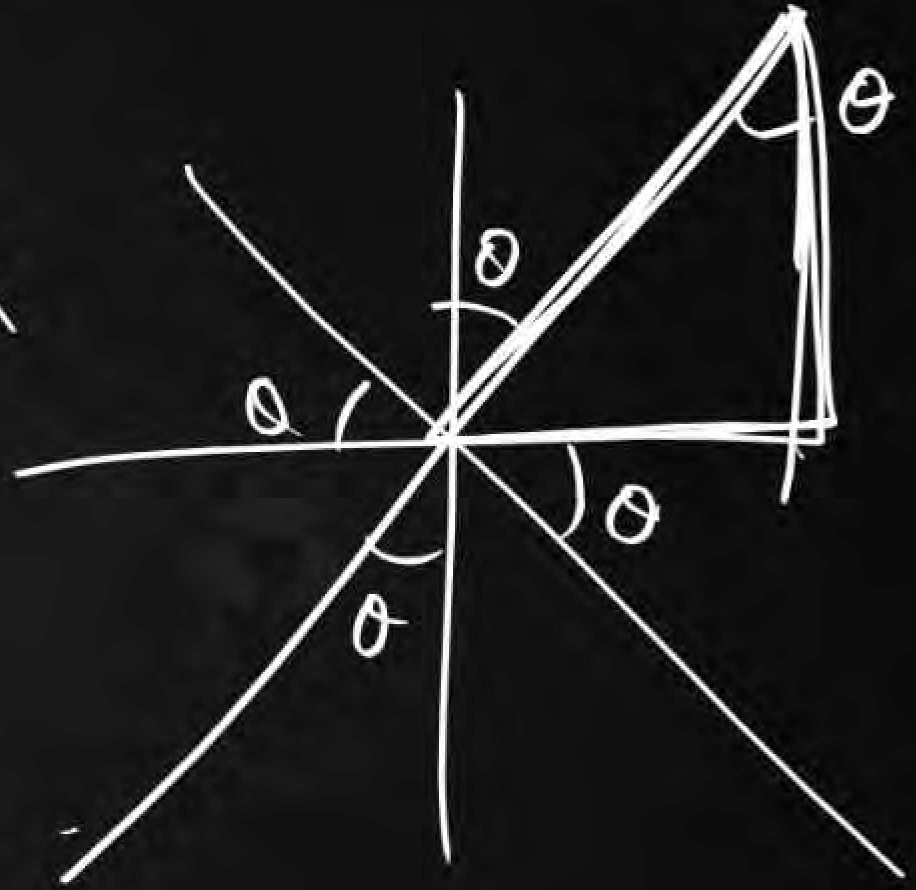
(A) $2\tan\theta$ (C) $\tan\theta$

(B) $\cot\theta$ (D) $2\cot\theta$

1.3 Angle nikalna







1.4

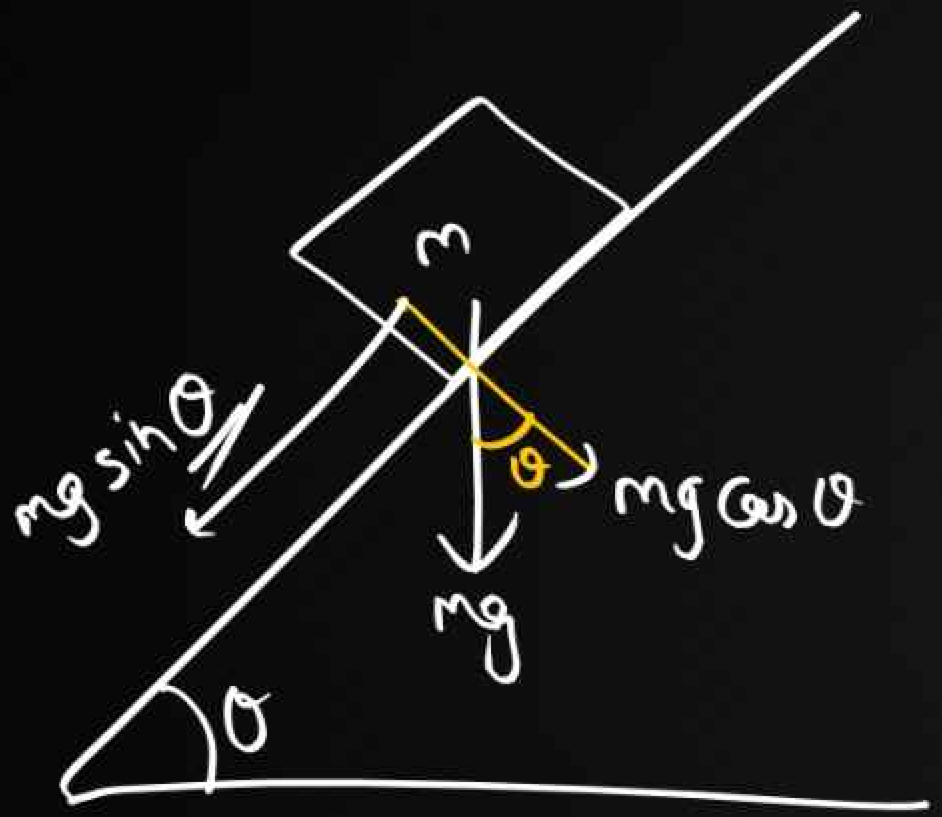
$$y = a\sin\theta + b\cos\theta$$

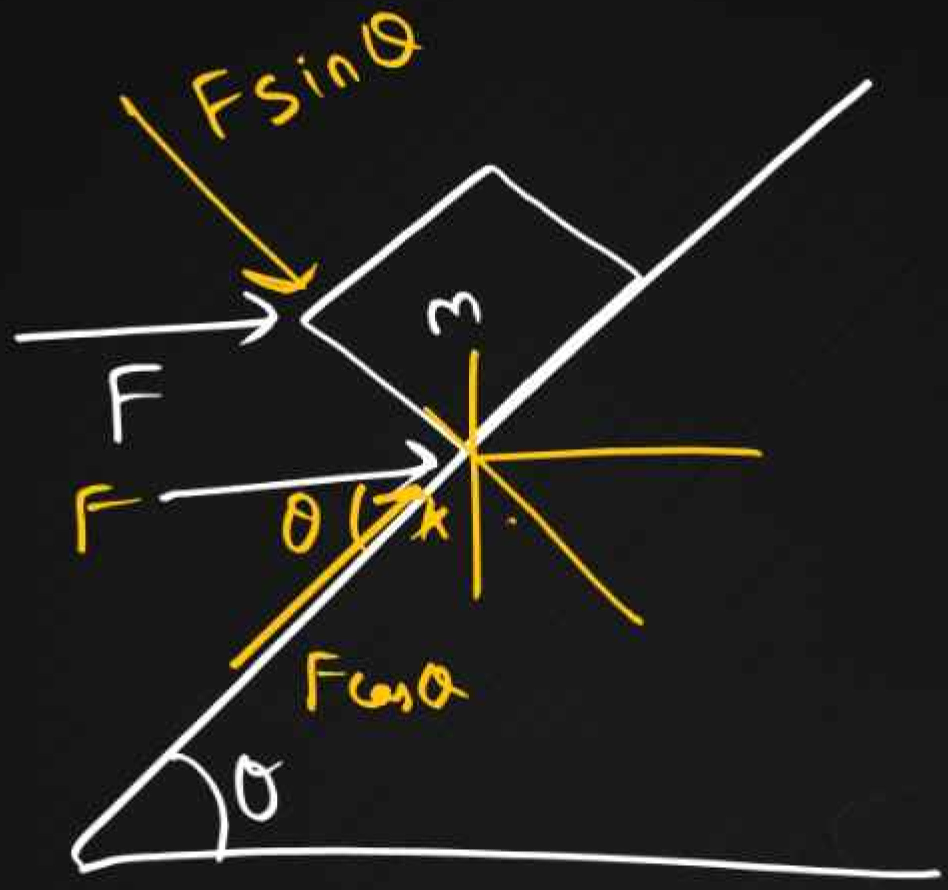
$$y_{max} = \sqrt{a^2 + b^2}$$

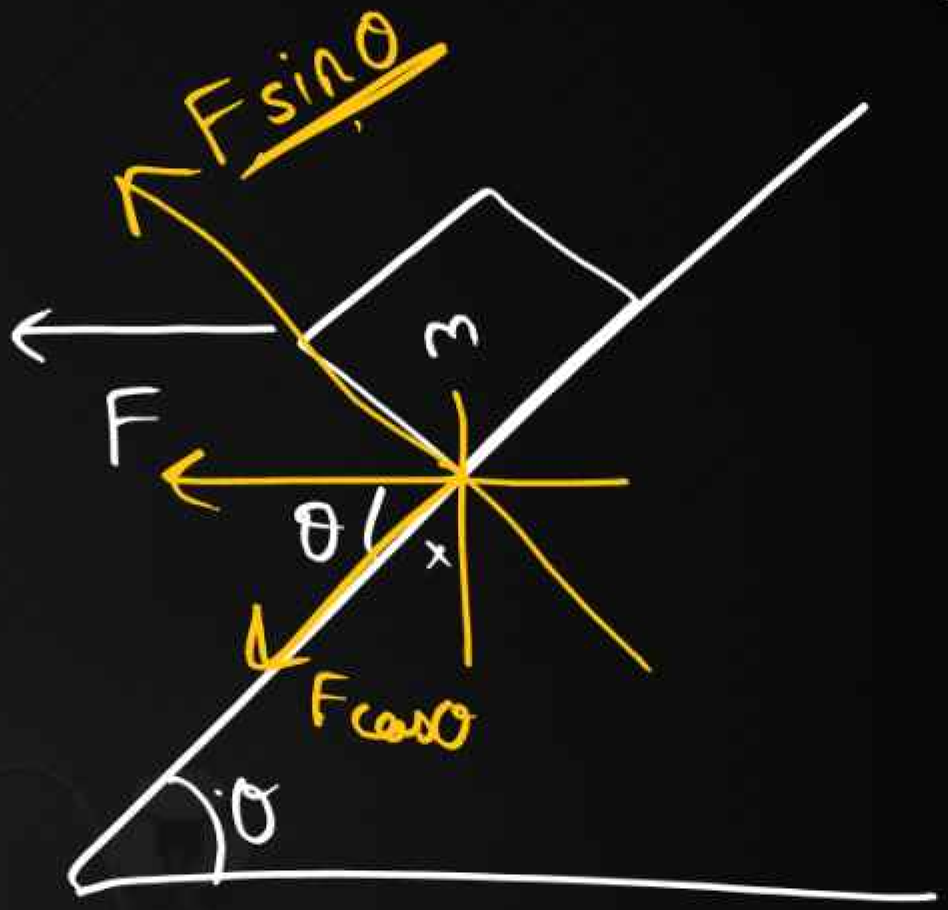
$$x = \frac{1}{a\sin\theta + b\cos\theta}$$

$$x_{min} = \frac{1}{\sqrt{a^2 + b^2}}$$

1.5







I-6

$$\tan(A+B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$$

Mamu

$$\tan(A-B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}$$

$$\tan(\phi+\theta) = \frac{\tan\phi + \tan\theta}{1 - \tan\phi\tan\theta}$$

$$\tan(\phi-\theta) = \frac{\tan\phi - \tan\theta}{1 + \tan\phi\tan\theta}$$

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

$$\tan(\phi+\theta) = \frac{\mu + \tan\theta}{1 - \mu\tan\theta}$$

$$\tan(\phi-\theta) = \frac{\mu - \tan\theta}{1 + \mu\tan\theta}$$

1.7 Values

	0°	30°	45°	60°	90°	37°	53°
sin	0	$1/2$	$1/\sqrt{2}$	$\sqrt{3}/2$	1	$3/5$	$4/5$
cos	1	$\sqrt{3}/2$	$1/\sqrt{2}$	$1/2$	0	$4/5$	$3/5$
tan	0	$1/\sqrt{3}$	1	$\sqrt{3}$	×	$3/4$	$4/3$

Solve

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

$\theta = ??$

(A) 0°

(B) 30°

(C) 60°

(D) 37°

Part 2 – Normally Dhakka Maro

2.1 Normal kya hai

Chipakne ka Force

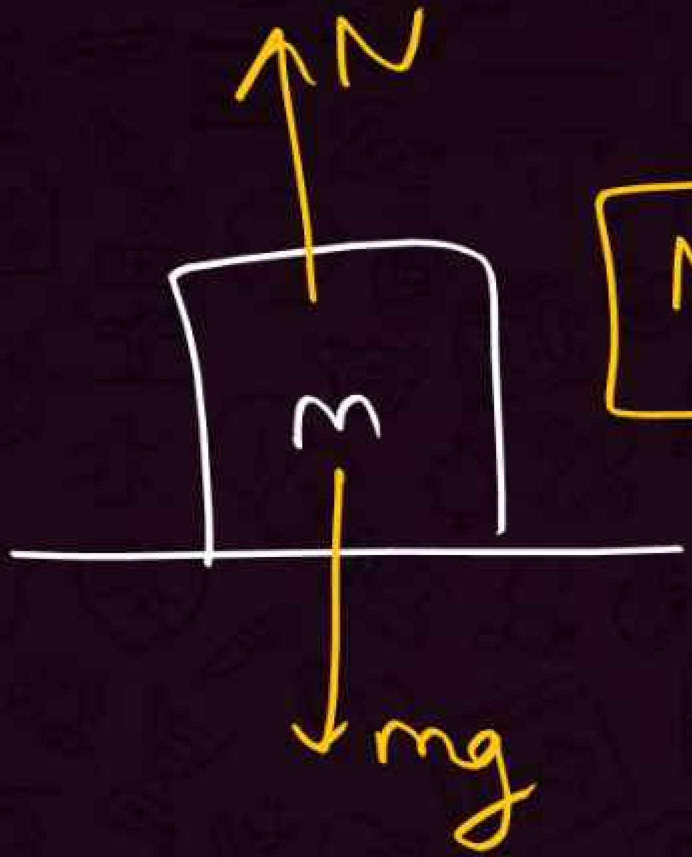
- N, mg are not action reaction pair
- (Action-Reaction cannot act on same object) ✓

<u>Dhakka</u> → Wo Force Jo end me balance nahi hua

Difficulty Level : Easy

QUESTION-01

Calculate value of Normal

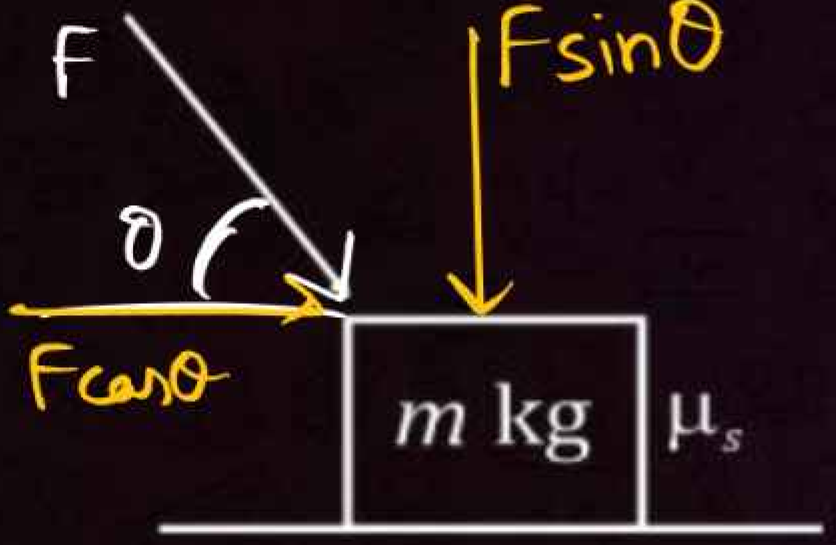


$\boxed{N = mg}$

Difficulty Level : Easy

QUESTION-02

Calculate value of Normal

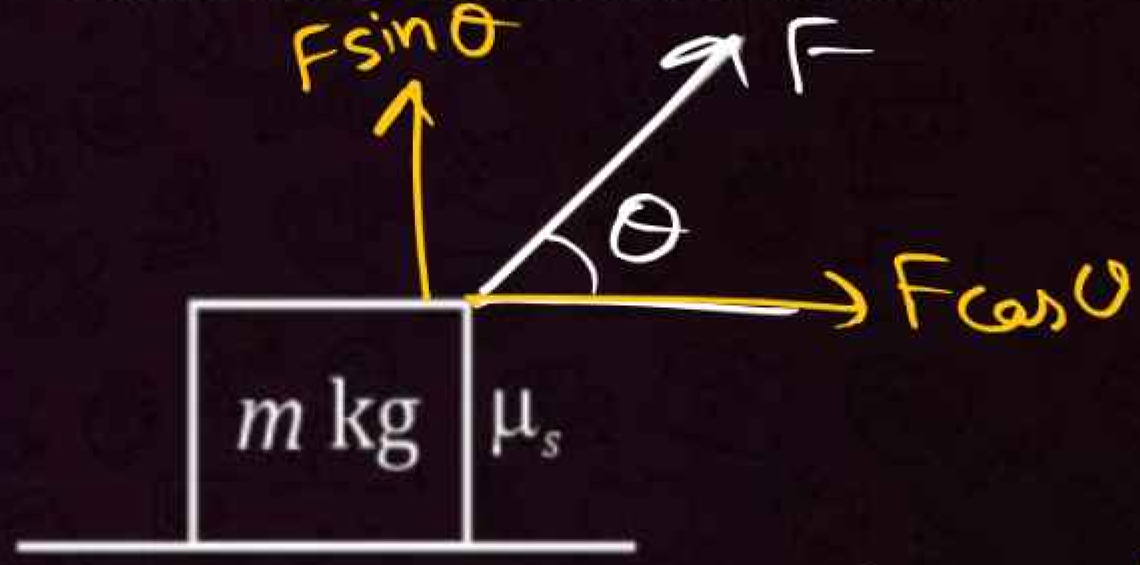


$N = mg + F\sin\theta$

$D = F\cos\theta$

QUESTION-03

Calculate value of Normal



$N = mg - F\sin\theta$

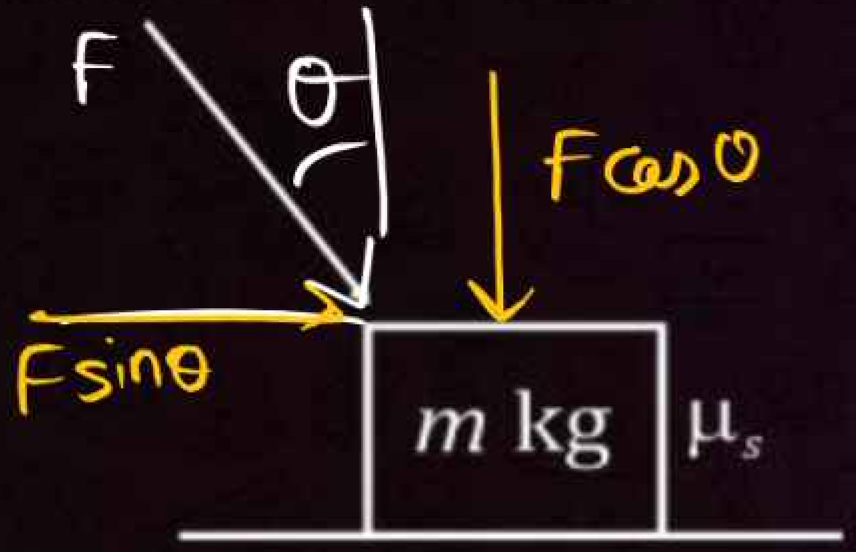
$D = F\cos\theta$

	N,	N
(A)	↑	↑
(B)	↓	↓
(C)	↑	↓
(D)	↓	↑

Difficulty Level : Easy

QUESTION-02

Calculate value of Normal

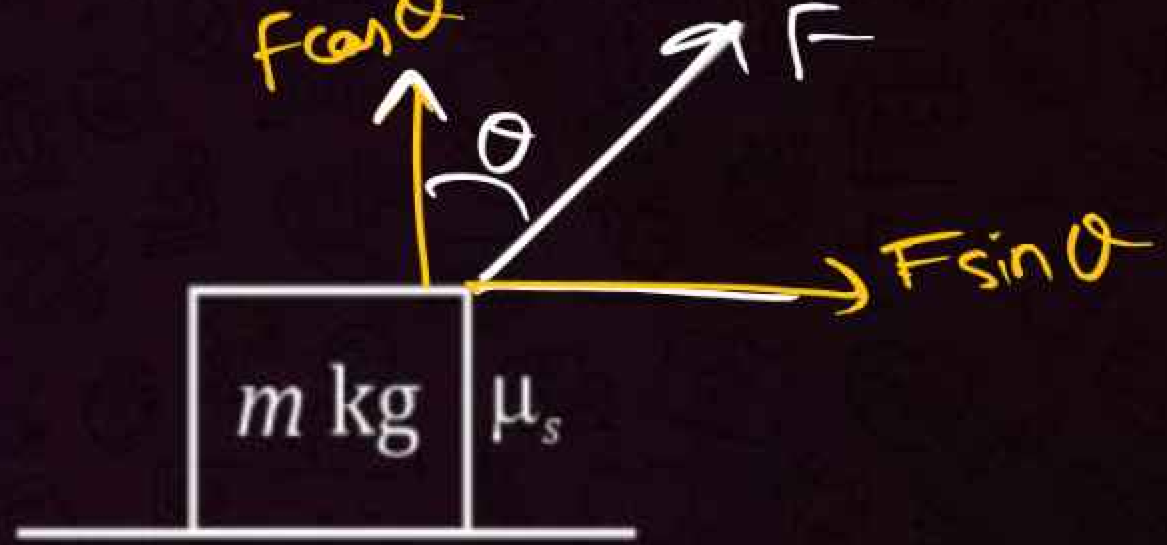


$N = mg + F\cos\theta$

$D = F\sin\theta$

QUESTION-03

Calculate value of Normal



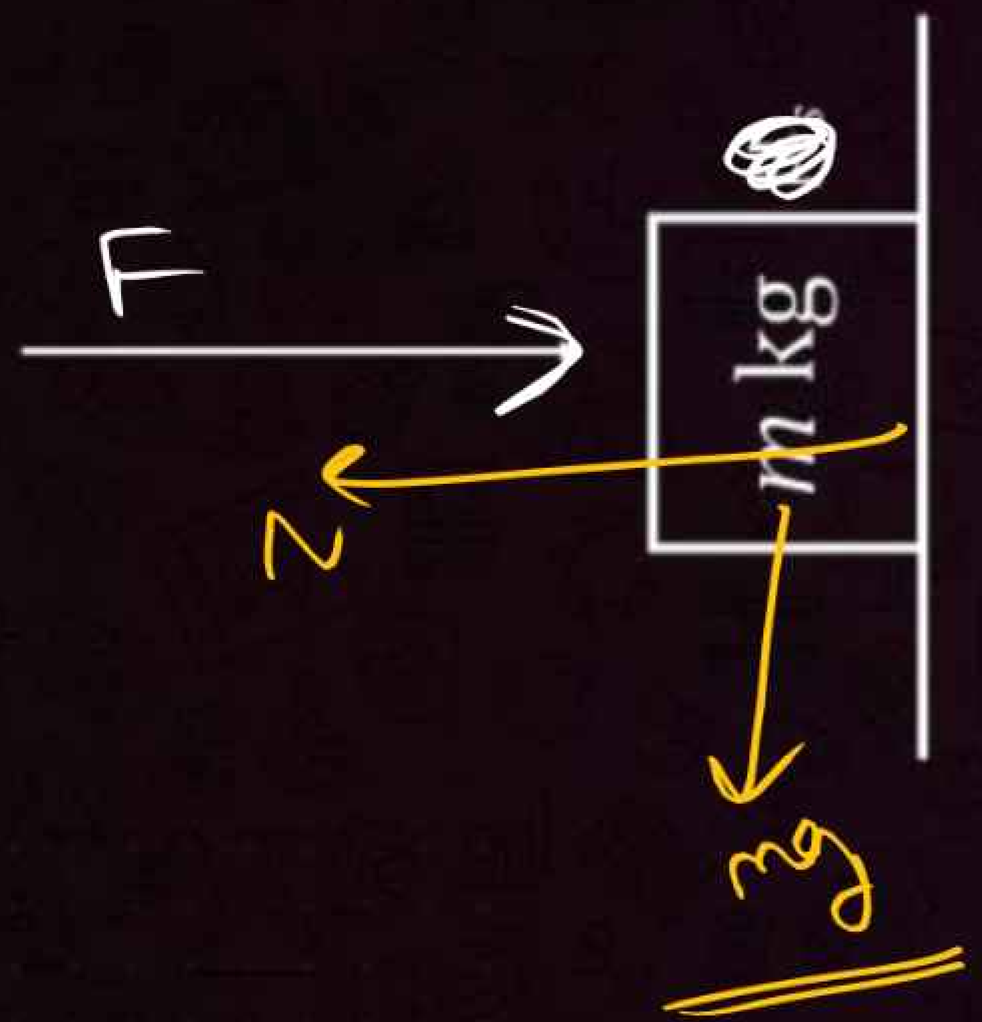
$N = mg - F\cos\theta$

$D = F\sin\theta$

QUESTION-04

Difficulty Level : Easy

Calculate value of Normal



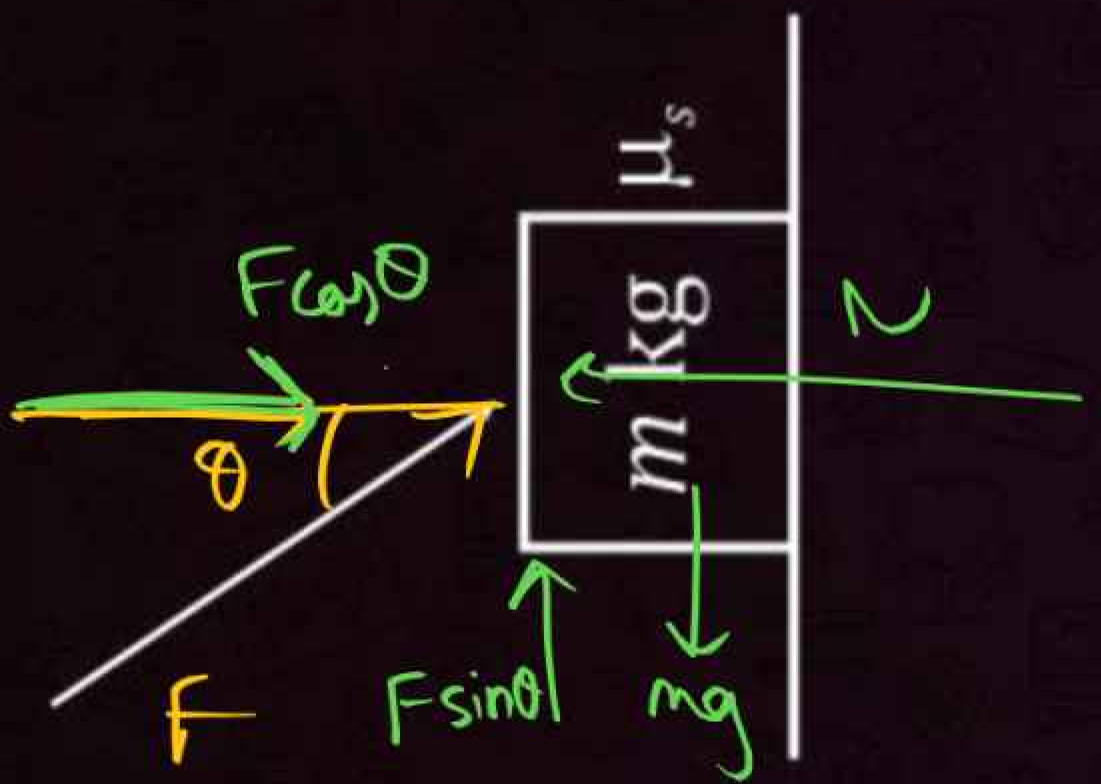
$N = F$

$D = mg$

Difficulty Level : Easy

QUESTION-05

Calculate value of Normal

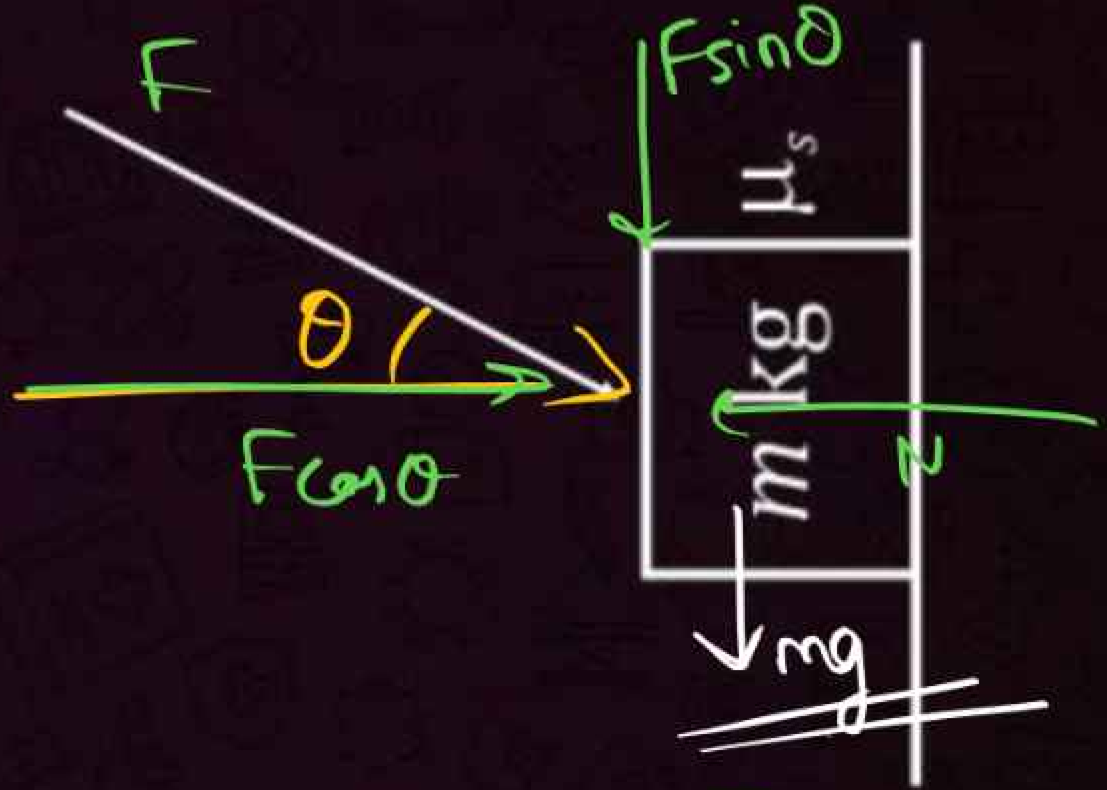


$N = F\cos\theta$

$D = mg - F\sin\theta$

QUESTION-06

Calculate value of Normal



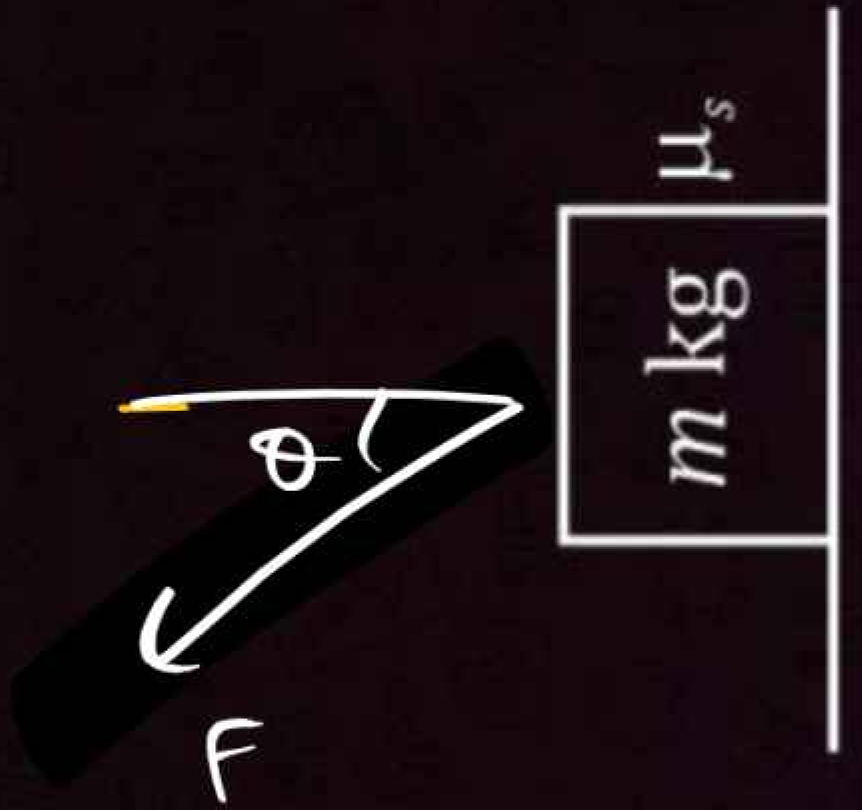
$N = F\cos\theta$

$D = mg + F\sin\theta$

Difficulty Level : Easy

QUESTION-05

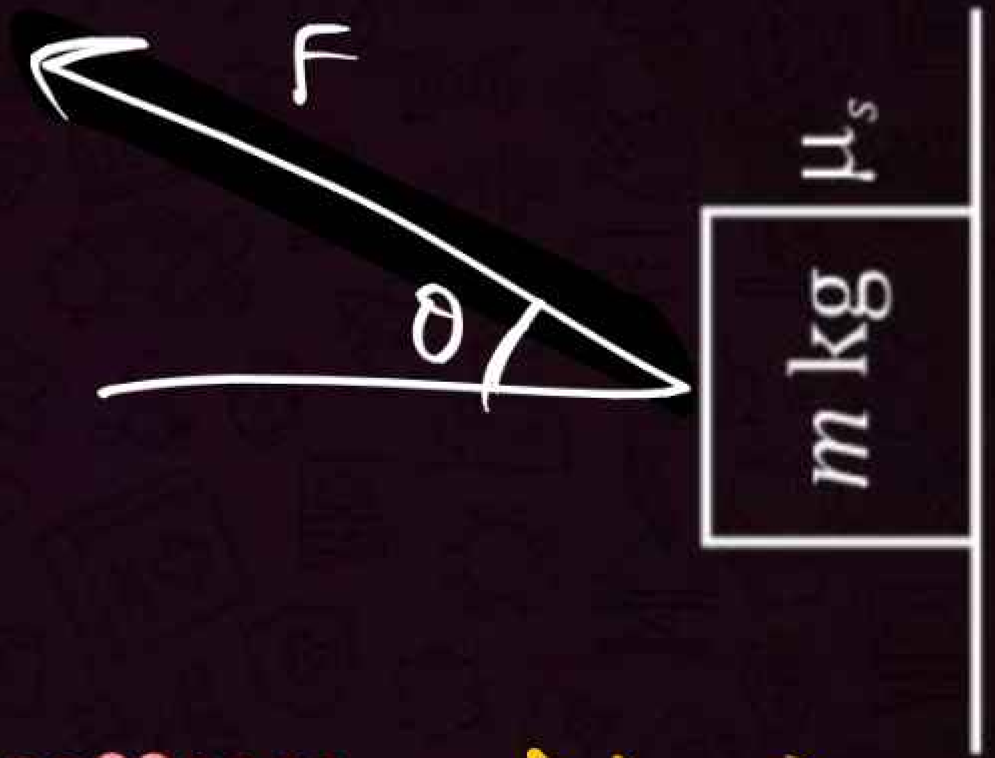
Calculate value of Normal



N= 0

QUESTION-06

Calculate value of Normal



N=0

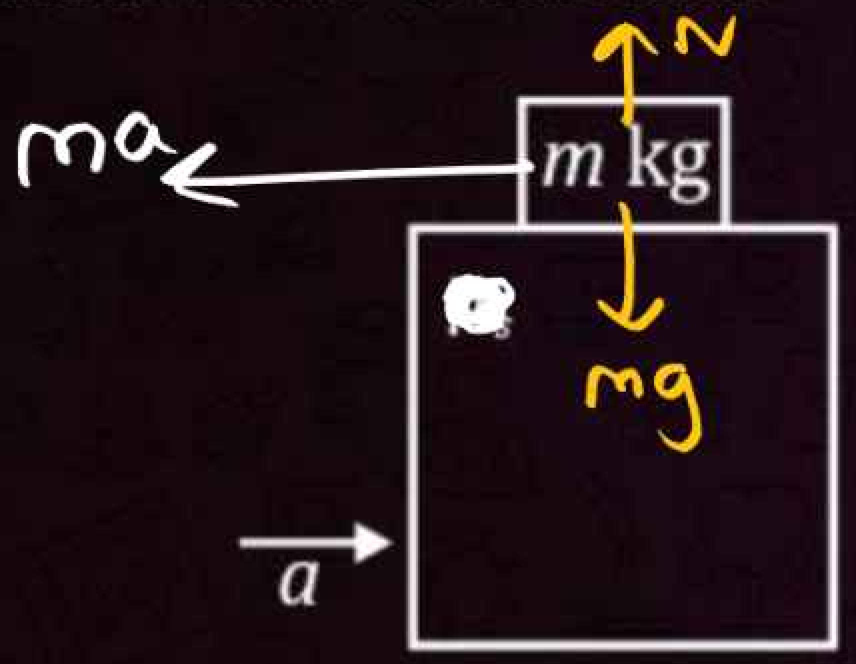
Contact loose

N=0

Difficulty Level : Easy

QUESTION-07

Calculate value of Normal



$N = mg$

$D = ma$

QUESTION-08

Calculate value of Normal

$N = ma$

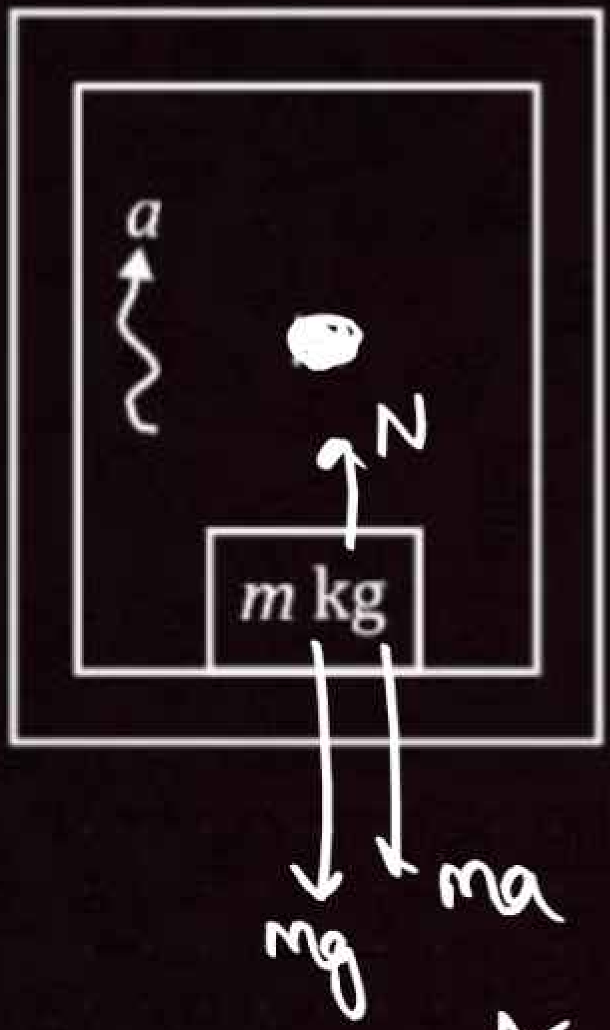
$D = mg$

$$\boxed{P = m(a \text{ palat kr})}$$

Difficulty Level : Easy

QUESTION-09

Calculate value of Normal



a

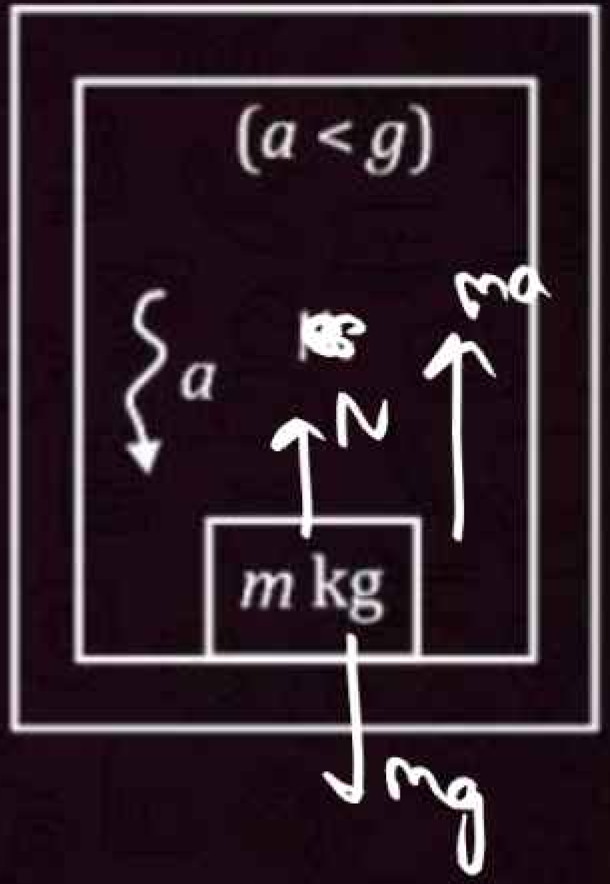
$g_{eff} = g + a$

$g = g$

$N = m(g+a)$

QUESTION-10

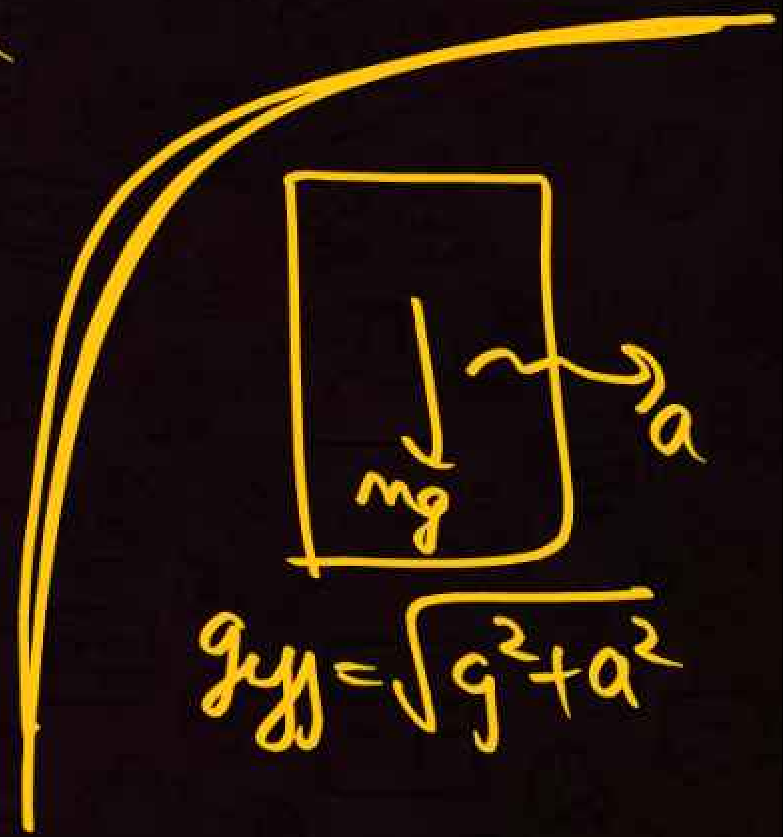
Calculate value of Normal



a

$g_{eff} = g - a$

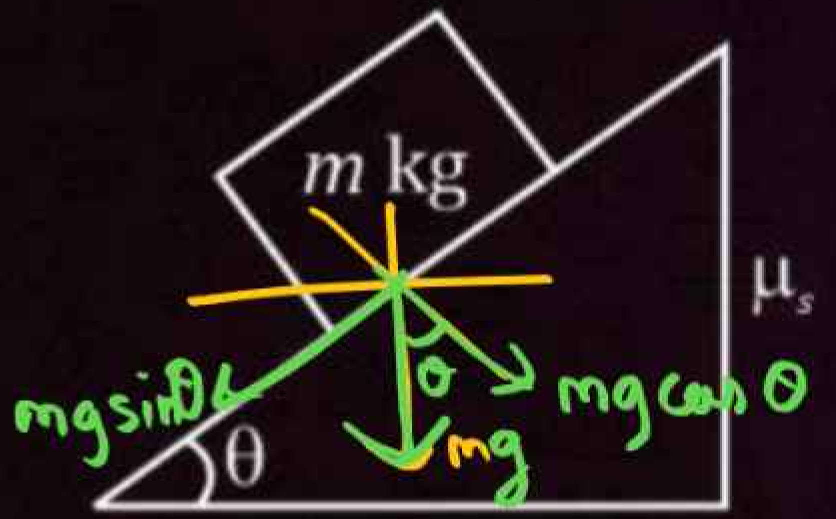
$N = m(g-a)$

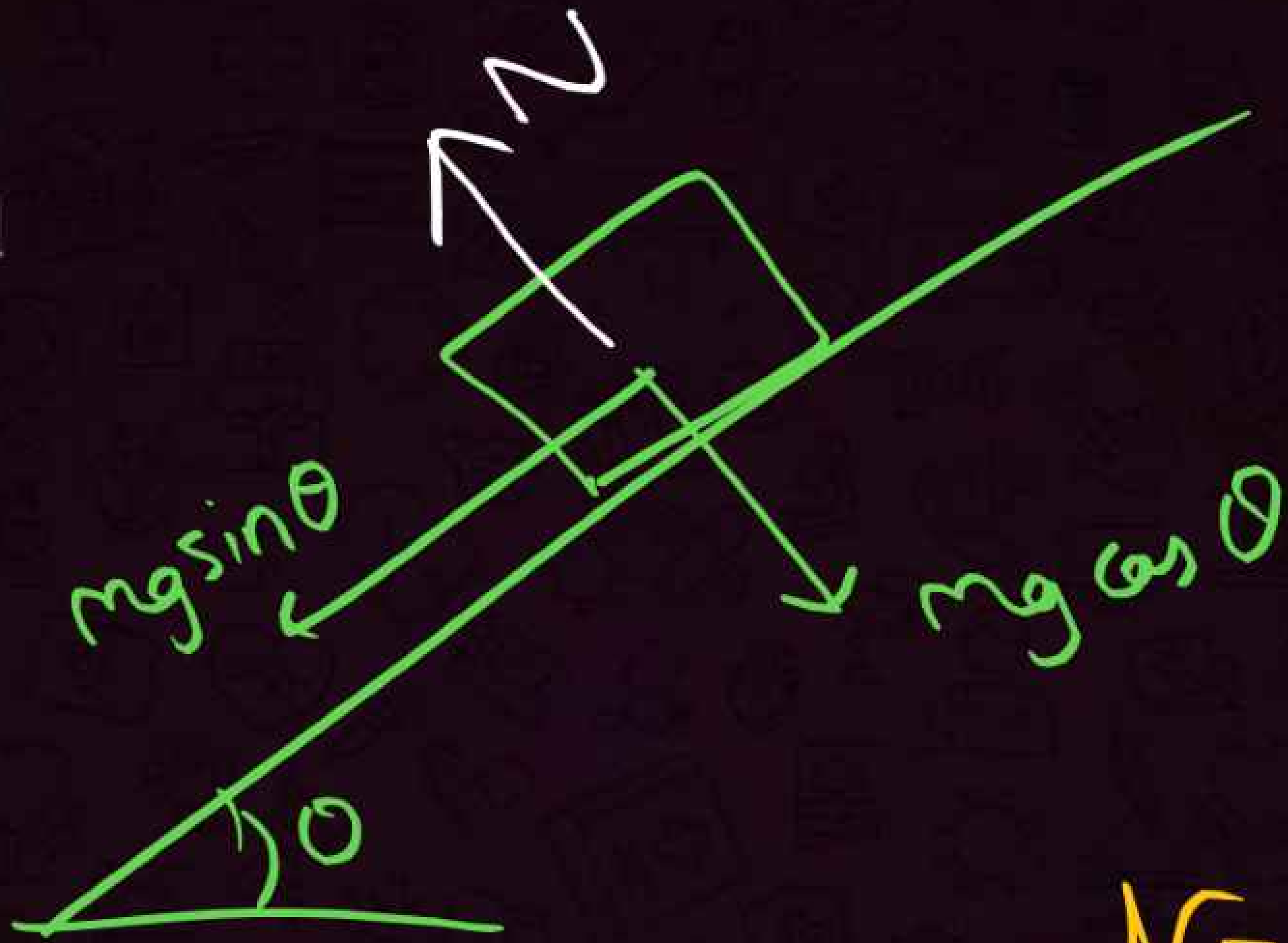


$g_{eff} = \sqrt{g^2 + a^2}$

QUESTION-11

Calculate value of Normal





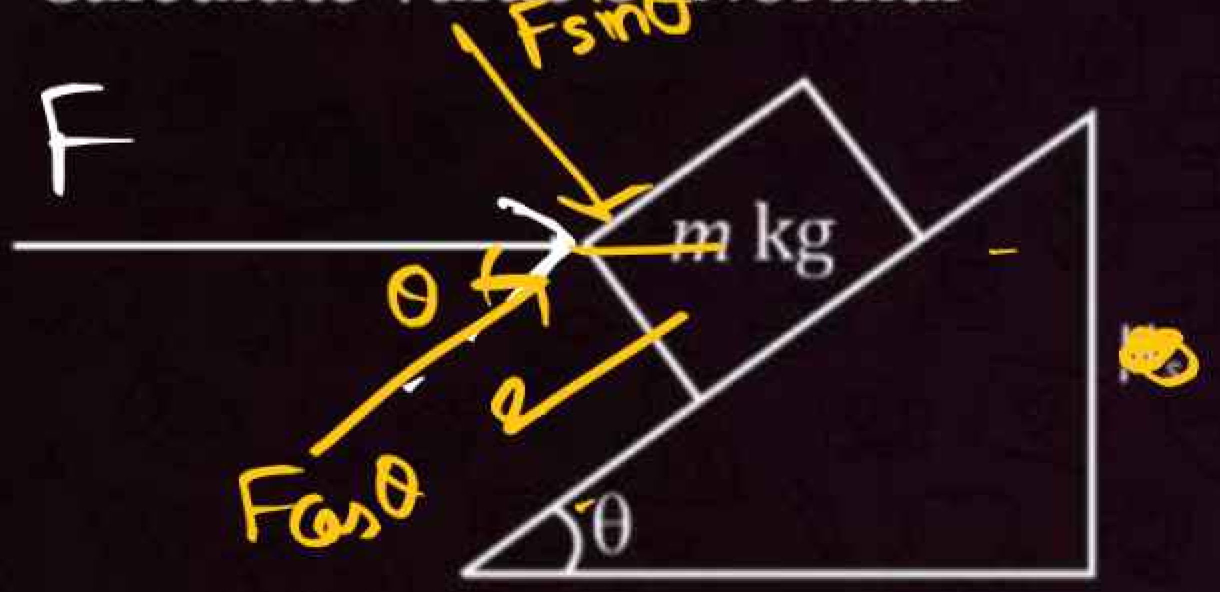
$N = mg\cos\theta$ ✓

$D = mg\sin\theta$ ✓

Difficulty Level : MEDIUM

QUESTION-12

Calculate value of Normal

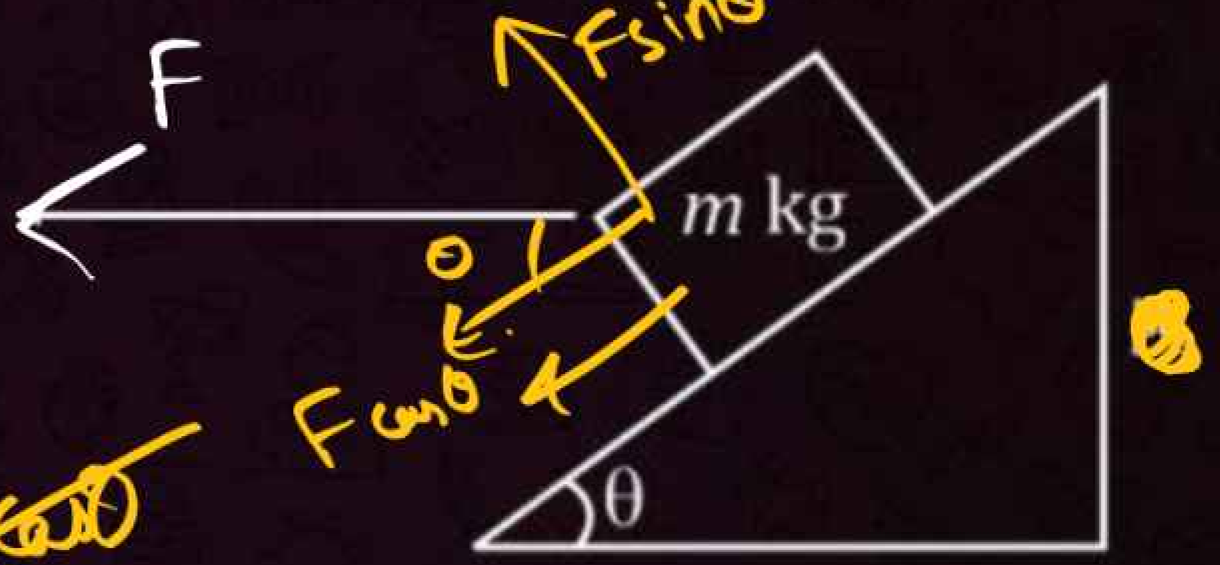


$N = mg\cos\theta + F\sin\theta$

$D = mg\sin\theta - F\cos\theta$

QUESTION-13

Calculate value of Normal



~~N = mg cosθ~~

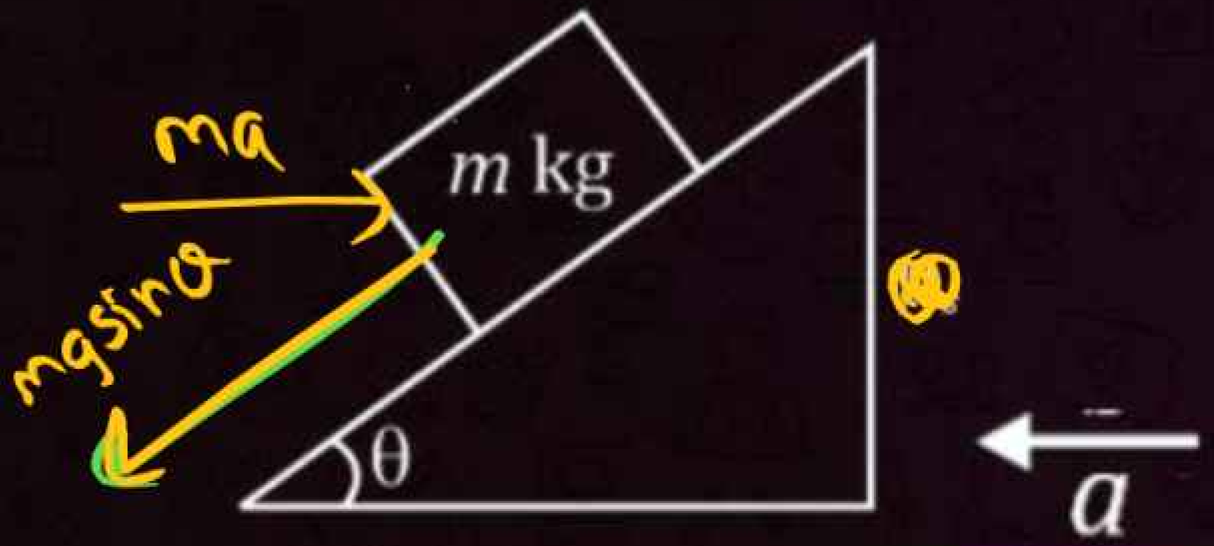
$N = mg\cos\theta - F\sin\theta$

$D = mg\sin\theta + F\cos\theta$

Difficulty Level : HARD

QUESTION-14

Calculate value of Normal

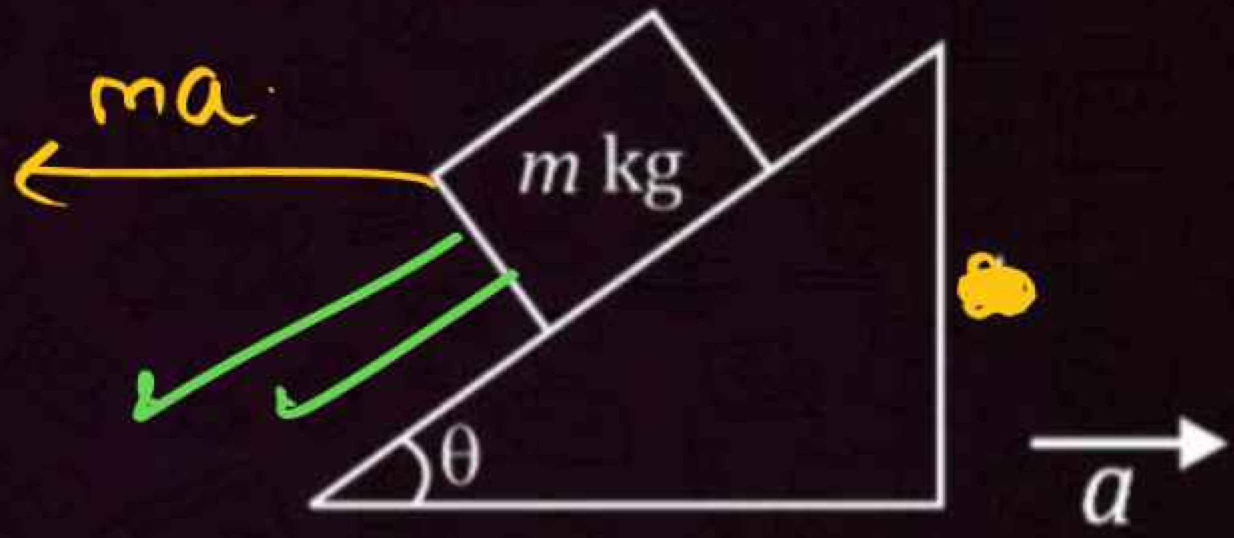


$N = mg\cos\theta + ma\sin\theta$

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

QUESTION-15

Calculate value of Normal

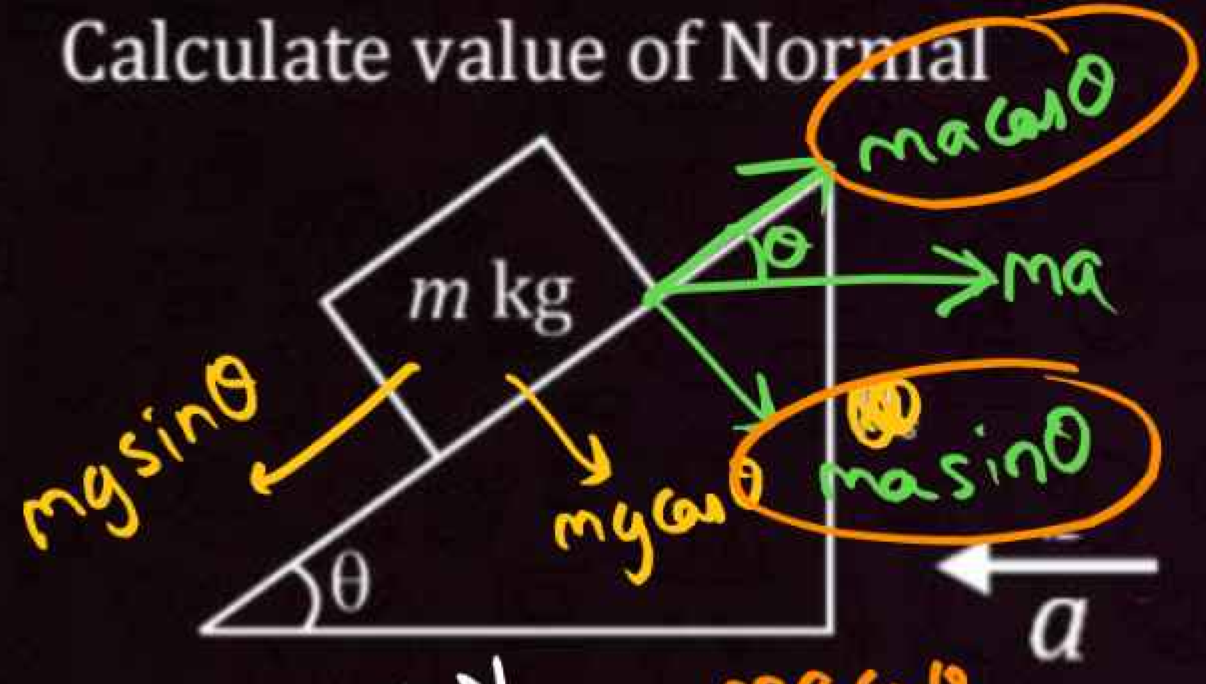


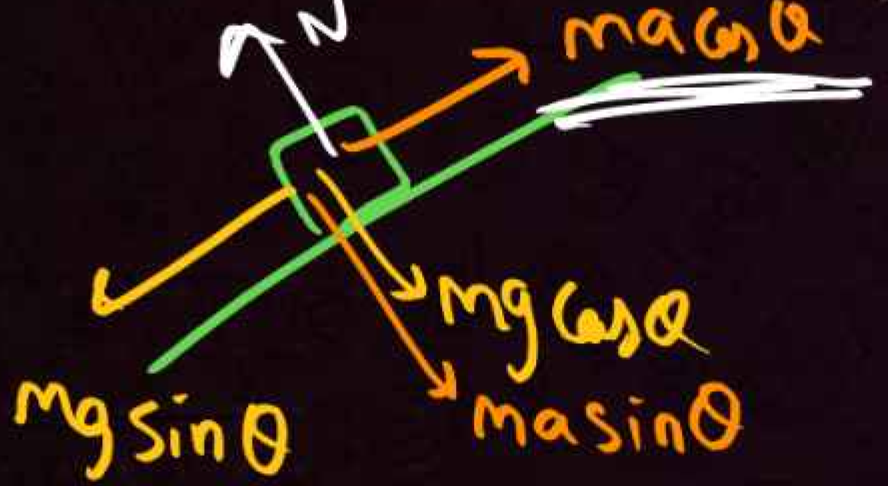
$N = mg\cos\theta - ma\sin\theta$

$D = mg\sin\theta + ma\cos\theta$

QUESTION-14

Calculate value of Normal



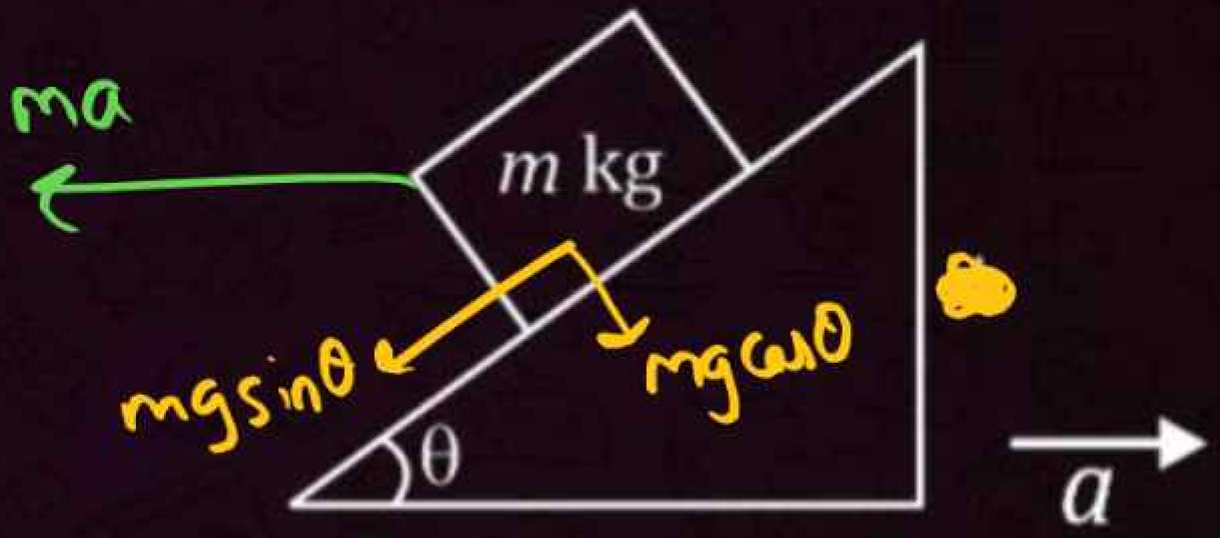


$N = mg\cos\theta + ma\sin\theta$

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

QUESTION-15

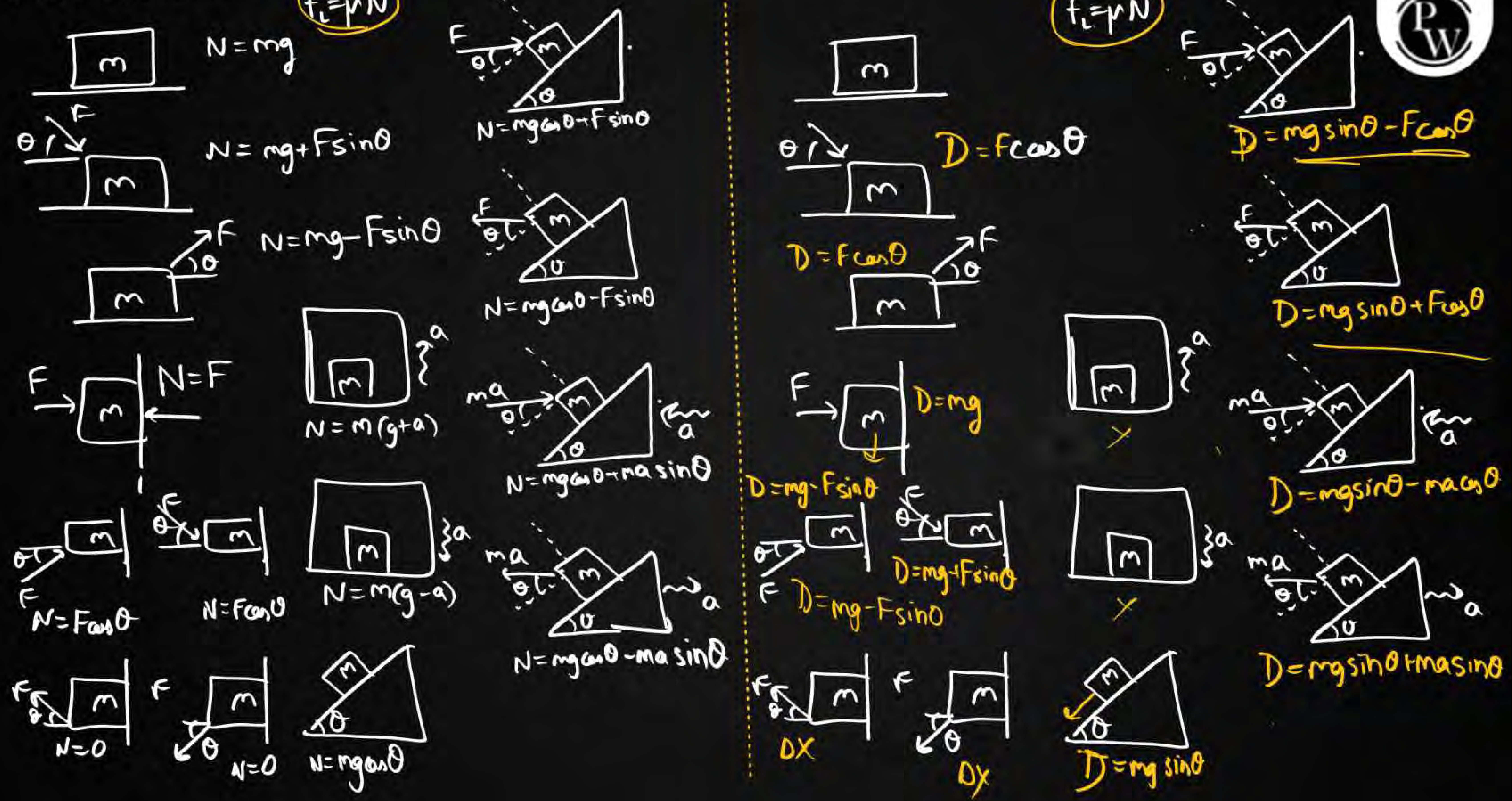
Calculate value of Normal



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

$D = mg\sin\theta + ma\cos\theta$

PUPPY POINTS - 1



Part 3 – Theory of friction

3.1 Why Friction

$f \rightarrow$ friction

Nothing is smooth

$\boxed{f \text{ is type of Electromagnetic Force}}$

3.2 Types of friction

Static Friction

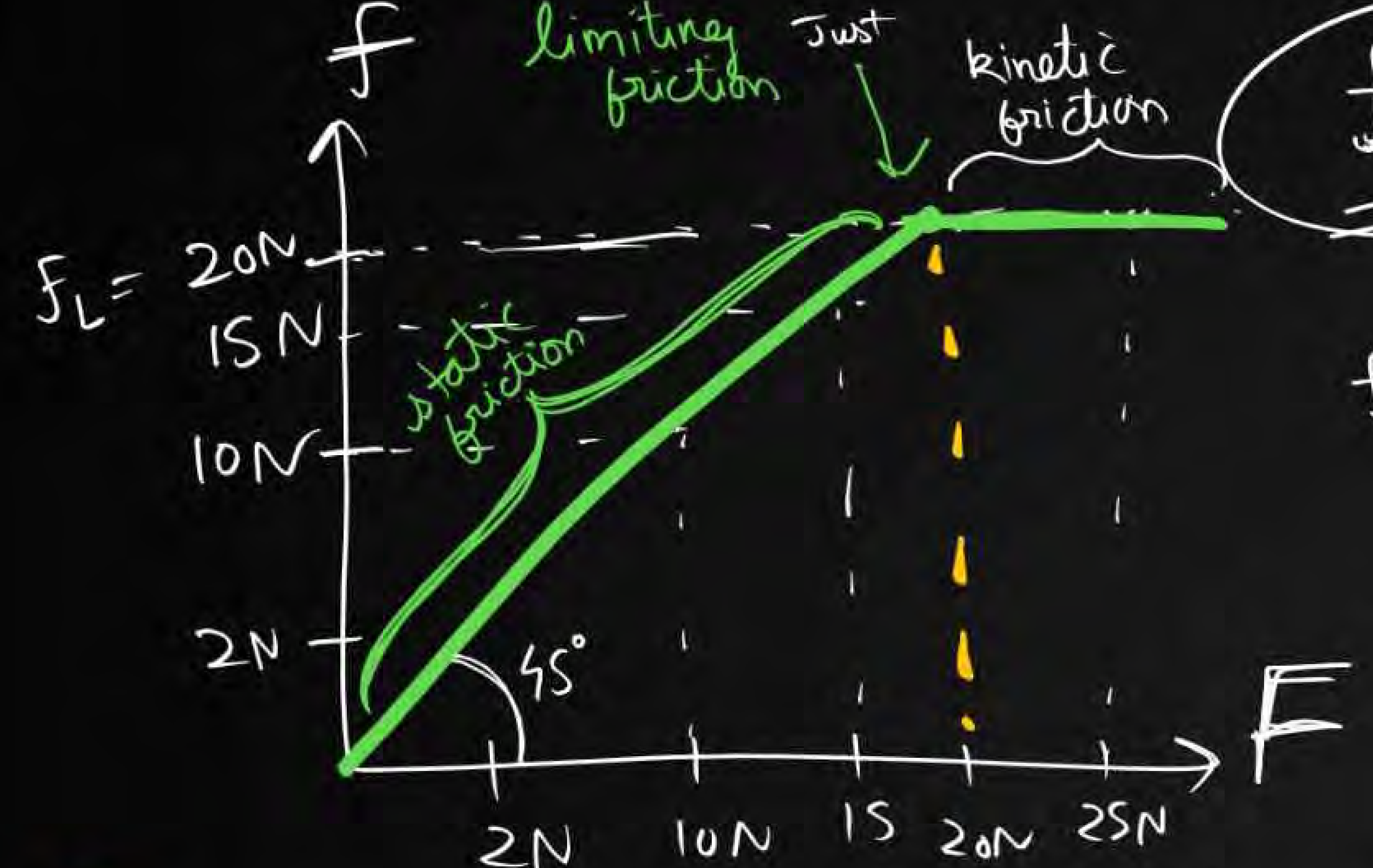
Friction (f)

- Static Friction
  (when object is at rest)
- Kinetic f
  (motion ✓
  v✓ a✓)
- Rolling f
  (Rotational Motion)

  f will reduce
  by large amount

  ⇒ (Point of contact
  changes, That se)
- Fluid f
  (viscocity)
  (Fluid)



$f_{limit} = 20N$

$f_s = 2N$ | 100kg | → 2N

$f_s = 10N$ | 100kg | → 10N

$f_s = 15$ | 100kg | → 15N

100kg → 20N

$f_k = 20N$

Slope of F-f graph for static f is $\tan 45° = 1$

$f_k = 20N$ | 100kg | → 25N

$a = \frac{D - f}{m} = \frac{25 - 20}{100} = \frac{5}{100} m/s^2$

$f_k = 20N$ | 100kg | → 50N

$a = \frac{D - f}{m} = \frac{50 - 20}{100} = \frac{30}{100} m/s^2$

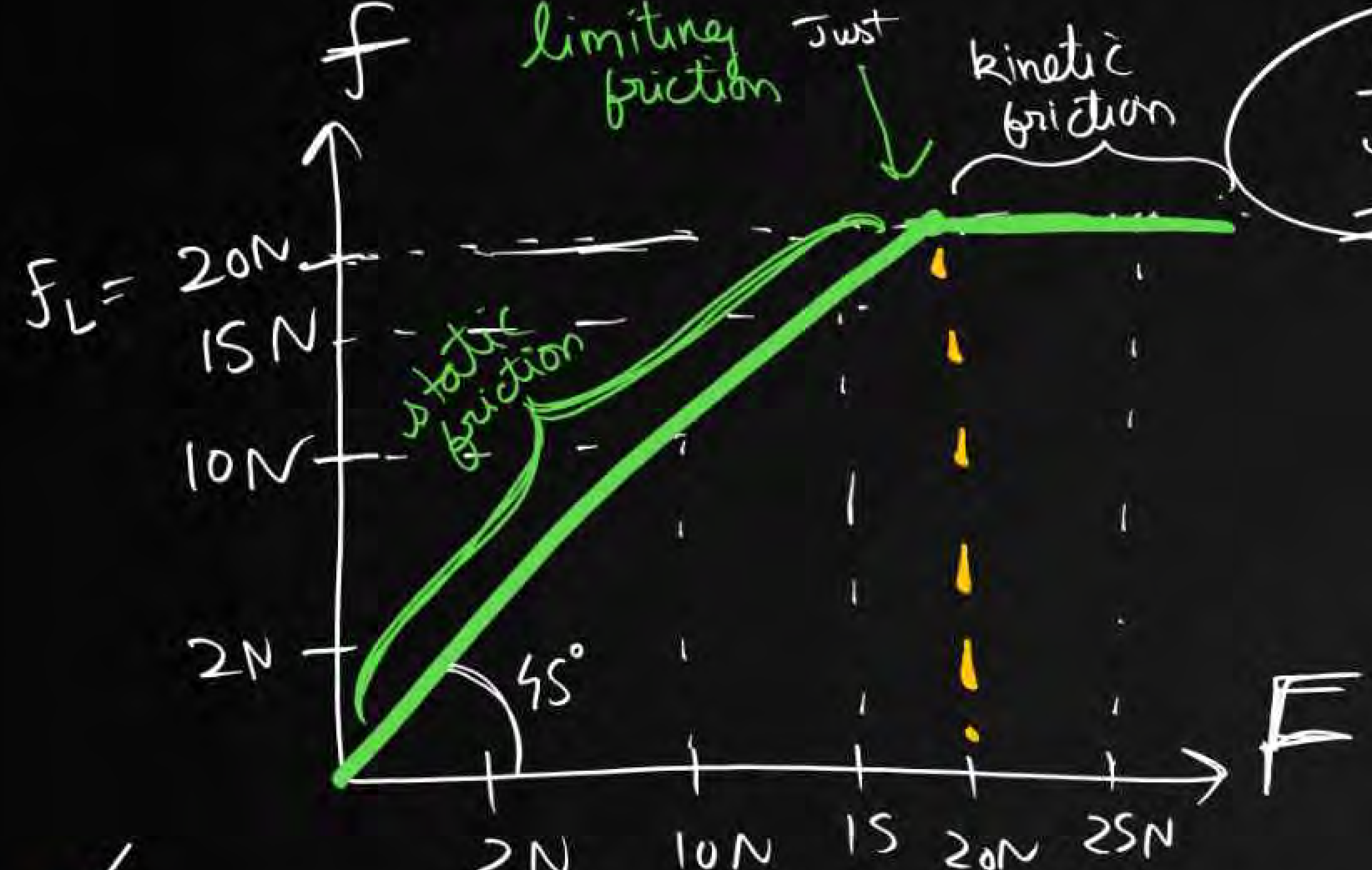
Real

$f_k = 20N$ | 100kg | → 120N

$a = \frac{D - f}{m} = \frac{120 - 20}{100} = 1 m/s^2$

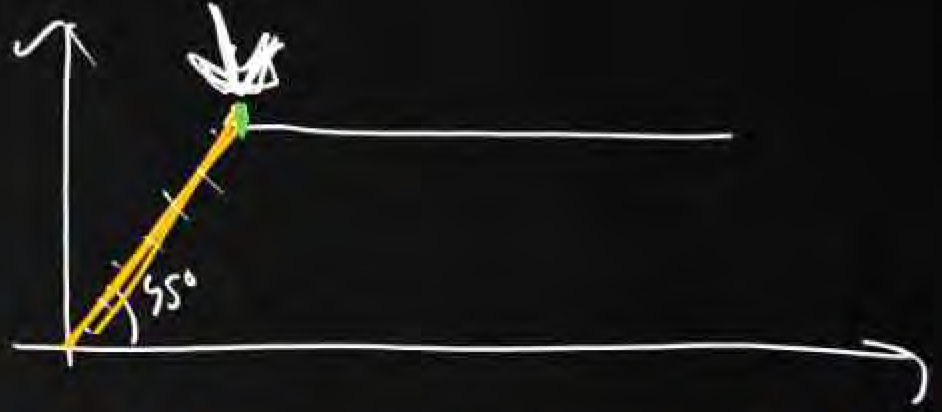
$f_k = 20N$ | 100kg | → 270N

$a = \frac{D - f}{m} = \frac{220 - 20}{100} = 2.5 m/s^2$



$f_{limit} = 20\,N$

Real



Slope of F-f graph for static f is $\tan 45° = 1$

- limiting f → maximum static f
- static f → self adjusting Force
- kinetic f is slighty less than limiting f

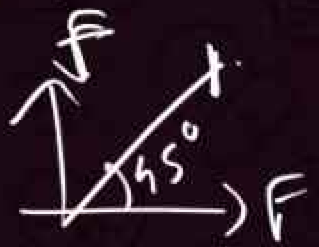
3.2 Types of friction

Direct

Static Friction

- Self – adjusting Force
- Equal to applied force
- No motion only tendency of motion
- Object at rest
- Slope of graph of F-fr is 1 or 45^0

Angle



Limiting Friction

- Maximum static friction
- Object just about to move
- Force required to start motion

Kinetic Friction

moving

- Object is moving with constant velocity
- Object is moving with acceleration

Difficulty Level : Easy

QUESTION-16

Which of the following is a self adjusting force? [NCERT Based]

1. Static friction
2. Rolling friction
3. Sliding friction
4. Dynamic friction

Difficulty Level : Easy

QUESTION-17

Mark the in correct statements about the friction between two bodies.

[HCV Objective]

1. Static friction is always greater than the kinetic friction.
2. Coefficient of static friction is always greater than the coefficient of kinetic friction.
3. Limiting friction is always greater than the kinetic friction.
4. Limiting friction is never less than static friction.

3.3 Calculation of friction

Practicals

Jyada Normal toh Jyada f lagega

$f_L \propto N$

$f_k \propto N$

$$f_L = \mu_s N$$

$$f_k = \mu_k N$$

$\mu \rightarrow$ experimentally

$f_{static} \rightarrow X$

$\hookrightarrow$ self adjusting

Jitni Jarurat Utna

$f_L = \mu_s N$

$\hookrightarrow$ coefficient of static f

$f_k = \mu_k N$

$\hookrightarrow$ Coefficient of kinetic f

$\mu \rightarrow$ Nature of objects in contact

$\rightarrow$ lubrication

$\rightarrow$ (road is wet, μ is less, gaadi slips easily)

$\rightarrow$ Temperature

$f_k \rightarrow \mu$ + Normal

$\mu, f_k \longrightarrow$ do not depend on Area of Contact

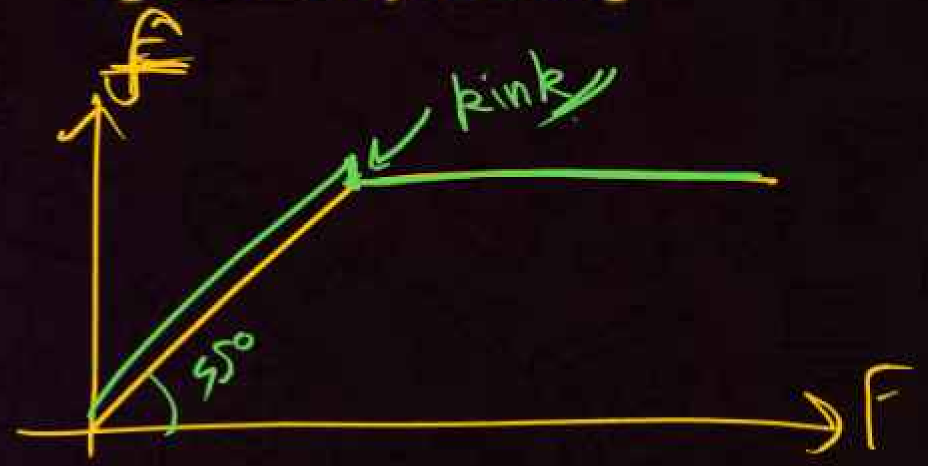
(in our syllabus)

Difficulty Level : MEDIUM

QUESTION-18

A block is placed on a rough floor and a horizontal force F is applied on it. The force of friction f by the floor on the block is measured for different values of F and a graph is plotted between them.

[HCV Objective]



1. The graph is a straight line of slope 45°.
2. The graph is a straight line parallel to the F-axis.
3. The graph is a straight line of slope 45° for small F and a straight line parallel to the F-axis for large F.
4. There is no small kink on the graph.

3.4 μ Depends on

Friction Coefficient μ Depends on

- Nature of Surfaces
- Temperature
- Wetting
- Surface Roughness
- Presence of Lubricants

Contact Area: While theoretically, friction is independent of contact area, ~~real-world factors~~ like ~~surface deformation can play a role.~~

Syllabus

Friction Depends on

All the above +

Normal Force

Difficulty Level : Easy

QUESTION-19

Identify the correct statement. **[NCERT Based]**

1. ~~Static friction depends on the area of contact.~~
2. ~~Kinetic friction depends on the area of contact.~~
3. Coefficient of static friction does not depend on the surfaces in contact.
4. Coefficient of kinetic friction is less than the coefficient of static friction.

(kink)

3.5 Rolling Friction

Reduced f by ~~small~~ / large value

(Point contant is changing continously)

3.6 Friction – necessary evil

GOOD

Walking and Running

Vehicle Control

Writing

Holding Objects

Machinery

EVIL

Energy Loss

Wear and Tear

Reduced Efficiency

Heat Generation

Noise

Friction is a double-edged sword, playing vital roles in our everyday life while also presenting challenges.

3.7 How to reduce friction

Lubrication: Applying lubricants like oil or grease between surfaces.

Smoothening Surfaces: Polishing or using materials with smoother surfaces.

Using Rollers or Ball Bearings: Replacing sliding motion with rolling motion.

Streamlining Shapes: Designing objects with aerodynamic shapes to reduce air friction.

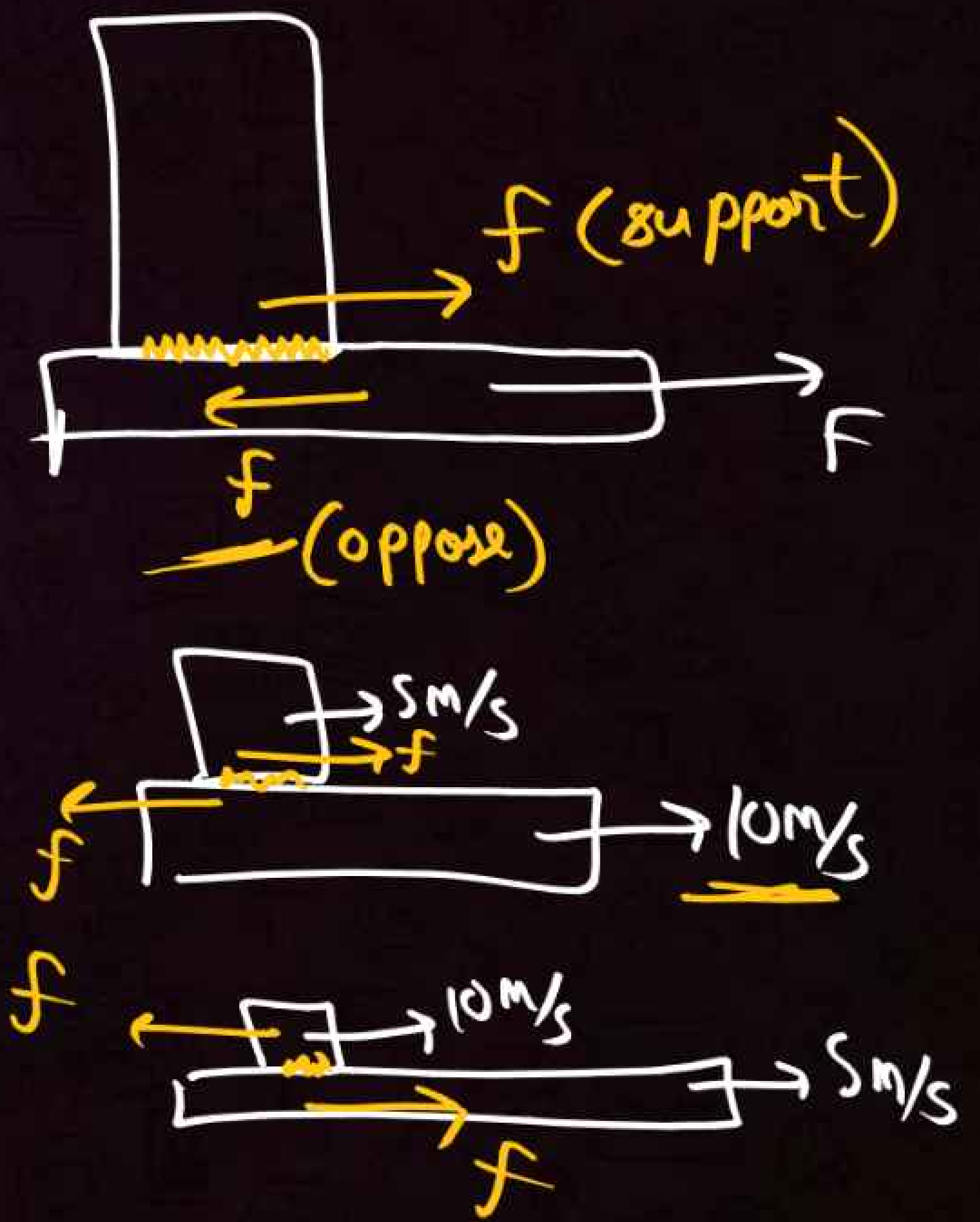
Using Advanced Materials: Employing materials like Teflon or other low-friction coatings.

3.8 Friction Directions

f always oppose relative motion or tendency of relative motion

- f may suppor motion (slower)
- f may oppose motion (faster)
- f must always oppose relative motion

- f is always oppisit to Dhakka

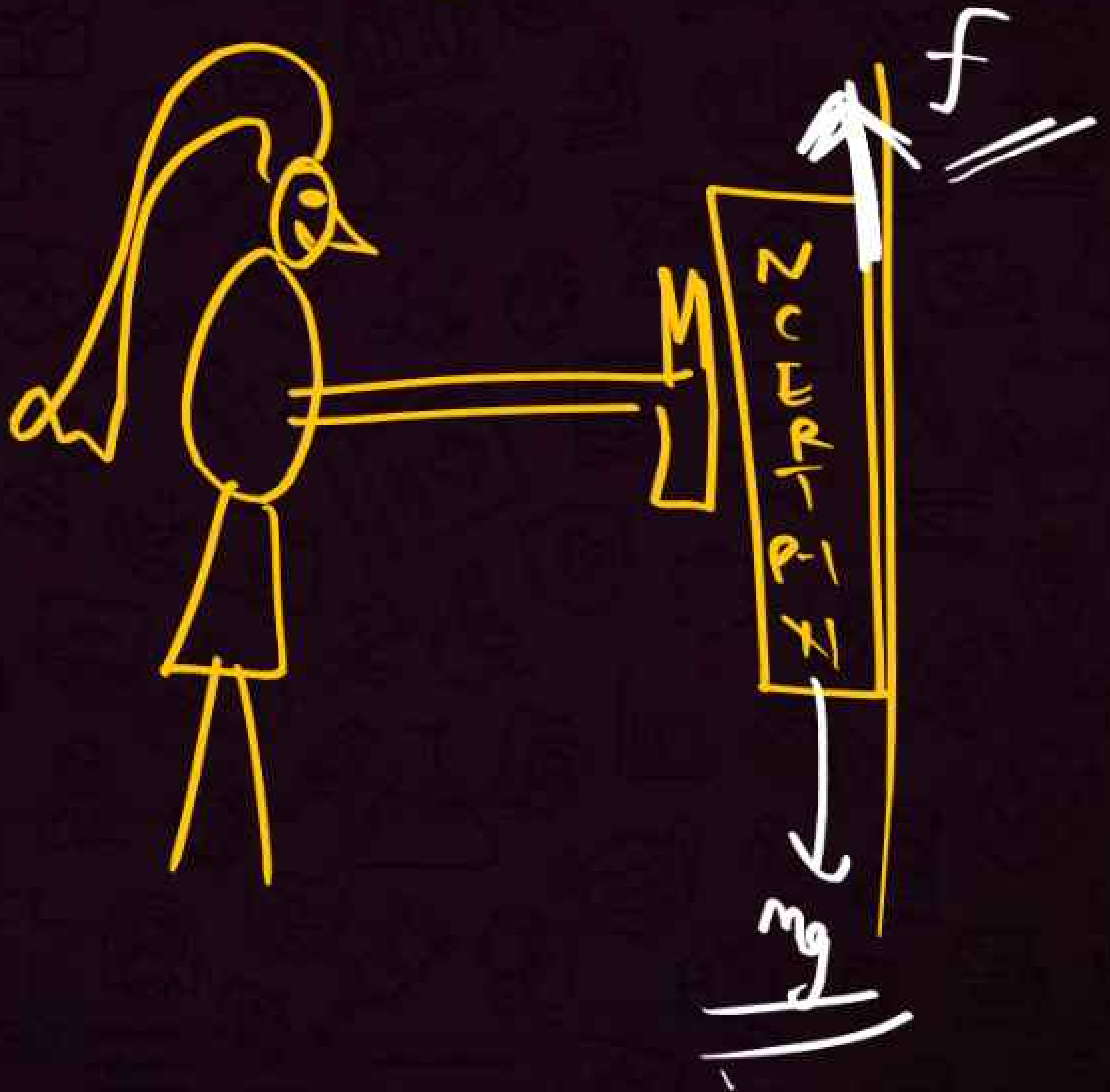


Difficulty Level : MEDIUM

QUESTION-20

A girl press her physics text book against a rough vertical wall with her hand. The direction of the frictional force on the book exerted by the wall is

[NCERT Based]

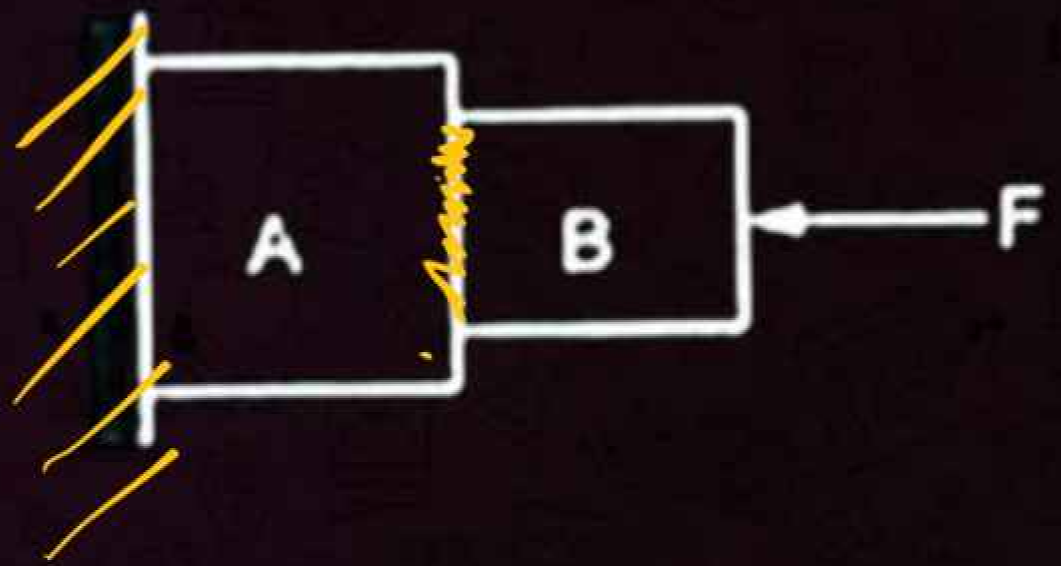


1. downwards
2. upwards
3. out from the wall
4. into the wall

Difficulty Level : MEDIUM

QUESTION-22

Consider the situation shown in figure. The wall is smooth but the surfaces of A and B in contact are rough. The friction on B due to A in equilibrium **[HCV Objective]**



(1) is upward

(2) is downward

(3) is zero

(4) the system cannot remain in equilibrium

Difficulty Level : ~~MEDIUM~~ YODHA

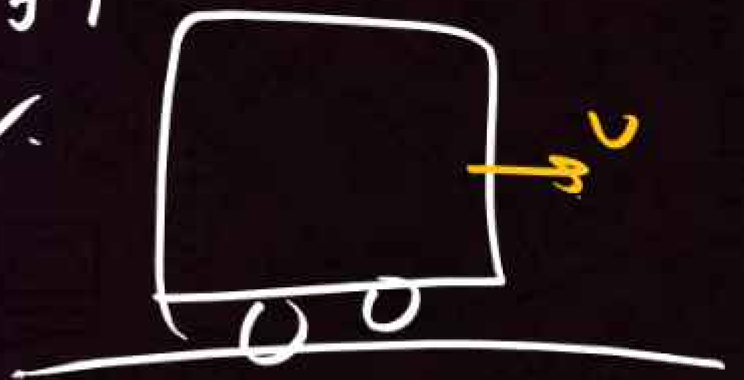
QUESTION-23

Consider a vehicle going on a horizontal road towards east. Neglect any force by the air. The frictional forces on the vehicle by the road can never be

[HCV Objective]

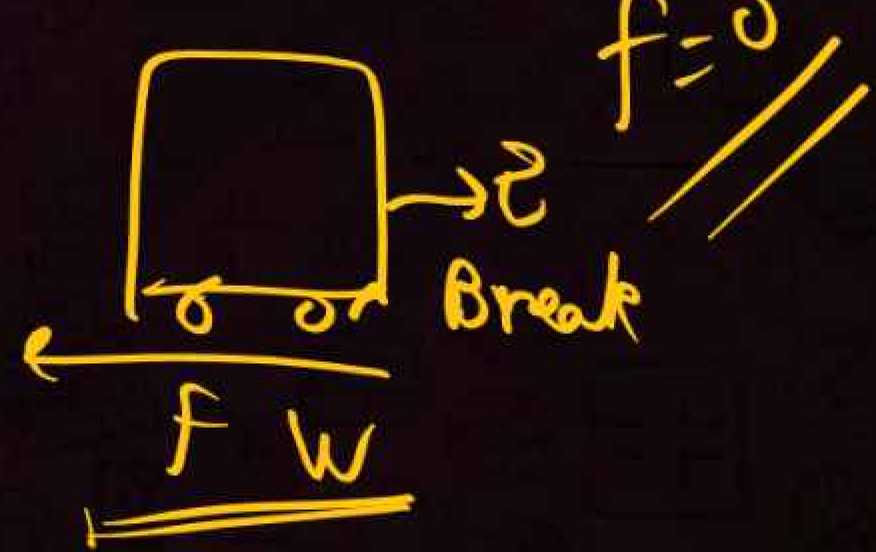
1. is towards east if the vehicle is accelerating

2. is zero if the vehicle is moving with a uniform velocity



3. must be towards east

4. may be towards west



Walking

Vechile

$\longrightarrow v$ (speed $\uparrow$) $\quad a \longrightarrow \quad f \longrightarrow$

$\longrightarrow v$ (speed $\downarrow$) $\quad a \longleftarrow \quad f \longleftarrow$

$\longrightarrow v$ (same) $\quad a = 0 \quad f = 0$

2.9 Friction & Relative Motion

- Friction force is contact force which acts
- parallel to contact surface or tangential direction

- It opposes relative motion or tendency of relative motion

kinetic static

- It may support motion
- It may oppose motion
- It always opposes relative motion

Difficulty Level : MEDIUM

QUESTION-24

Which one of the following statements is incorrect? [2018]

(1) Frictional force opposes the relative motion. ✓

(2) Limiting value of static friction is directly proportional to normal reaction ✓

(3) Rolling friction is smaller than sliding friction ✓

(4) Coefficient of sliding friction has dimensions of length ✗

$f_L \propto N$

$f_L = \mu_s N$

$\boxed{\mu \rightarrow \text{dimensionless}}$

✓

Difficulty Level : Easy

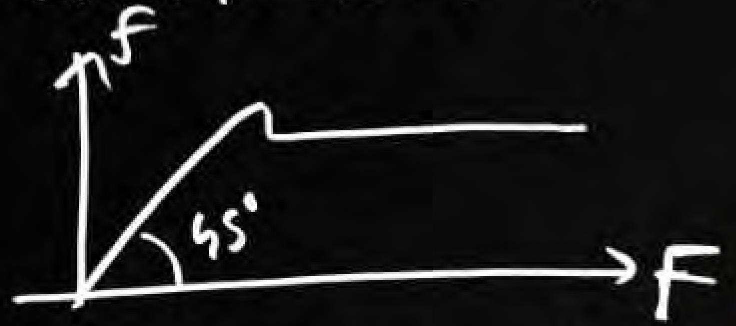
QUESTION-25

Which one of the following can also act as a lubricant in the machines?

[NCERT Based]

1. Iron fillings
2. Polish on machines
3. Flow of water through the machine
4. Flow of compressed and purified air.

PUPPY POINTS - 2



f opposes rel. motion ✓

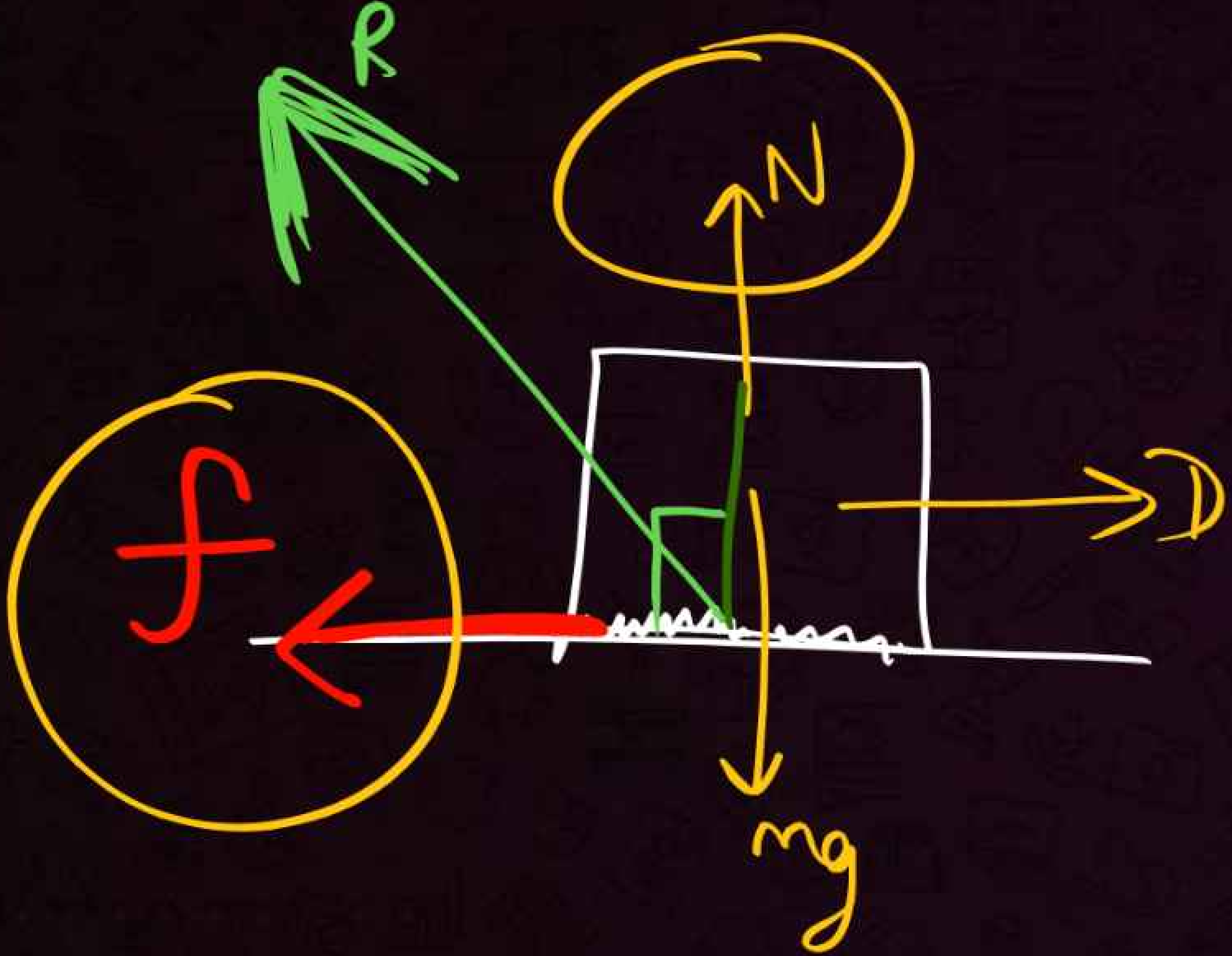
f jitni jarurat utna ✓

DILBAR POINTS

PP - 3

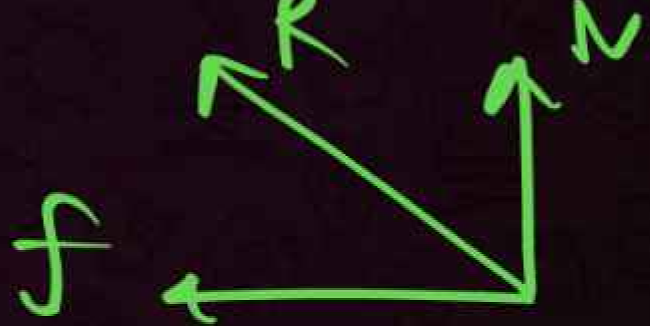
Part 4 – Cone of Friction

4.1 Cone of Friction

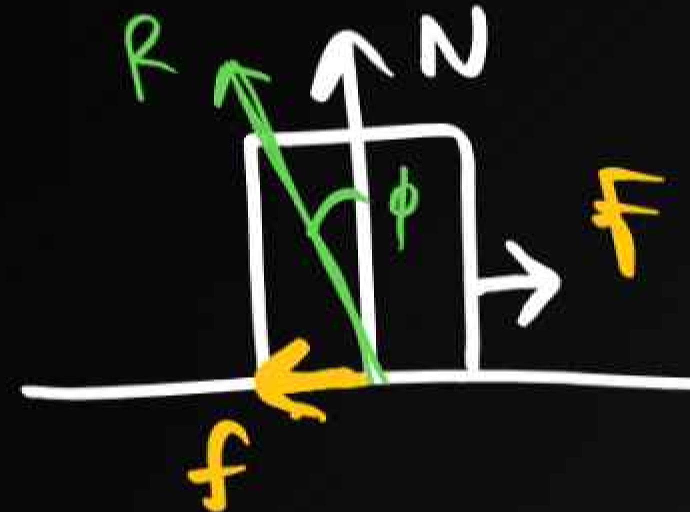


Contact Force/Reaction Force (R)

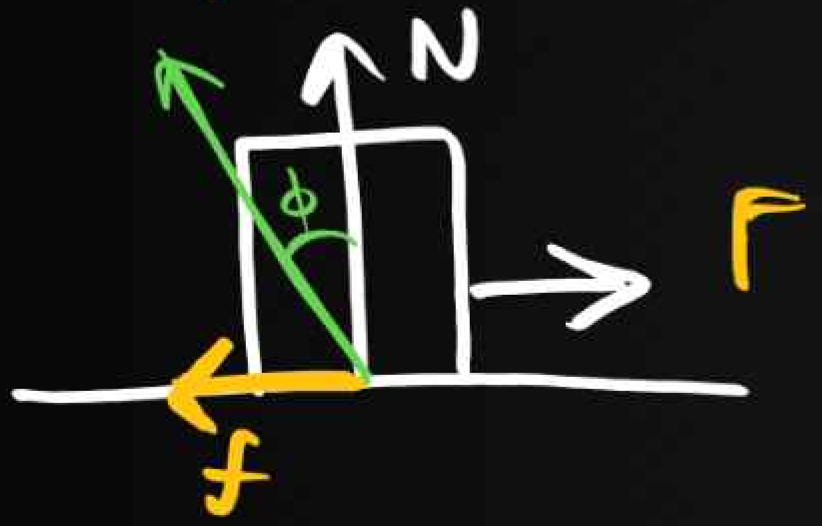
N f



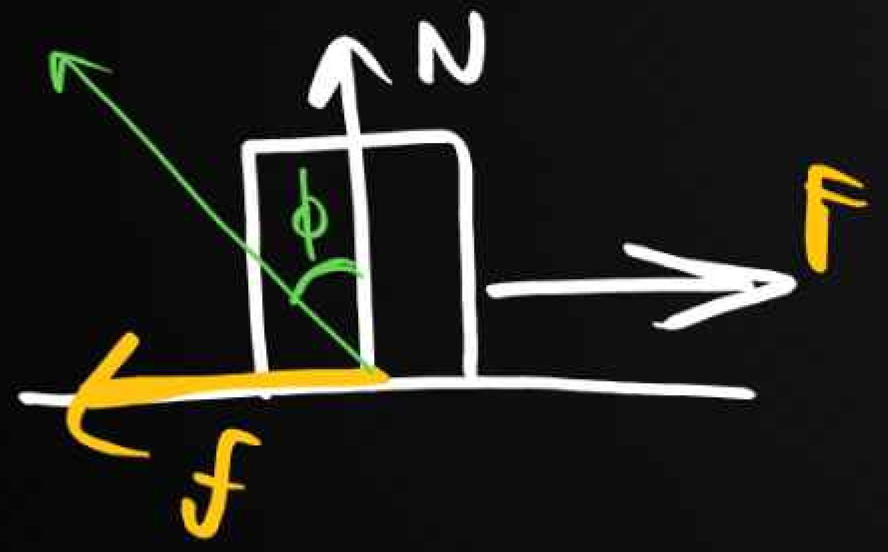
$$\boxed{R = \sqrt{N^2 + f^2}}$$



Cone of friction



$\phi \longrightarrow$ Angle of friction.

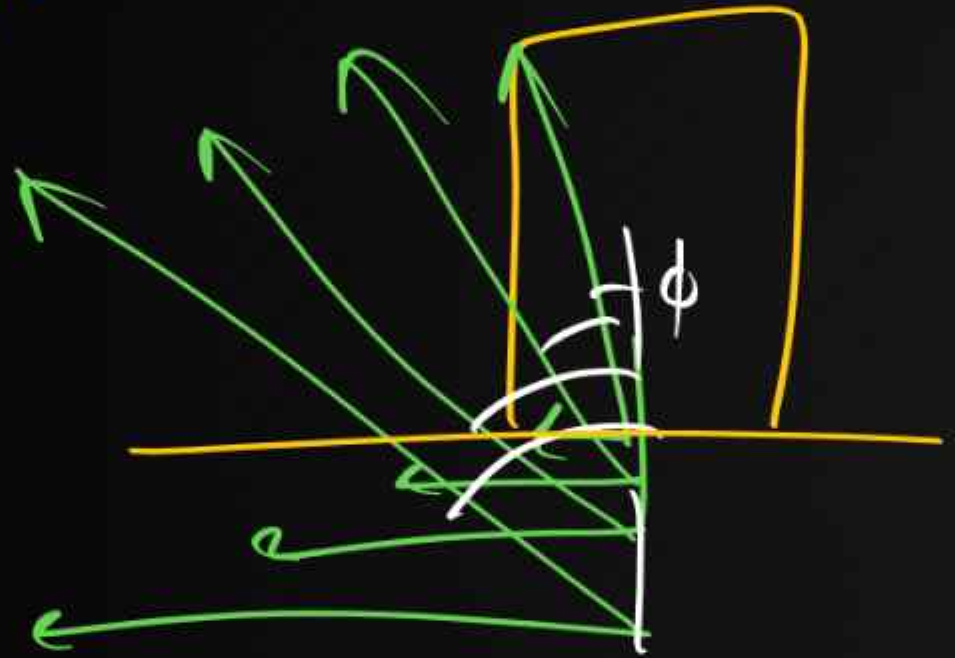


$$\boxed{\tan\phi = \frac{f}{N}}$$

At limiting value $f_L = \mu N$

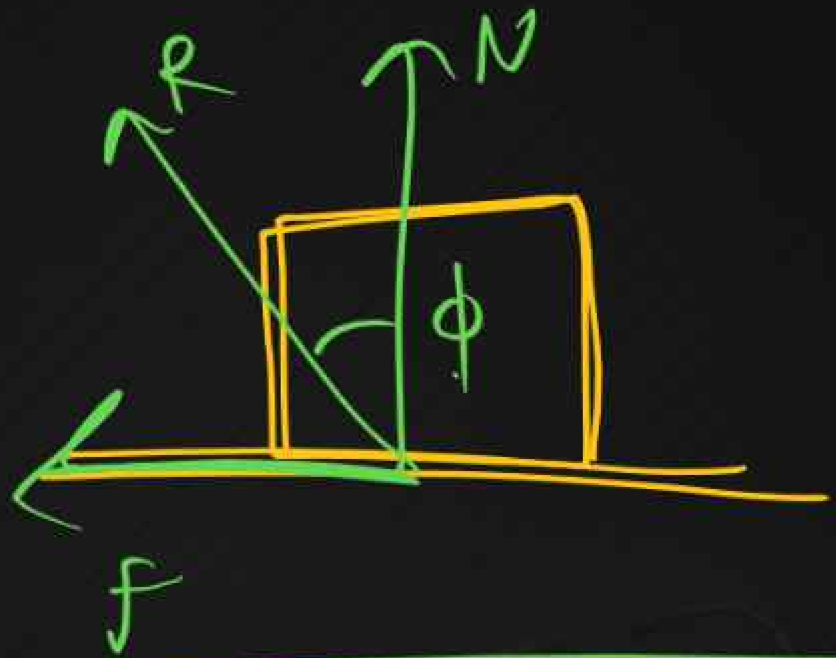
$$\boxed{\tan\phi = \frac{\mu \cancel{N}}{\cancel{N}}}$$

As $f \uparrow \phi \uparrow$



Limiting

$\tan\phi = \mu$



$\tan\phi = \frac{f}{N}$

$R = \sqrt{N^2 + f^2}$

$\cos\phi = \frac{N}{R}$

$\tan\phi \rightarrow \mu$
limiting

$\sin\phi = \frac{f}{R}$

$f = \mu N$

Difficulty Level : HARD

QUESTION-26

Let F, F_N and f denote the magnitudes of the contact force, normal force and the friction exerted by one surface on the other kept in contact. If none of these is zero

F F_N

f (Wrong)

[HCV Objective]

1. $F > F_N$ ✓
2. $F > f$ ✓
3. $\boxed{F_N > f}$ ✗
4. $F_N - f < F < F_N + f$ ✓

$$\boxed{\vec{a}+\vec{b} \to \begin{cases} \text{min } a-b \\ \text{Max } a+b \end{cases}}$$

Contact = N & f

$R = \sqrt{N^2 + f^2}$

Difficulty Level : HARD

QUESTION-27

hw

Which of the following statements is correct about friction? [NCERT Based]

(1) The coefficient of friction between a given pair of substances is largely independent of the area of contact between them.

(2) The frictional force can never exceed the reaction force on the body from the support surface.

(3) Rolling friction is only slightly smaller than sliding friction.

(4) The main source of friction is the irregularity of the surfaces in contact.

N

Difficulty Level : HARD

QUESTION-28

In a situation the contact force by a rough horizontal surface on a body placed on it has constant magnitude. If the angle between this force and the vertical is decreased, the frictional force between the surface and the body will **[HCV Objective]**

1. increase
2. decrease
3. remain the same
4. may increase or decrease

Difficulty Level : HARD

QUESTION-29

Hw

While walking on ice, one should take small steps to avoid slipping. This is because smaller steps ensure [HCV Objective]

(1) larger friction

(2) smaller friction

(3) larger normal force

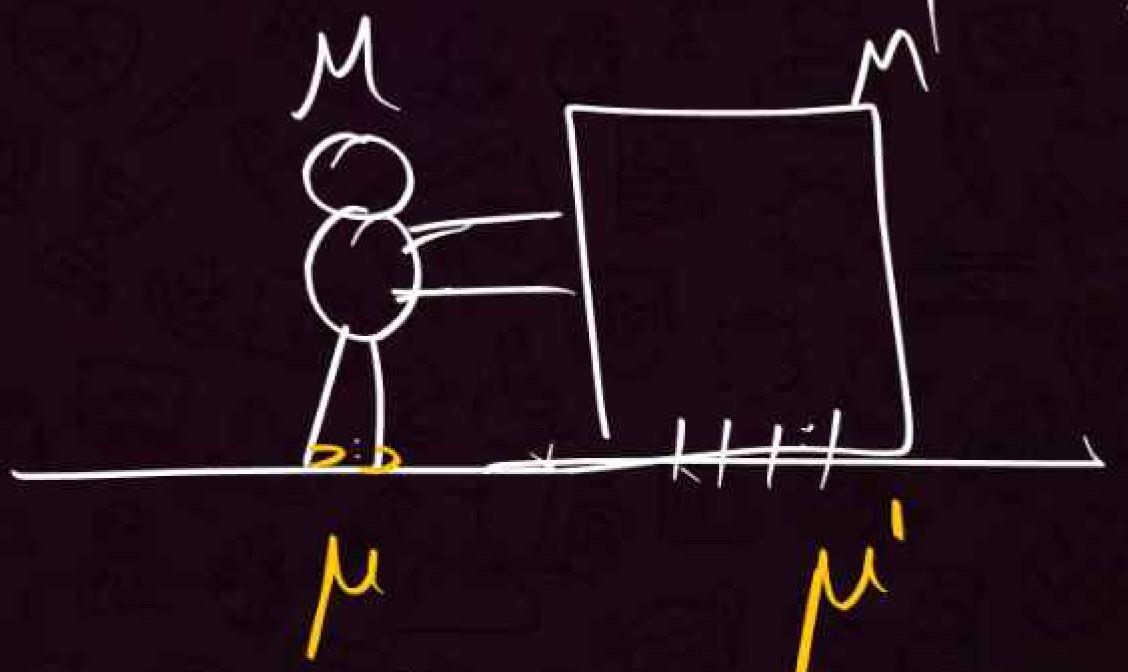
(4) smaller normal force

Difficulty Level : YODHA

QUESTION-30

A boy of mass M is applying a horizontal force to slide a box of mass M' on a rough horizontal surface. The coefficient of friction between the shoes of the boy and the floor is μ and that between the box and the floor is μ'. In which of the following cases it is certainly not possible to slide the box? **[HCV Objective]**

1. $\mu < \mu', M < M'$
2. $\mu > \mu', M < M'$
3. $\mu < \mu', M > M'$
4. $\mu > \mu', M > M'$



$f_L < f'_L$

$\mu N < \mu' N'$

$\mu m g < \mu' m' g$

$\boxed{\mu m < \mu' m'}$

Dabba Not move

Difficulty Level : MEDIUM

QUESTION-31

hw

The contact force exerted by a body A on another body B is equal to the normal ($f=0$) force between the bodies. Incorrect statement is [HCV Objective]

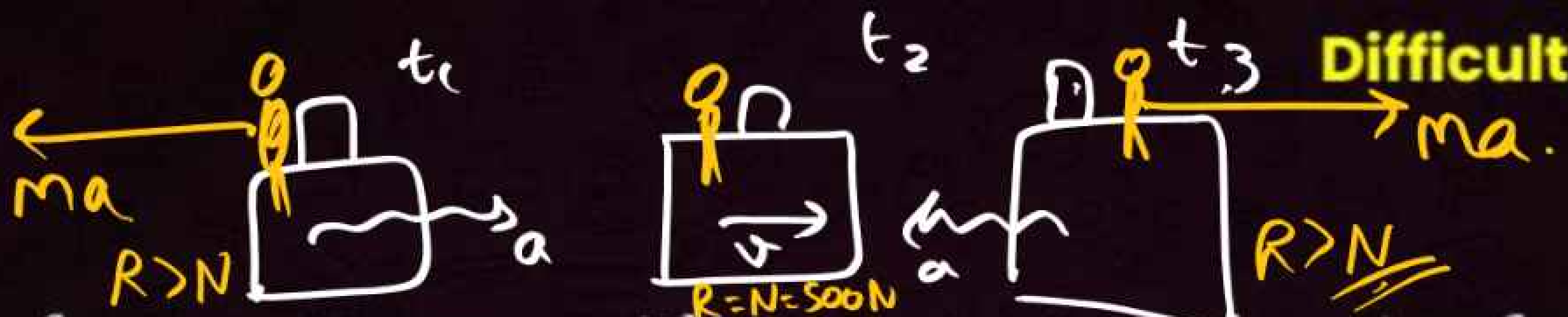
1. the surfaces may be frictionless ✓
2. the force of friction between the bodies is zero ✓
3. the magnitude of normal force equals that of friction ✗
4. the bodies may be rough but they don't slip on each other. ✓

$R = N$

$f = 0$

Difficulty Level : HARD

QUESTION-21



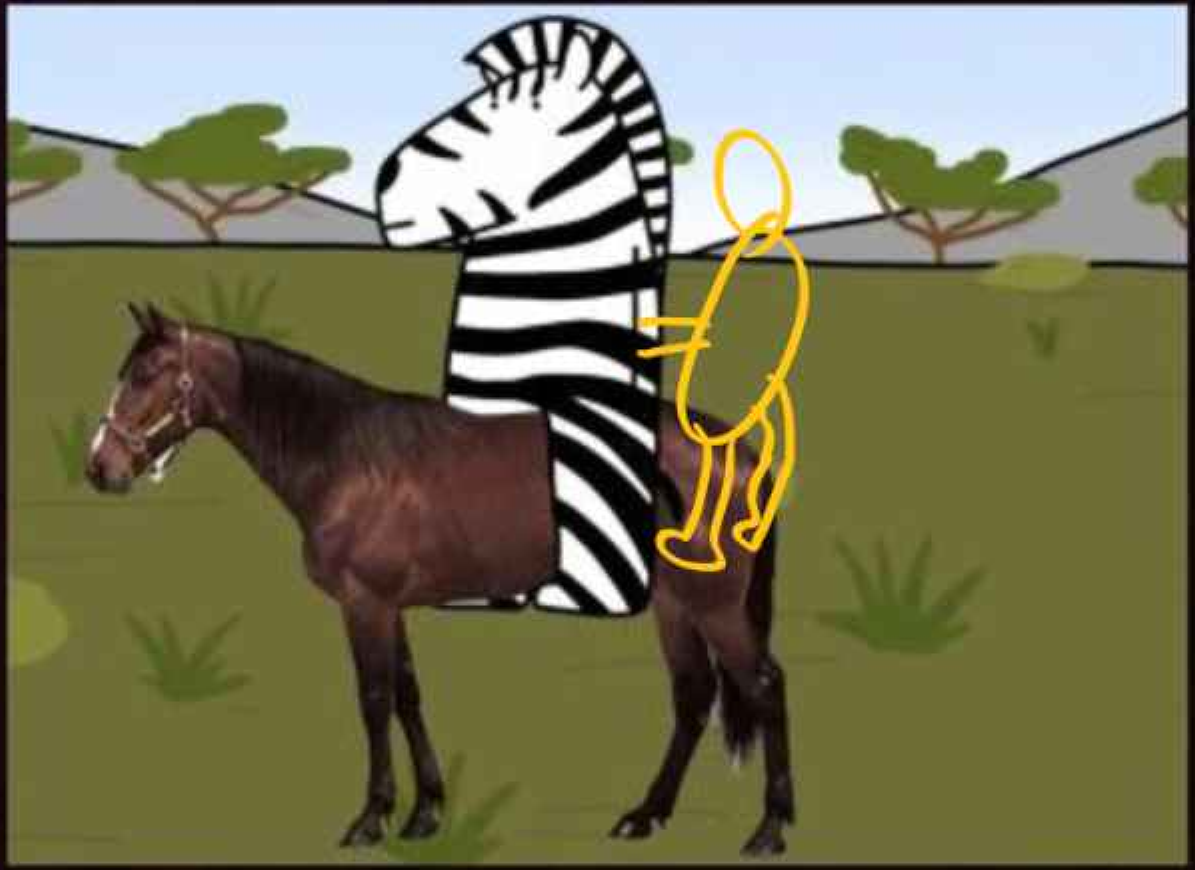
A scooter starting from rest moves with a constant acceleration for a time Δt_1, then with a constant velocity for the next Δt_2 and finally with a constant deceleration for the next Δt_3 to come to rest. A 500 N man sitting on the scooter behind the driver manages to stay at rest with respect to the scooter without touching any other part. The force exerted by the seat on the man is **[HCV Objective]**

(1) 500 N throughout the journey

(2) less than 500 N throughout the journey

(3) more than 500 N throughout the journey

(4) > 500 N for time Δt_1 and Δt_3 and 500 N for Δt_2



Difficulty Level : YODHA

QUESTION-32

A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be:

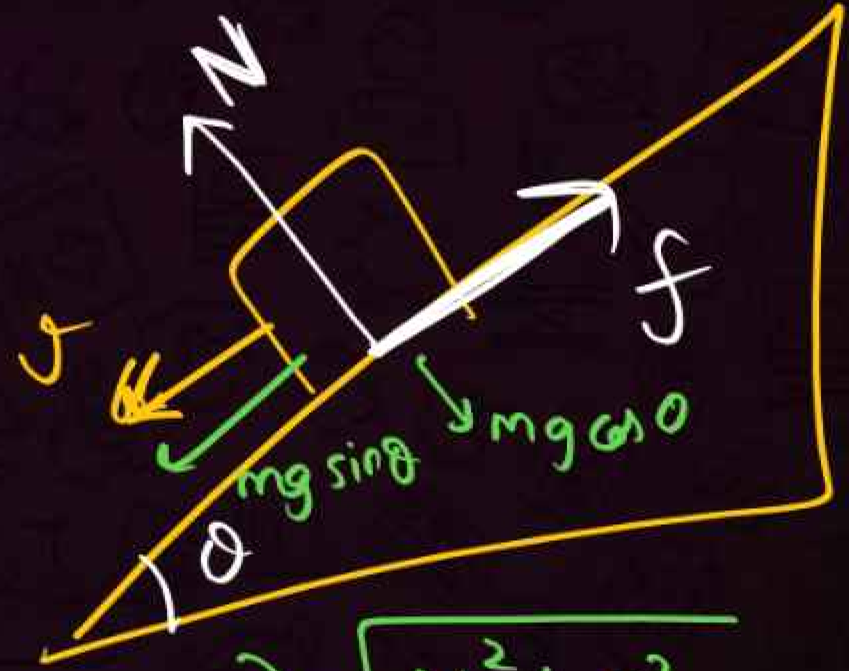
[Main 27th July 2nd Shift 2022]

(1) Mg

(2) $Mg\cos\theta$

(3) $\sqrt{Mg\sin\theta + Mg\cos\theta}$

(4) $Mg\sin\theta\sqrt{1+\mu}$



$$R = \sqrt{N^2 + f^2}$$

$$= \sqrt{M^2g^2\cos^2\theta + M^2g^2\sin^2\theta}$$

$$R = mg\sqrt{\sin^2\theta + \cos^2\theta}$$

$$\boxed{R = mg}$$

QUESTION-32

Difficulty Level : YODHA

A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ. The magnitude of the contact force will be:

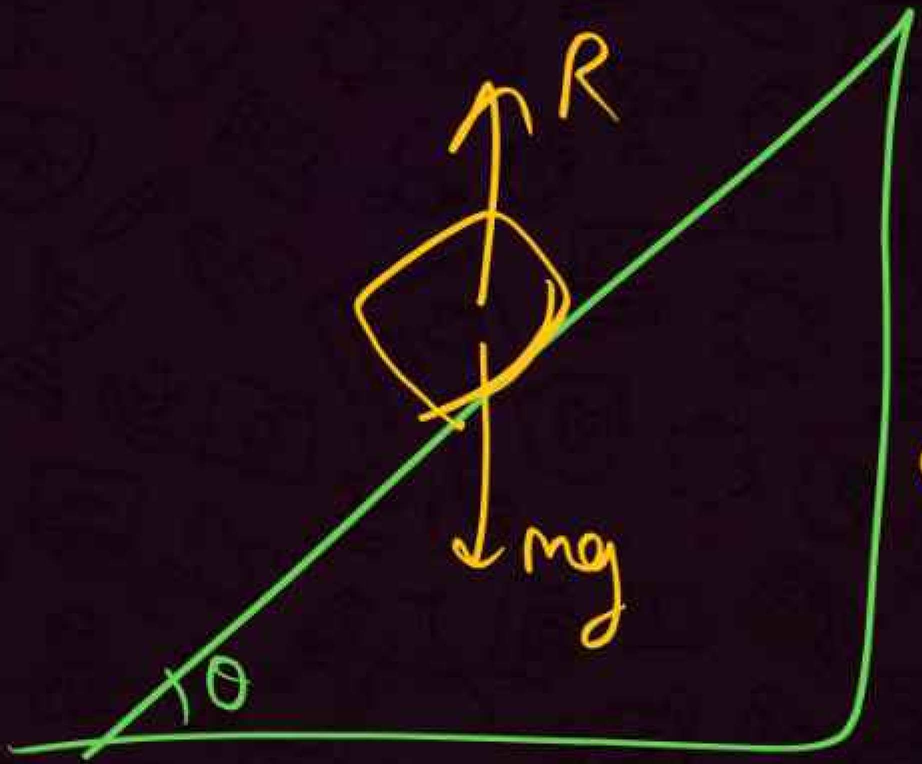
[Main 27th July 2nd Shift 2022]

(1) Mg

(2) $Mg\cos\theta$

(3) $\sqrt{Mg\sin\theta + Mg\cos\theta}$

(4) $Mg\sin\theta\sqrt{1+\mu}$



Constant $\vec{v}$ / Rest

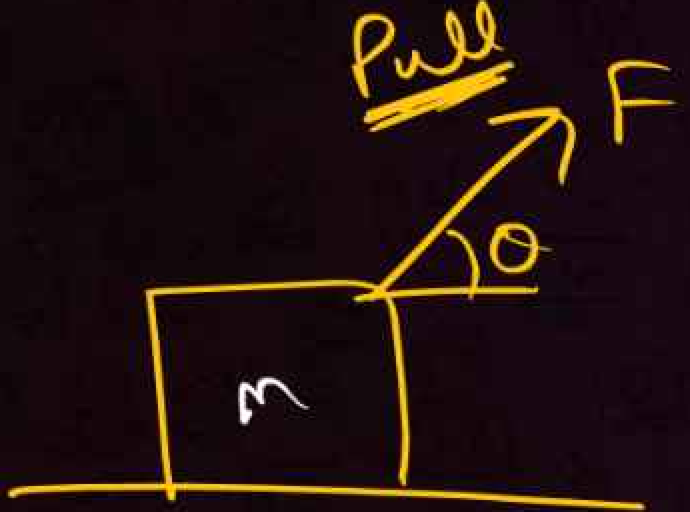
$F_{net} = 0$

$\boxed{R = mg}$

4.2 F_{min} to move

- Pulling is easier than Pushing

Pull

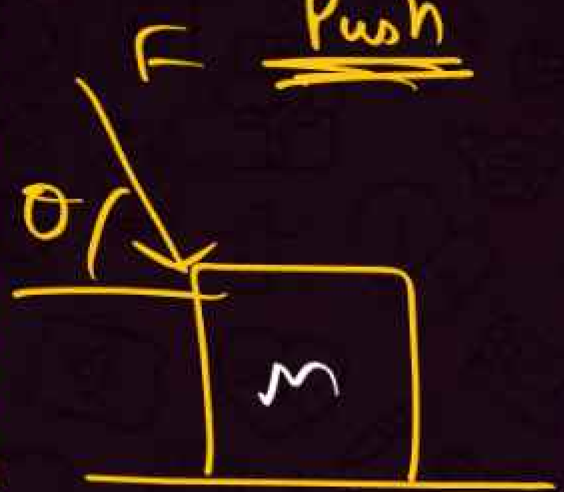


$N = mg - F\sin\theta$

$D = F\cos\theta$

$f_L = \mu N = \mu(mg - F\sin\theta)$

Push

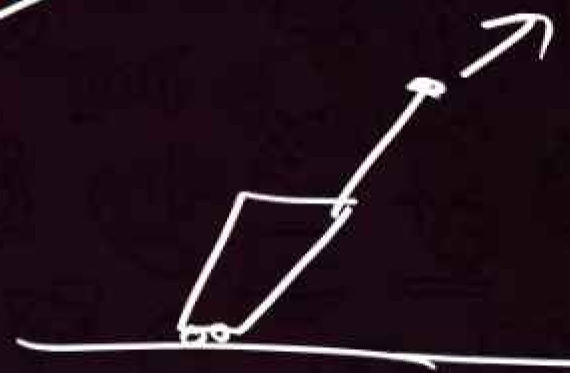


$N = mg + F\sin\theta$

$D = F\cos\theta$

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

Pulling is easier than Pushing



$x = \dfrac{1}{a\sin\theta + b\cos\theta}$

$x_{min} = \dfrac{1}{\sqrt{a^2+b^2}}$

Just about to move

$D = f_L$

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

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

$\boxed{F_{min} = \dfrac{\mu mg}{1\cos\theta + \mu\sin\theta}} = \dfrac{\mu mg}{\sqrt{1+\mu^2}}$

Pulling is easier than Pushing

F_{min} to move

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

$$\boxed{F_{min} = mg\sin\phi} \longleftrightarrow \boxed{\mu = \tan\phi}$$

Difficulty Level : HARD

HW

QUESTION-33

Which of the following statements is incorrect? [NCERT Based]

1. A cricketer moves his hands backwards while holding a catch.
2. A person falling from a certain height receives more injuries when he falls on a cemented floor than when he falls on a heap of sand.
3. It is easier to push a lawn mower than to pull it.
4. Mountain roads are generally made winding upwards rather than going straight up.

Difficulty Level : HARD

QUESTION-34

A block of weight W rests on a horizontal floor with coefficient of static friction μ. It is desired to make the block move by applying minimum amount of force. The angle θ from the horizontal at which the force should be applied and the magnitude F of the force is: **[AIEEE Online 2012]**

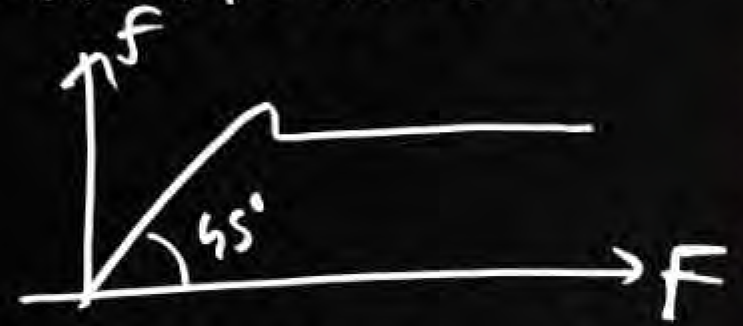
(1) $\theta = \tan^{-1}(\mu),\ F = \dfrac{\mu W}{\sqrt{1+\mu^2}}$

(2) $\theta = \tan^{-1}(\mu),\ F = \dfrac{\mu W}{\sqrt{\cancel{1+\mu^2}}}$ $1-\mu^2$

(3) $\theta = 0,\ F = \mu W$

(4) $\theta = \tan^{-1}\left(\dfrac{\mu}{1+\mu}\right),\ F = \dfrac{\mu W}{1+\mu}$

PUPPY POINTS - 2



f opposes rel. motion

f jitni jarurat utna

Angle of $F_r = \phi$

$R\cos\phi = N$

$R\sin\phi = f$

$\tan\phi = \frac{f}{N}$

$R = \sqrt{N^2 + f^2}$

For limiting f

$\tan\phi = \mu$

$\tan\theta = \mu$ *

✓ $F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Part 5 – Block Hilega ki nahi

5.1 Limiting Friction nikalo

(I) N, D, f_L

$f_L > D$

static

$$\boxed{f_s = D}$$

Jitni Jarurat utna

$$f = D$$

$f_L < D$

kinetic

$$\boxed{a = \frac{D - f}{m}}$$

Difficulty Level : Easy

QUESTION-35

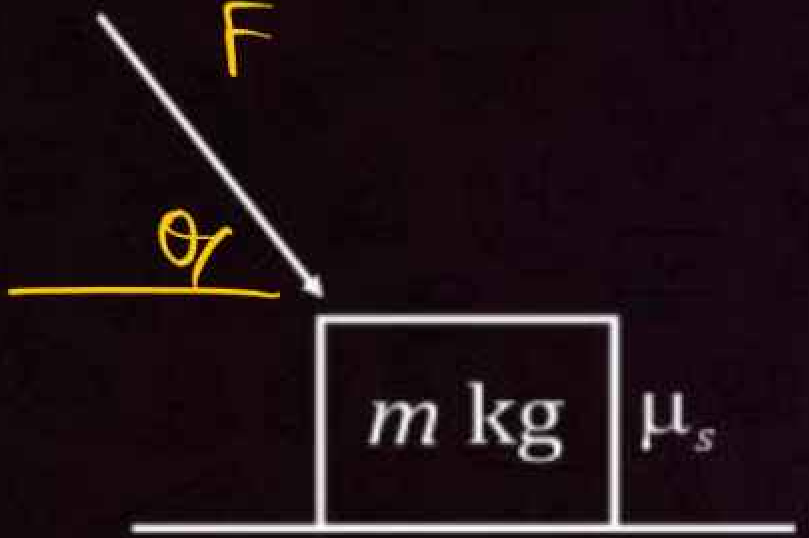
Calculate value of limiting friction

$$\boxed{\begin{aligned} N &= mg \\ f_L &= \mu N \end{aligned}}$$

Difficulty Level : HARD

QUESTION-36

Calculate value of limiting friction



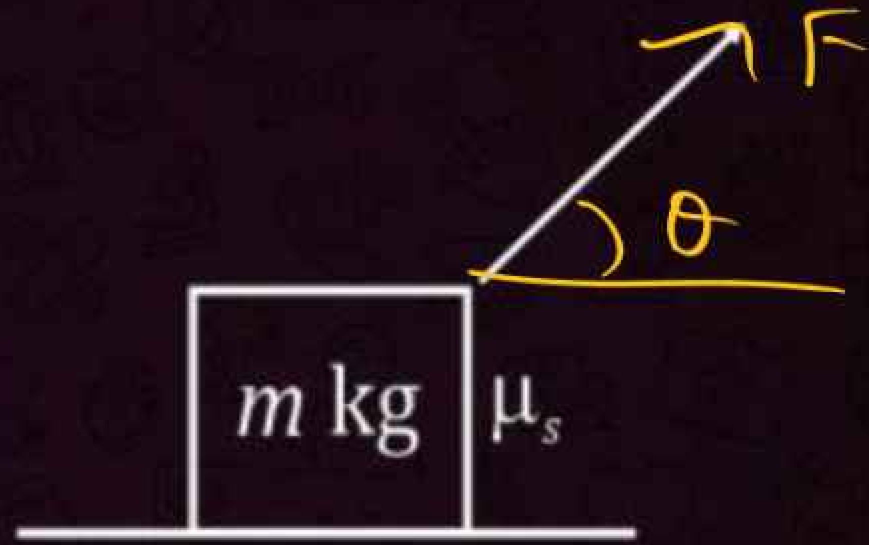
$N = mg + F\sin\theta$

$D = F\cos\theta$

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

QUESTION-37

Calculate value of limiting friction



$N = mg - F\sin\theta$

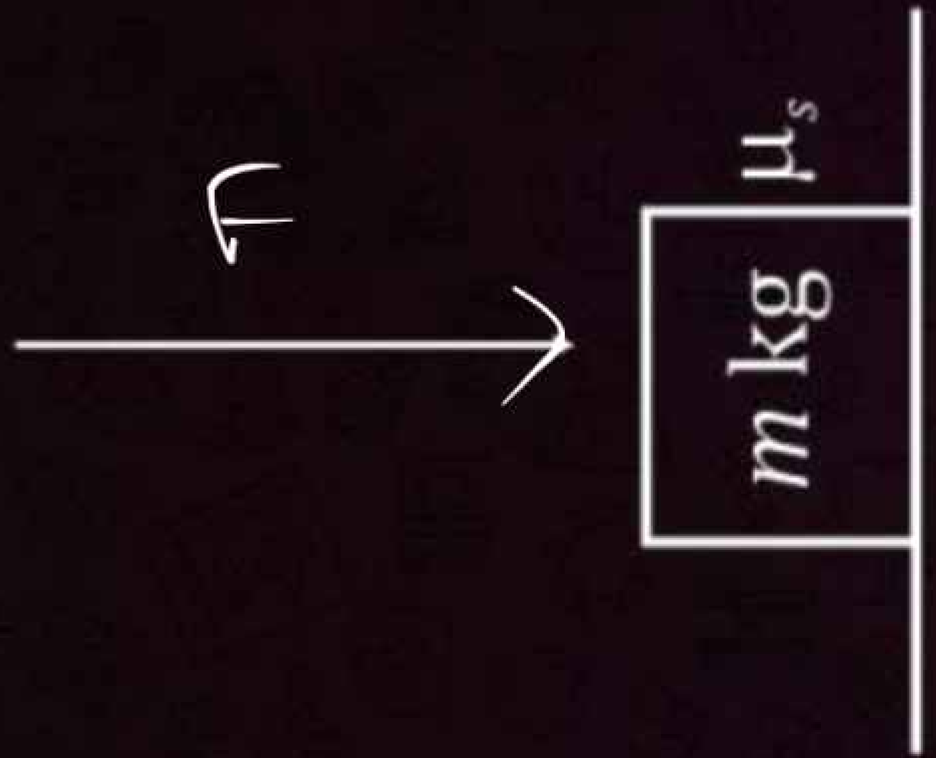
$D = F\cos\theta$

$f_L = \mu(mg - F\sin\theta)$

Difficulty Level : Easy

QUESTION-38

Calculate value of limiting friction



$N = F$

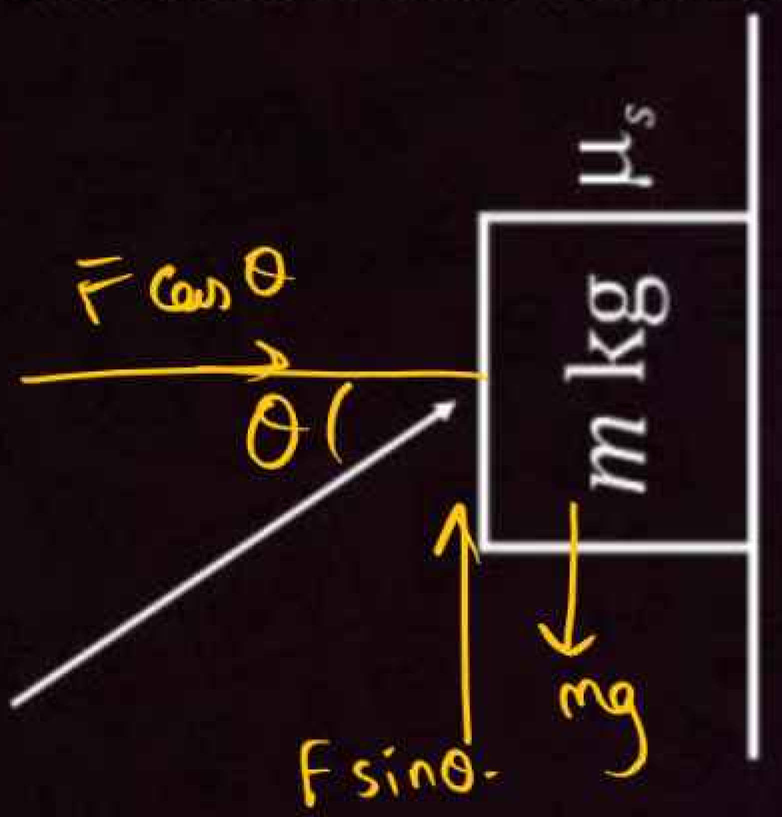
$D = mg$

$f_L = \mu N = \mu F$

Difficulty Level : HARD

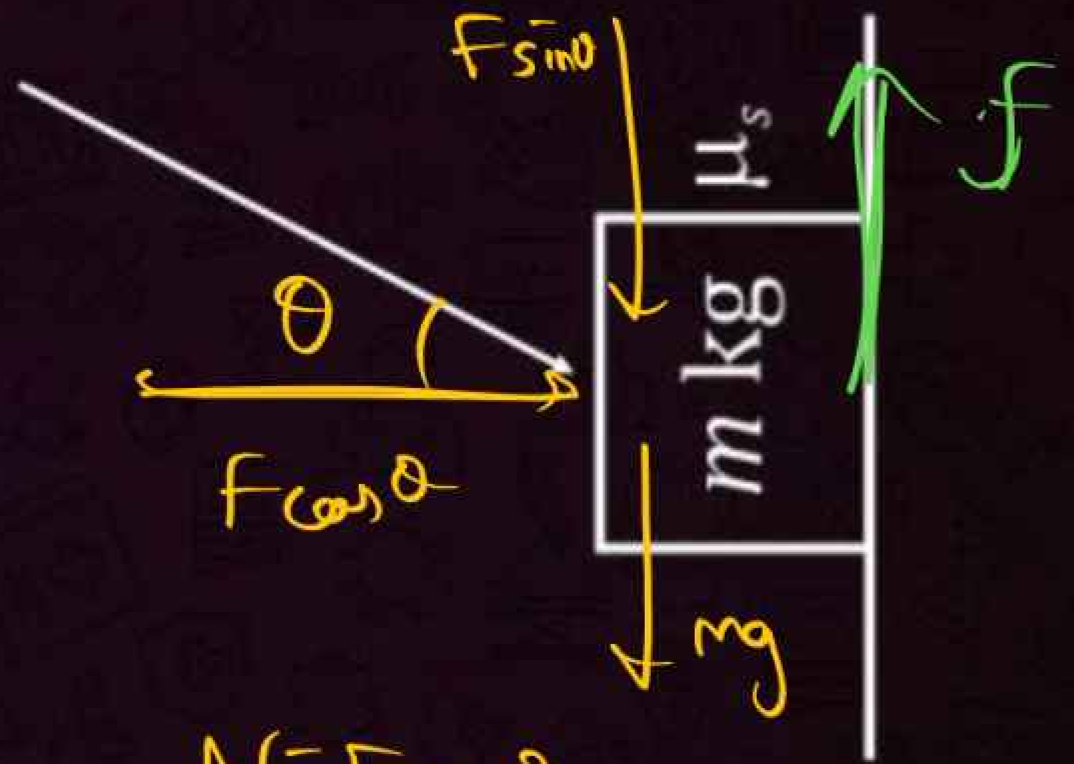
QUESTION-39

Calculate value of limiting friction



QUESTION-40

Calculate value of limiting friction



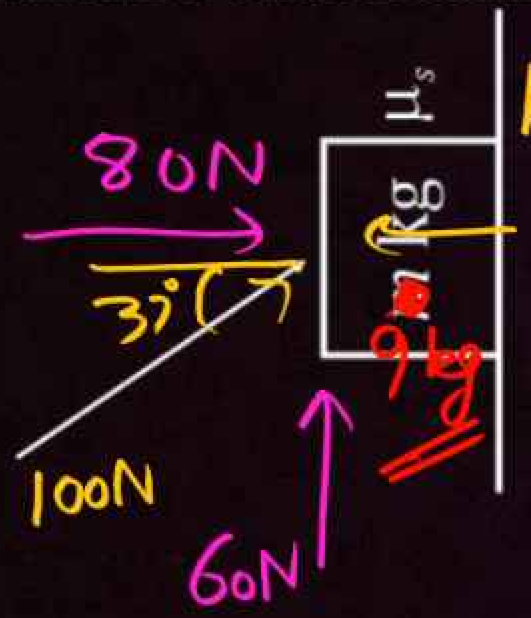
$N = F\cos\theta$

$D = mg + F\sin\theta$

$f_L = \mu(F\cos\theta)$

QUESTION-39

Calculate value of limiting friction

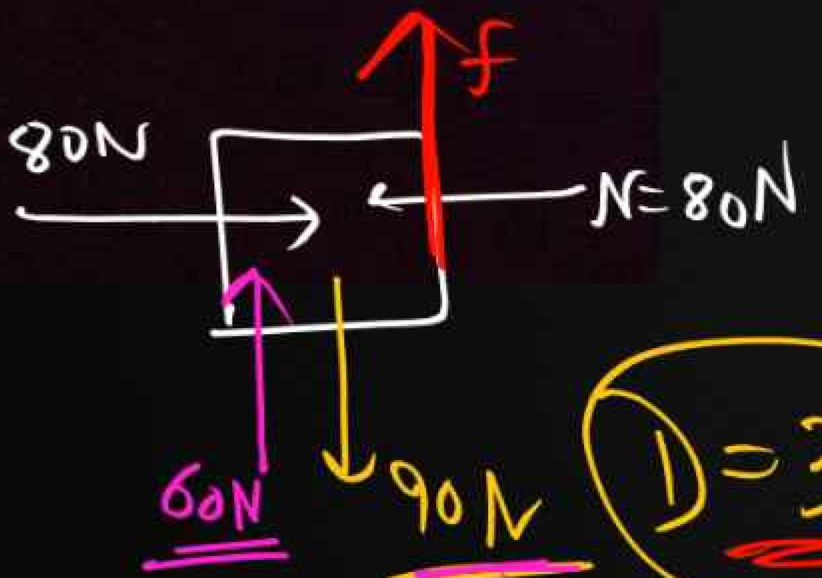


$N = 80N$

$f_L = 0.5 N$

$= 0.5 \times 80$

$f_L = 40N$



$\boxed{f_L = 40N}$

$D = 30N$

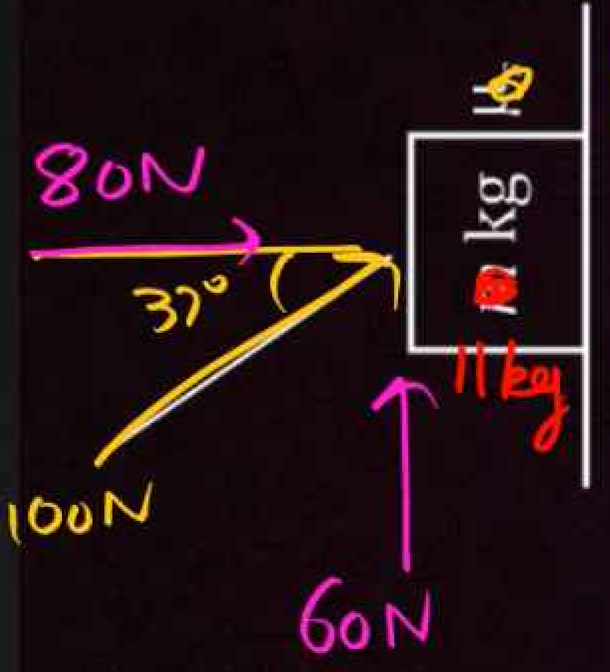
$f_L > D$

will not move.

static $\uparrow f = 30N$

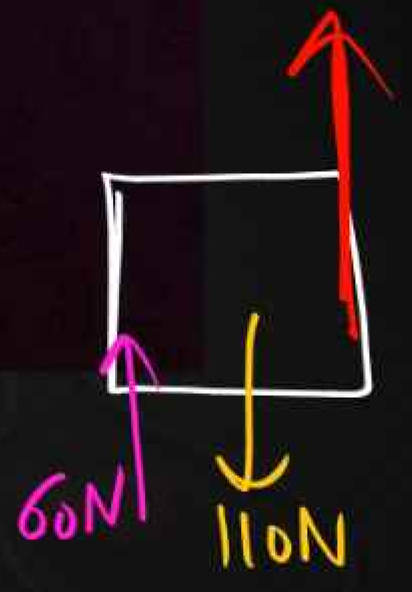
QUESTION-39

Calculate value of limiting friction



$N = 80N$

$f_L = \mu N = 0.5 \times 80 = 40N$



$\boxed{f_L = 40N}$

$\boxed{D = 50N}$

$D > f_L$

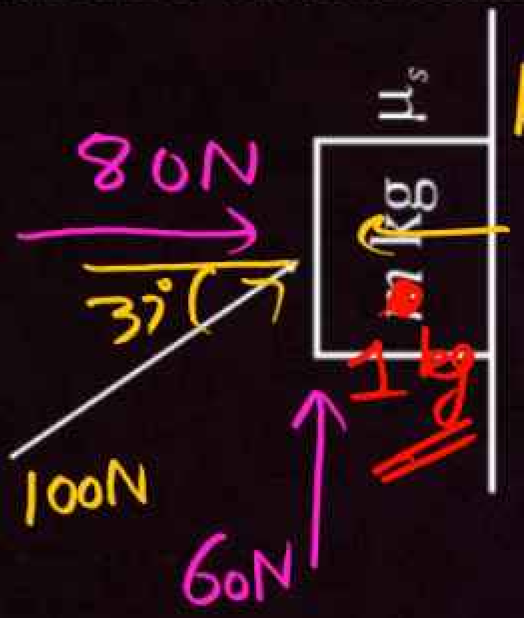
will move

Kinetic

$a = \frac{D - f}{m} = \frac{50 - 40}{11} = \frac{10}{11} m/s^2$

QUESTION-39

Calculate value of limiting friction

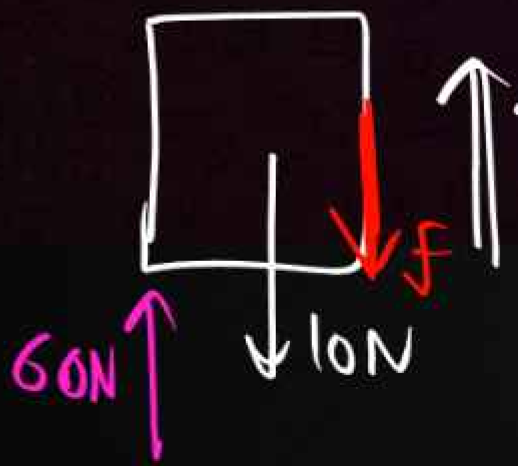


$N = 80N$

$F_L = 0.5N$

$= 0.5 \times 80$

$F_L = 40N$



$\uparrow D = 50N$

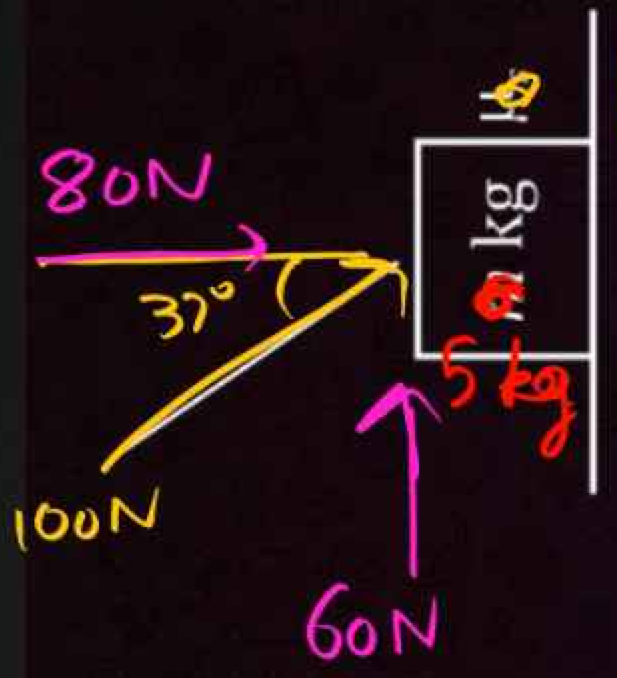
$D > f_L$ ×

kinetic

$a = \frac{D - f}{m} = \frac{50 - 40}{1} = 10 m/s^2$

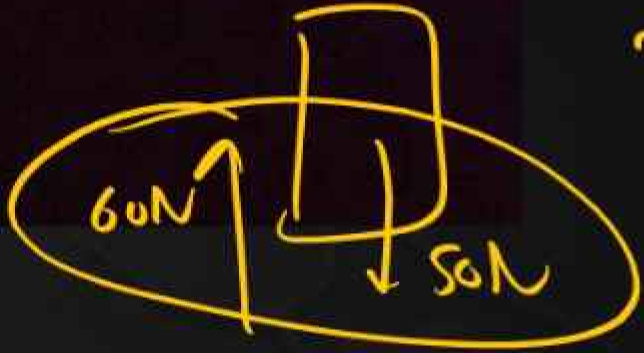
QUESTION-39

Calculate value of limiting friction



$N = 80N$

$f_L = \mu N = 0.5 \times 80 = 40N$



$D = 10N \uparrow < f_L$

static

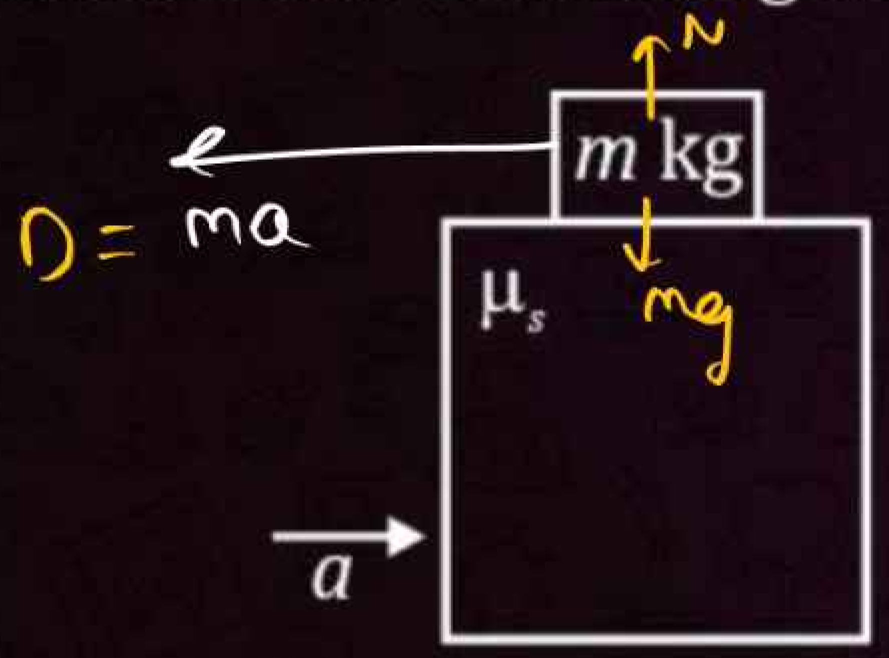
$f = ??$

$f = 10N \downarrow$

Difficulty Level : Easy

QUESTION-41

Calculate value of limiting friction



$N = mg$

$D = ma \quad f_L = \mu mg$

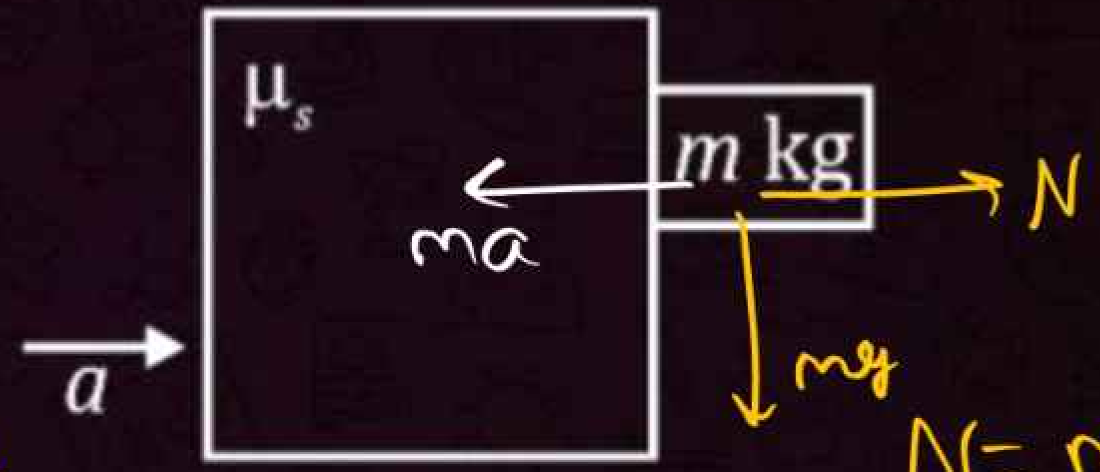
Just about to move $(D = f_L)$

$\cancel{m}a = \mu \cancel{m} g$

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

QUESTION-42

Calculate value of limiting friction



$N = ma$

$D = mg$

$f_L = \mu ma$

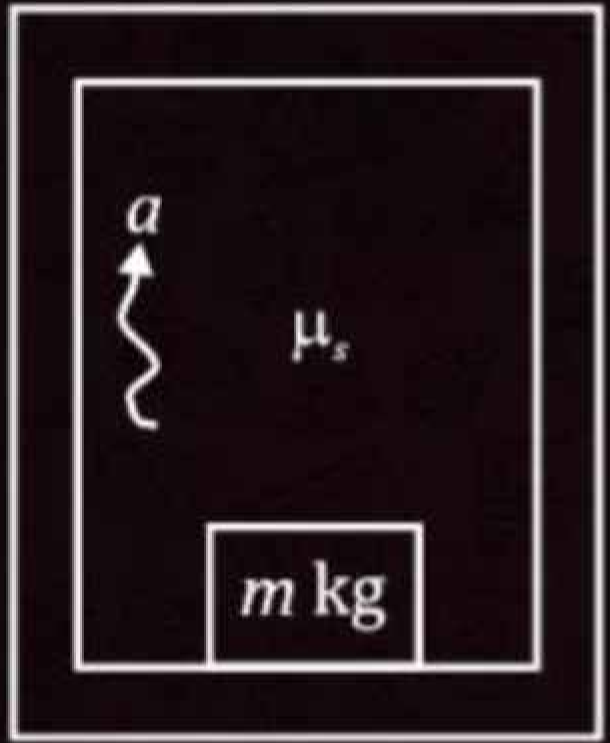
Just. . . . . . .

$\cancel{m}g = \mu \cancel{m} a$

$\boxed{a_{min} = \frac{g}{\mu}}$

QUESTION-43

Calculate value of limiting friction

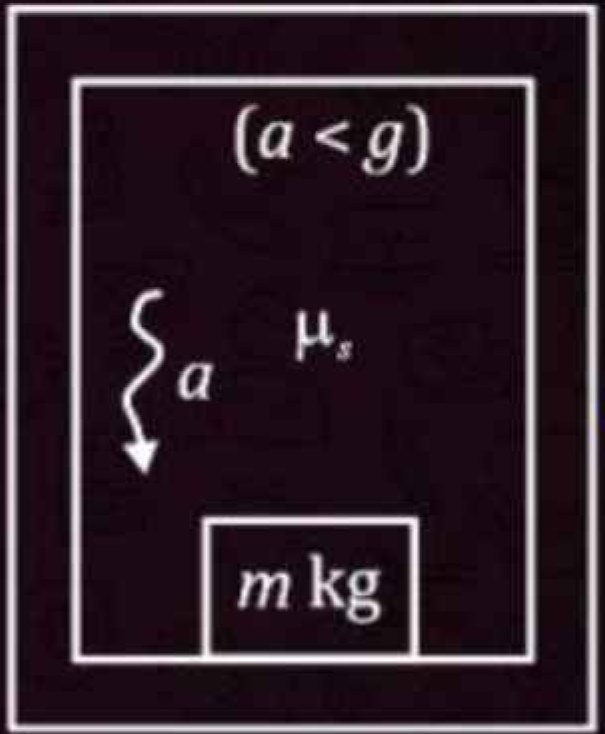


$N = m(g+a)$

$f_L = \mu m(g+a)$

QUESTION-44

Calculate value of limiting friction

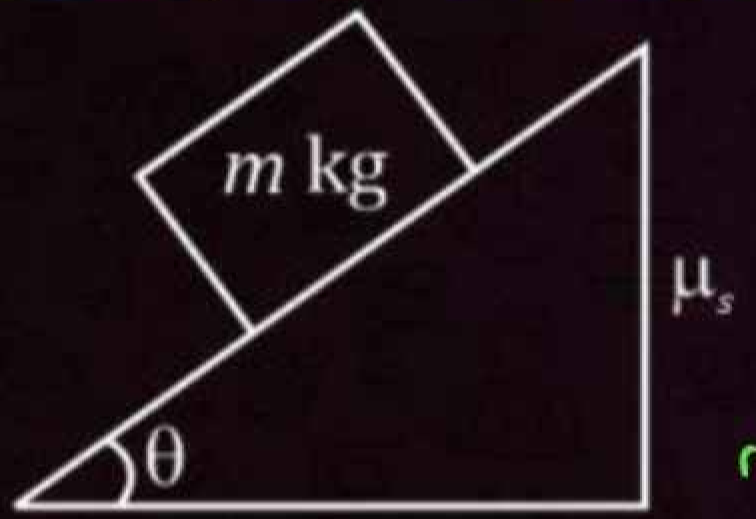


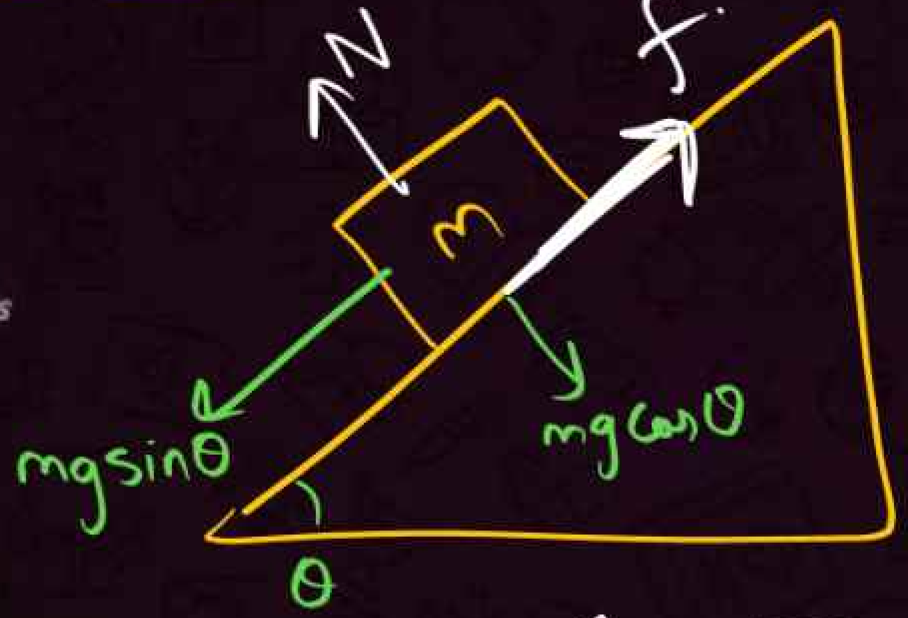
$N = m(g-a)$

$f_L = \mu m(g-a)$

QUESTION-45

Calculate value of limiting friction





$N = mg\cos\theta$ ✓

$D = mg\sin\theta$ ✓

$f_L = \mu mg\cos\theta$ ✓

(I) Just about to move

$D = f_L$

$\cancel{mg}\sin\theta = \mu \cancel{mg}\cos\theta$

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

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

Angle of Repose

(II) Moving $D > f_L$

$a = \frac{D - f}{m}$

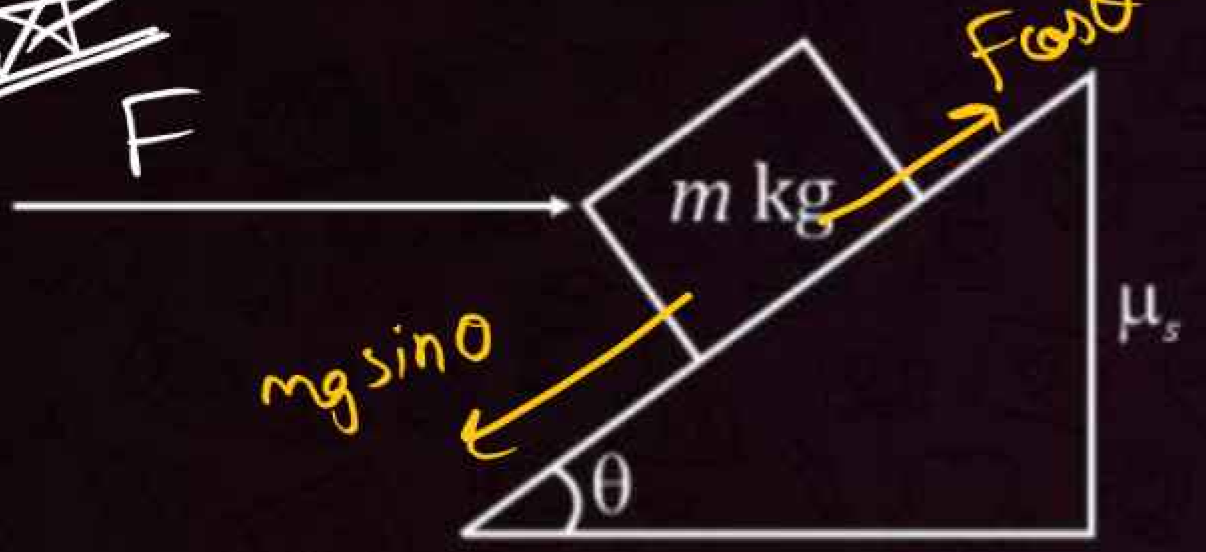
$a = \frac{mg\sin\theta - \mu mg\cos\theta}{m}$

$\boxed{a = g\sin\theta - \mu g\cos\theta}$

Difficulty Level : HARD

QUESTION-46

Calculate value of limiting friction



$N = mg\cos\theta + F\sin\theta$

$D = mg\sin\theta - F\cos\theta$

or

$D = F\cos\theta - mg\sin\theta$

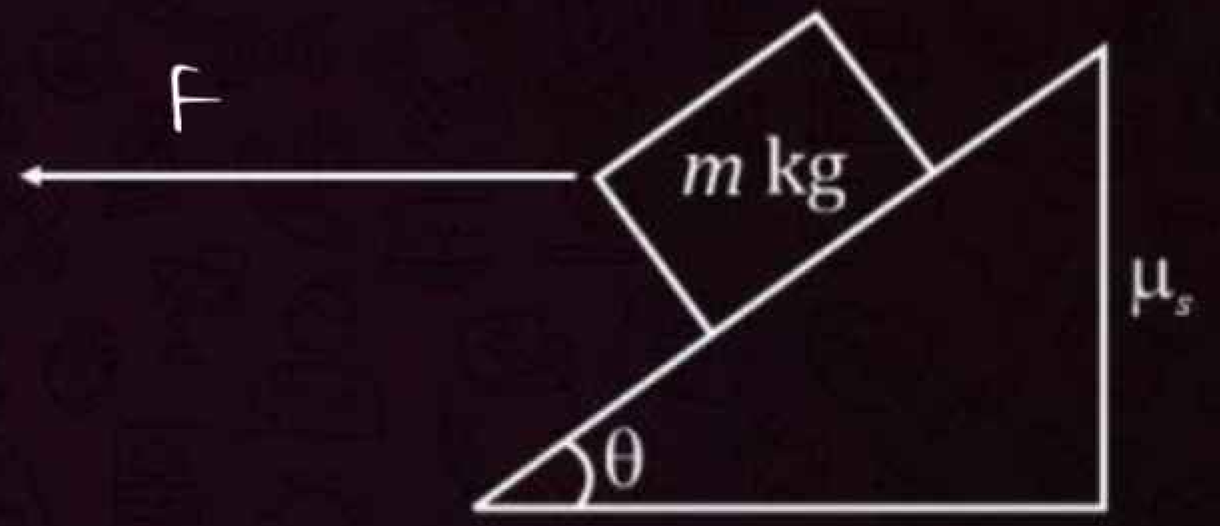
D ↙ f ↗

D ↗ f ↙

$$\boxed{f_L = \mu \times N = \mu\,(mg\cos\theta + F\sin\theta)}$$

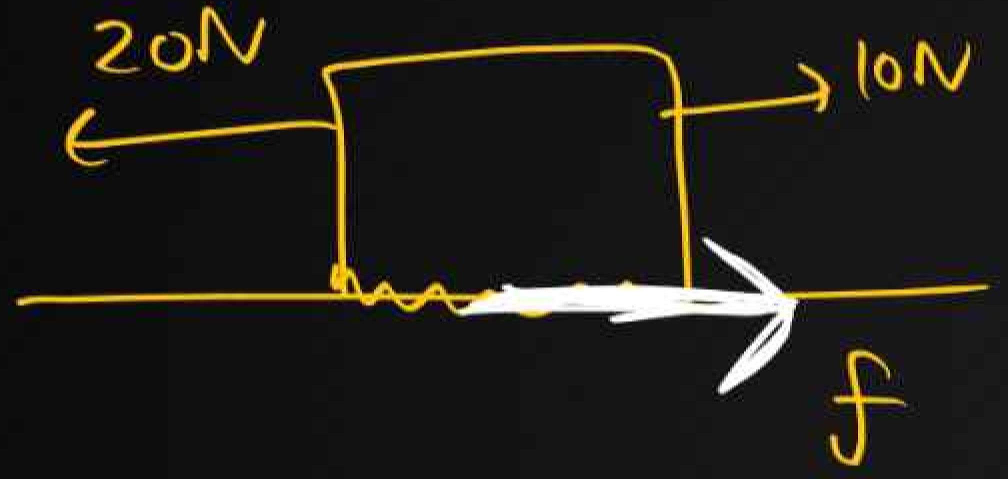
QUESTION-47

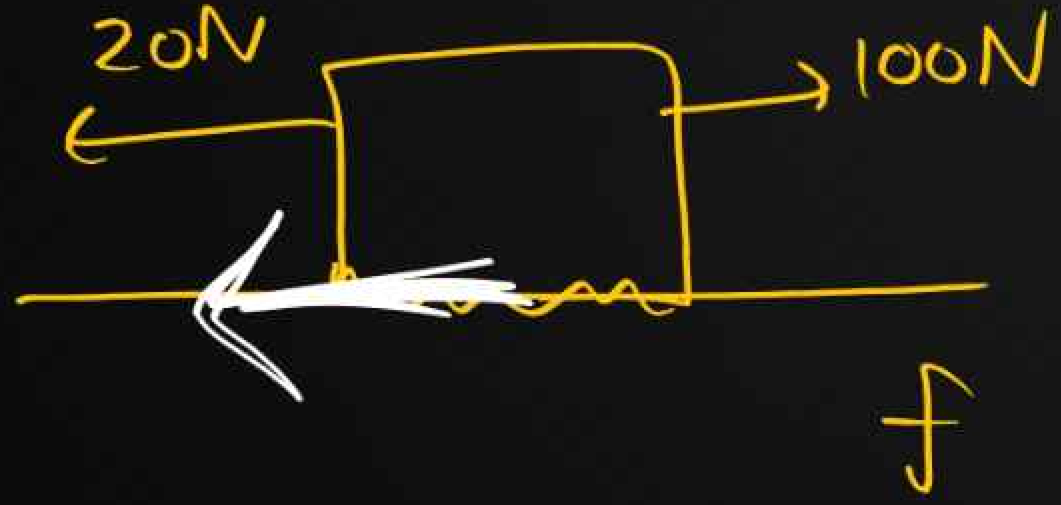
Calculate value of limiting friction



$N = mg\cos\theta - F\sin\theta$

$D = mg\sin\theta + F\cos\theta$

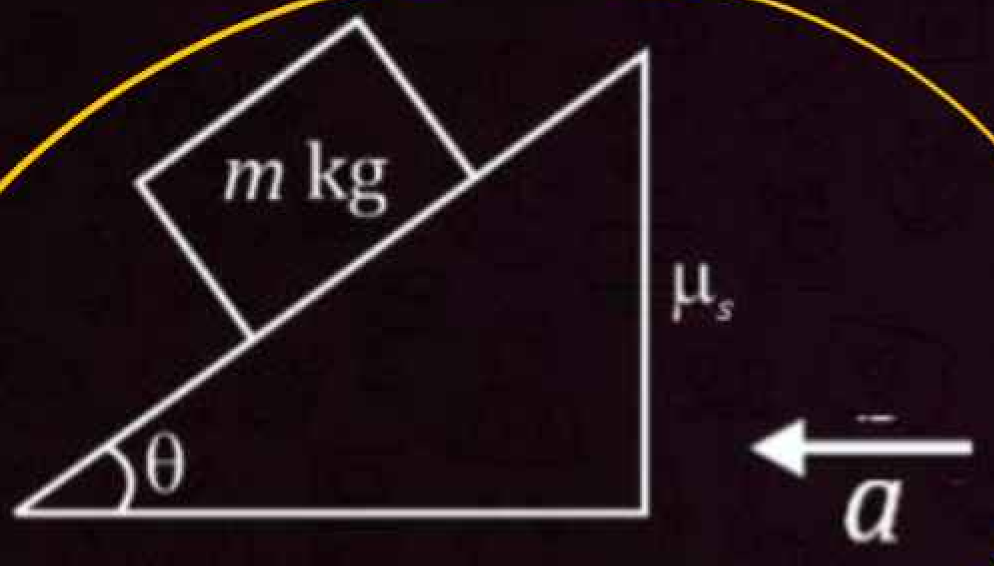

20N
10N
f


20N
100N
f

Difficulty Level : HARD

QUESTION-48

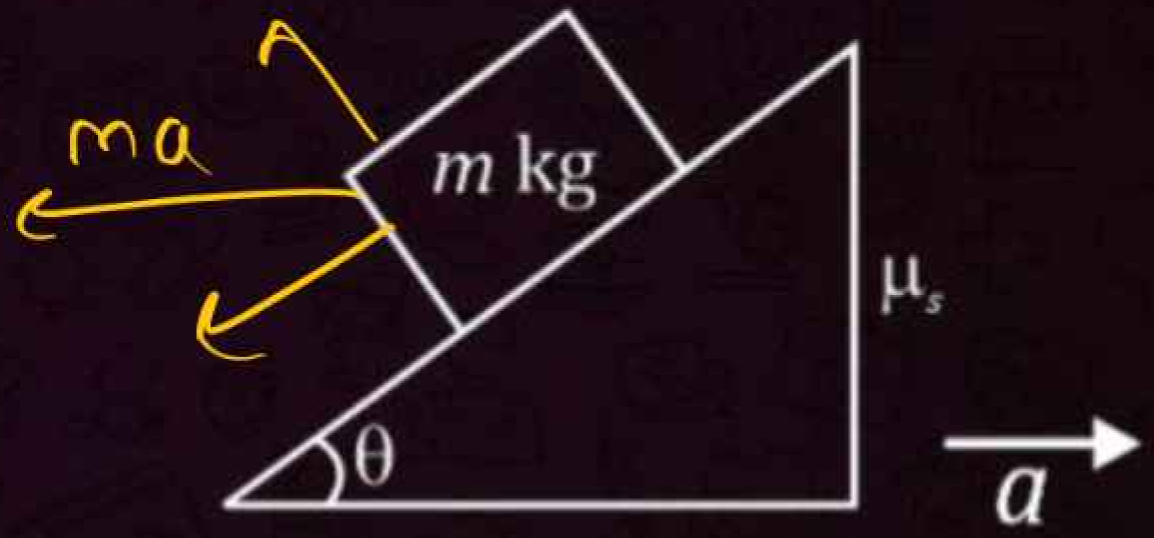
Calculate value of limiting friction



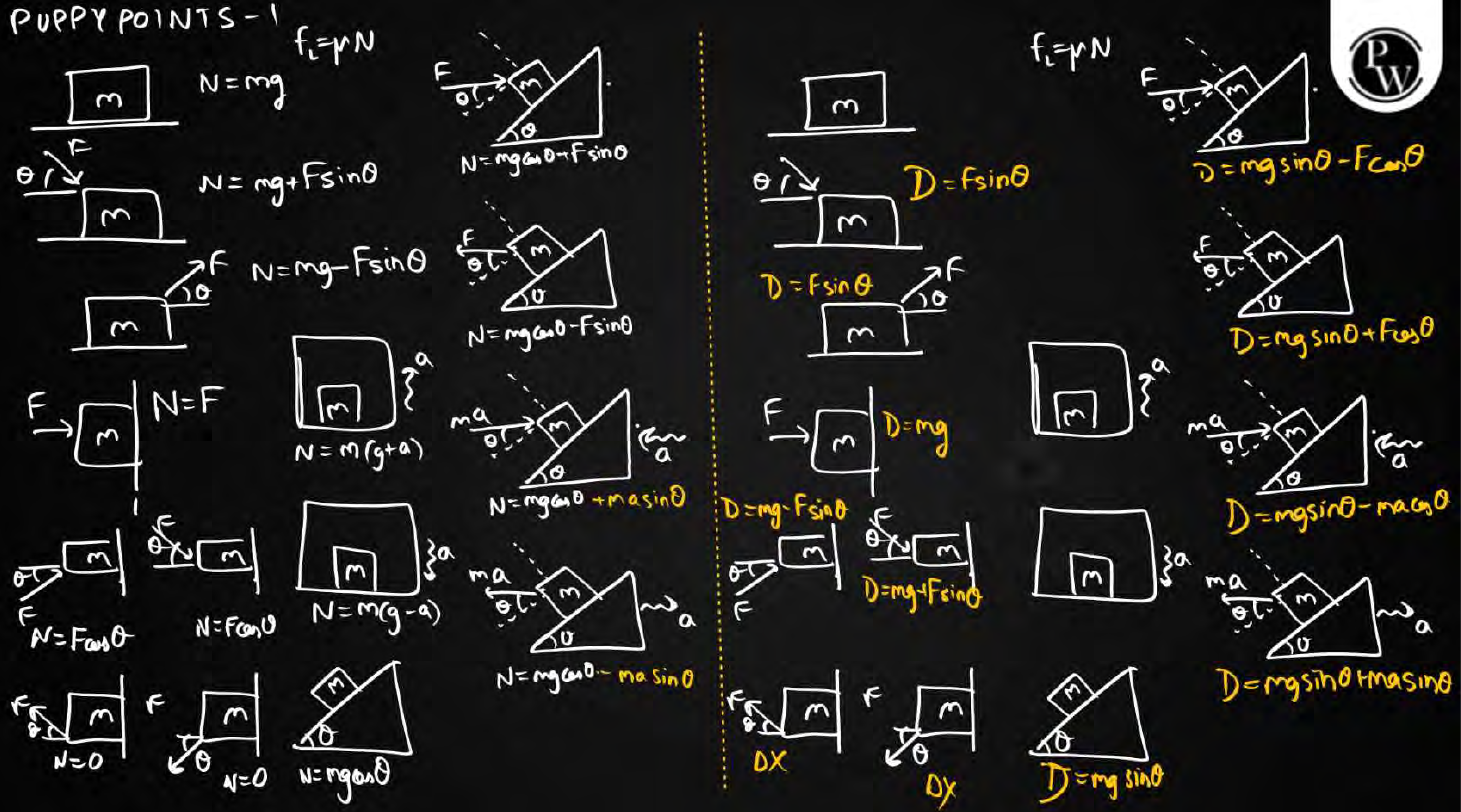
Most Difficult case

QUESTION-49

Calculate value of limiting friction

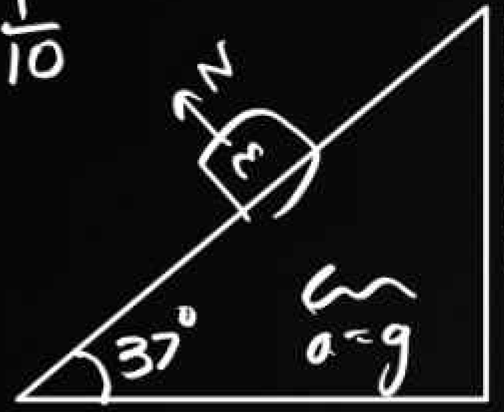


$$\boxed{\begin{aligned} N &= mg\cos\theta - ma\sin\theta \\ D &= mg\sin\theta + ma\cos\theta \\ f &= \mu \times N = \mu mg\cos\theta - \mu ma\sin\theta \end{aligned}}$$



PUPPY POINTS - 1
$f_L = \mu N$
$N = mg$
$N = mg + F\sin\theta$
$N = mg - F\sin\theta$
$N = F$
$N = m(g+a)$
$N = F\cos\theta$
$N = F\cos\theta$
$N = m(g-a)$
$N = 0$
$N = 0$
$N = mg\cos\theta$
$N = mg\cos\theta + F\sin\theta$
$N = mg\cos\theta - F\sin\theta$
$N = mg\cos\theta + ma\sin\theta$
$N = mg\cos\theta - ma\sin\theta$
$f_L = \mu N$
$D = F\sin\theta$
$D = F\sin\theta$
$D = mg$
$D = mg - F\sin\theta$
$D = mg + F\sin\theta$
DX
DX
$D = mg\sin\theta$
$D = mg\sin\theta - F\cos\theta$
$D = mg\sin\theta + F\cos\theta$
$D = mg\sin\theta - ma\cos\theta$
$D = mg\sin\theta + ma\sin\theta$

$\mu = \frac{1}{10}$



$D = \frac{mg}{5}$ f

$f_L = \mu\, \frac{7mg}{5}$

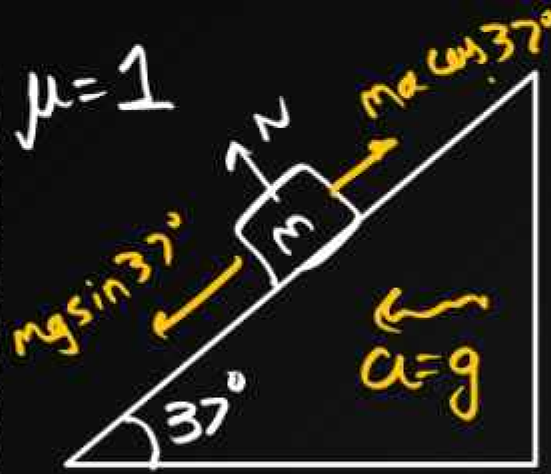
$f_L = \frac{0.7mg}{5}$

$D > f_L$ kinetic

$a = \frac{D - f}{m} = \frac{mg}{5m} - \frac{0.7mg}{5m}$

$\boxed{a = \frac{0.3g}{5}}$

$\mu = 1$



$mg\frac{3}{5} \longleftrightarrow mg\frac{4}{5}$

$D = \frac{4mg}{5} - \frac{3mg}{5}$

$D = \frac{mg}{5}$ f

$f_L = \mu N$

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

$= \mu\left(mg\frac{4}{5} + mg\frac{3}{5}\right)$

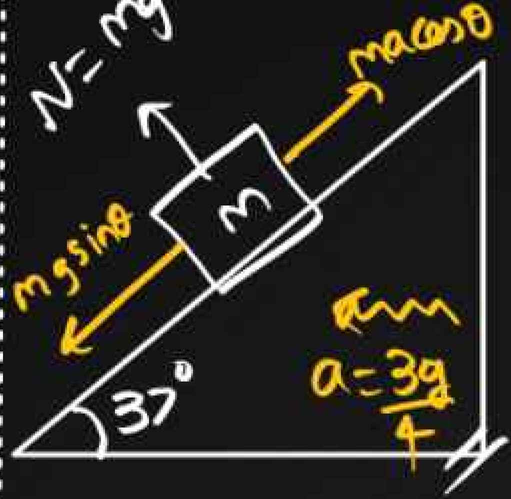
$f_L = \mu\, \frac{7mg}{5}$

$f_L > D$ static

rest

$\left(f = D = \frac{mg}{5}\right)$

$N = mg\cos\theta + ma\sin\theta$



$m \times g \times \sin 37 = mg\frac{3}{5}$

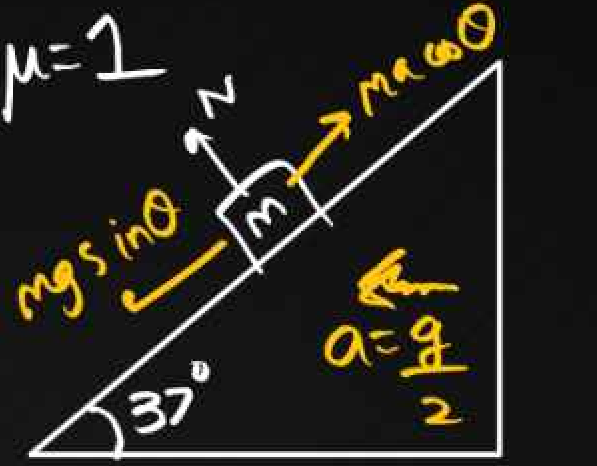
$m\, a \cos 37° = m \times \frac{3g}{\cancel{4}} \times \frac{\cancel{4}}{5}$

No slipping

$\boxed{a = g\tan\theta}$

$f = 0$

$\mu = 1$



$mg\frac{3}{5} \longleftrightarrow \frac{mg}{\cancel{2}} \times \frac{\cancel{4}\,2}{5}$

$D = \frac{mg}{5}$ f

$N = (mg\cos\theta + ma\sin\theta)$

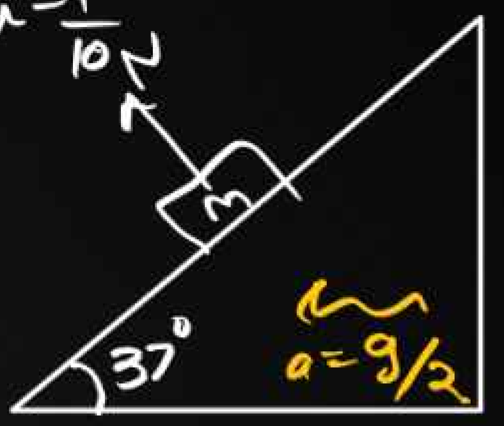
$f_L = \mu\left(mg\frac{4}{5} + \frac{mg}{\cancel{2}} \times \frac{\overset{1.5}{\cancel{3}}}{5}\right)$

$f_L = \mu\, \frac{5.5mg}{5}$

$f_L > D$

$f = \frac{mg}{5}$

$\mu = \frac{1}{10}$



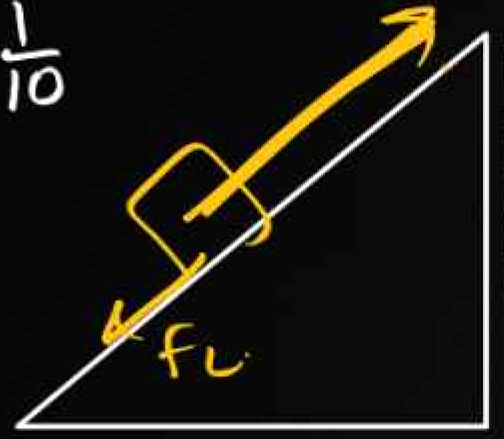
$D = \frac{mg}{5}$ f

$f_L = \frac{0.55mg}{5}$

$a = \frac{D - f}{m}$

$\boxed{a = \frac{0.45g}{5}}$

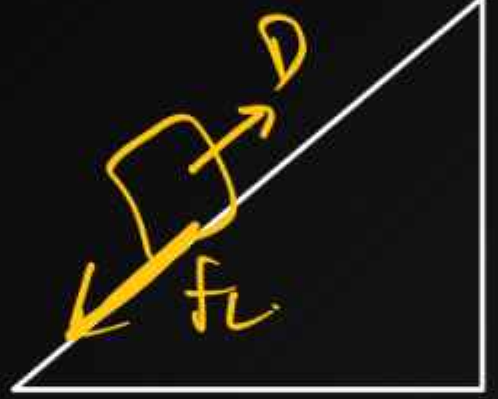
$\mu = \frac{1}{10}$



$a > g\tan(\theta+\phi)$

$a \geq g\left(\frac{\tan\theta+\mu}{1-\mu\tan\theta}\right)$

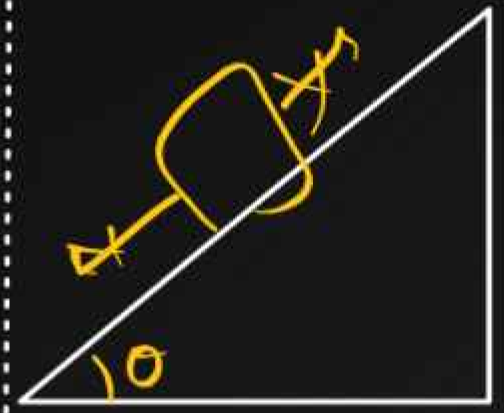
$D \nearrow > f_L \swarrow$



$> a > g\tan\theta$

$D \nearrow < f_L \swarrow$

$a = 0$

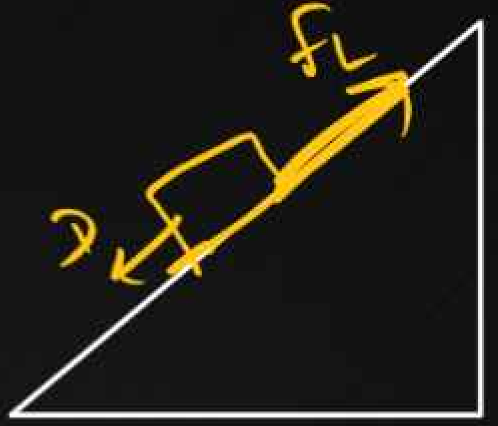


$a = g\tan\theta$ $D=0$

No slipping

$f = 0$

No wear No tear



$a < g\tan\theta <$

$\swarrow D < f_L \nearrow$

$a = 0$

$a < g\tan(\theta-\phi)$

$a < g\left(\frac{\tan\theta-\mu}{1+\mu\tan\theta}\right)$

$\swarrow D > f_L \nearrow$

a ✓

$a = g\tan\theta$

No slip $\quad D = 0$

$f = 0$

No wear tear

$g\tan\theta < a$

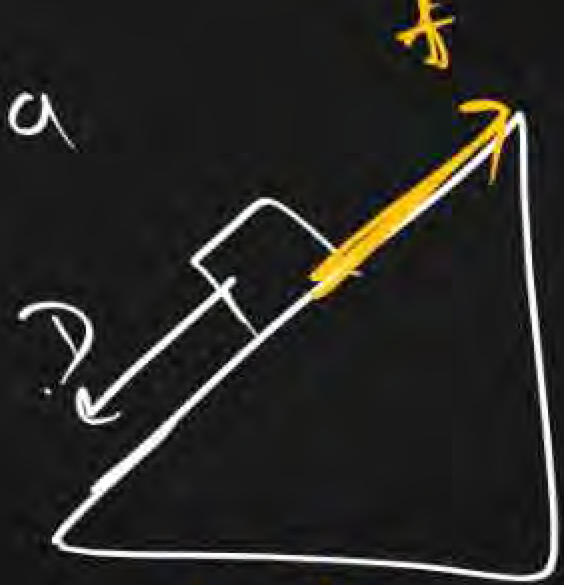
No slip

$g\tan(\theta+\phi) < a$

Slip up the incline

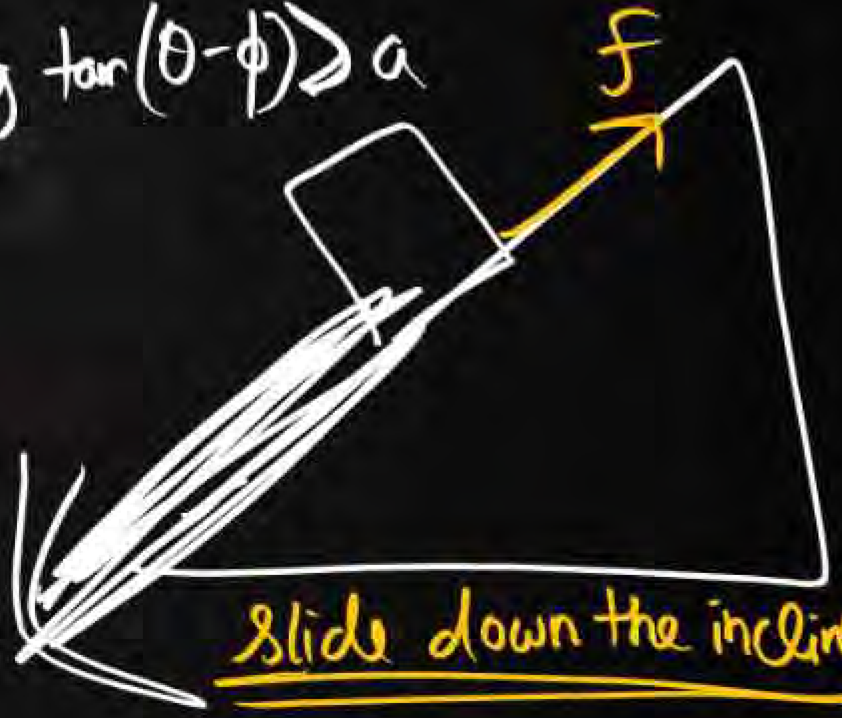
$D > f$

$g\tan\theta > a$

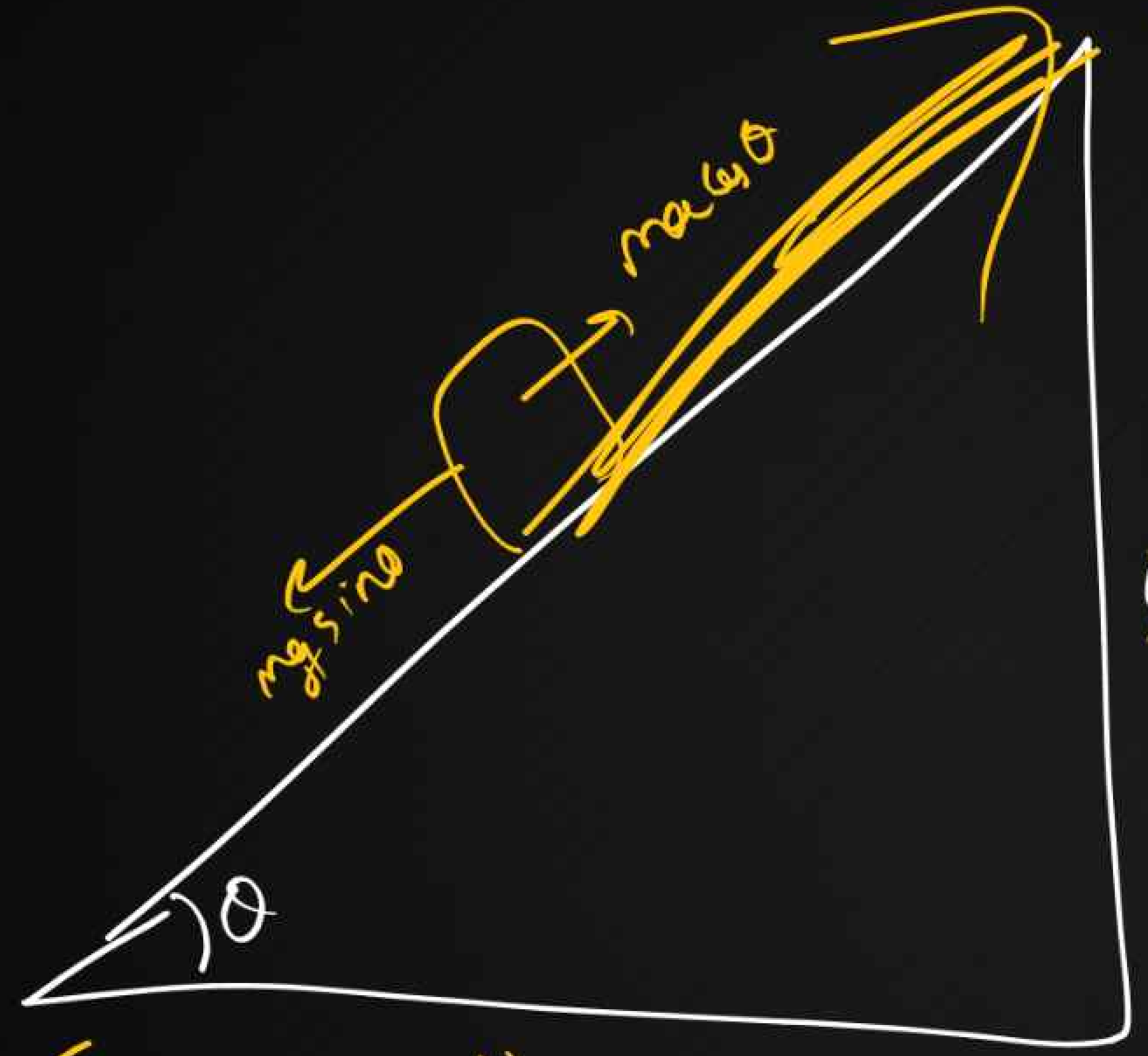


No slip

$g\tan(\theta-\phi) > a$



Slide down the incline



(If $\mu = \tan\phi$)

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

$$f_L = \mu N$$
$$= \mu(mg\cos\theta + ma\sin\theta)$$

$$D = f_L$$

$$\frac{\cancel{m}a\cos\theta}{\cos\theta} - \frac{\cancel{m}g\sin\theta}{\cos\theta} = \frac{\mu \cancel{m}g\cos\theta}{\cos\theta} + \frac{\mu \cancel{m}a\sin\theta}{\cos\theta}$$

$$a - g\tan\theta = \mu g + \mu a\tan\theta$$

$$a - \mu a\tan\theta = \mu g + g\tan\theta$$

$$a(1-\mu\tan\theta) = g(\mu + \tan\theta)$$

$$\boxed{a = g\left(\frac{\mu + \tan\theta}{1-\mu\tan\theta}\right) = g\tan(\theta+\phi)}$$

5.2 Word Problems

Difficulty Level : MEDIUM

QUESTION-50

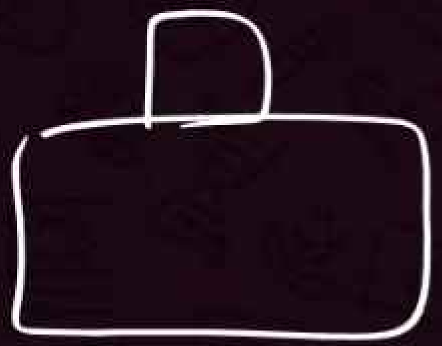
Calculate the maximum acceleration of a moving car so that a body lying on the floor of the car remains stationary. The coefficient of static friction between the body and the floor is 0.15 ($g = 10\ ms^{-2}$). **[2023]**

(1) $50\ ms^{-2}$

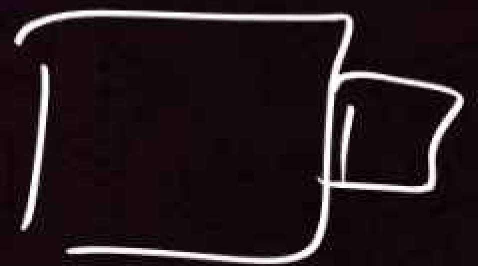
(2) $1.2\ ms^{-2}$

(3) $150\ ms^{-2}$

(4) $1.5\ ms^{-2}$



$$\boxed{\begin{aligned} a_{max} &= \mu g \\ &= 0.15 \times 10 \\ &= 1.5\ m/s^2 \end{aligned}}$$



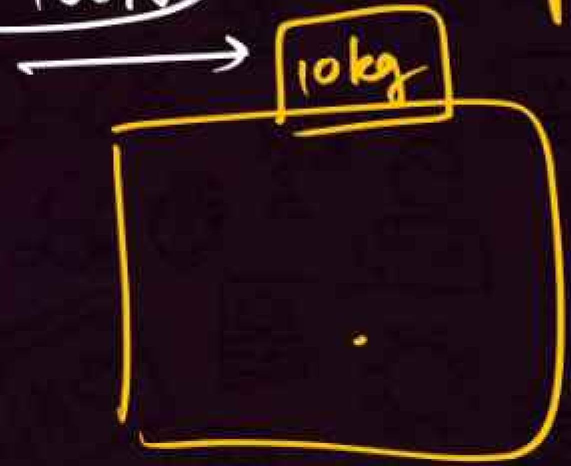
$$a_{min} = \frac{g}{\mu}$$

Difficulty Level : MEDIUM

QUESTION-51

A block of mass 10 kg is placed on rough horizontal surface whose coefficient of friction is 0.5. If a horizontal force of 100 N is applied on it, then acceleration of the block will be [Take g = 10 m s^{-2}] [NCERT Based]

$F = 100\,N$ $\mu = 0.5$



(1) 10 m s^{-2}

(2) 5 m s^{-2} ✓

(3) 15 m s^{-2}

(4) 0.5 m s^{-2}

$N = 100\,N \quad f_L = 0.5 \times 100 = \underline{\underline{50\,N}}$

$a = \dfrac{F - f}{m} = \dfrac{100 - 50}{10} = \dfrac{50}{10} = \underline{\underline{5\,m/s^2}}$

Difficulty Level : MEDIUM

QUESTION-52

nw μ

The coefficient of static friction between the box and the train's floor is 0.2. The maximum acceleration of the train in which a box lying on its floor will remain stationary is (Take g = 10 m s^{-2}) **[NCERT Based]**

(1) 2 m s^{-2} ✓

$a = \mu g$

(2) 4 m s^{-2}

(3) 6 m s^{-2}

(4) 8 m s^{-2}

Difficulty Level : MEDIUM

QUESTION-53

A block of mass 1 kg lies on a horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6 . If the acceleration of the truck is 5 m s^{-2}. The frictional force acting on the block is [NCERT Based]

$\mu = 0.6$

5N

(1) 10 N

(2) 5 N

(3) 2.5 N

(4) 20 N

$D = ma = 1 \times 5 = 5N$

$N = 10N$

$f_L = \mu N = 0.6 \times 10 = 6N$

$f_L > D$

Static

$f = D$

Difficulty Level : MEDIUM

QUESTION-54

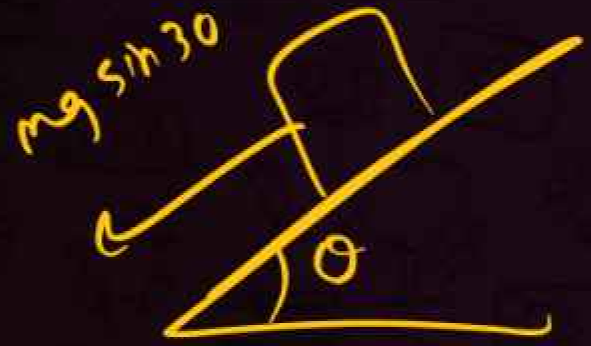
A block of mass 2 kg rest on a plane inclined at an angle of 30° with the horizontal. The coefficient of friction between the block and the surface is 0.7. What will be the maximum possible frictional force acting on the block? **[NCERT Based]**

(1) 10.3 N

(2) 23.8 N

(3) 11.9 N

(4) 6.3 N



$\therefore D = mg \sin 30$

$= \cancel{2} \times 10 \times \frac{1}{\cancel{2}}$

$= 10 N$

1.7×7

$= 11.9$

Difficulty Level : HARD

QUESTION-55

A block of mass M is held against a rough vertical wall by pressing it with a finger. If the coefficient of friction between the block and the wall is μ and the acceleration due to gravity is g, what is the minimum force required to be applied by the finger to hold the block against the wall? [NCERT Based]

(1) μMg

(2) Mg

(3) $\frac{Mg}{\mu}$

(4) $2\mu Mg$

$\downarrow D = mg \quad \uparrow f_L = \mu N = \mu F$

$mg = \mu F$

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

Difficulty Level : HARD

QUESTION-56

Two blocks A and B of masses 10 kg and 15 kg are placed in contact with each other rest on a rough horizontal surface as shown in the figure. The coefficient of friction between the blocks and surface is 0.2. A horizontal force of 200 N is applied to block A. The acceleration of the system is (Take $g = 10 \text{ m s}^{-2}$)

[NCERT Based]

(1) 4 m s^{-2}

(2) 6 m s^{-2}

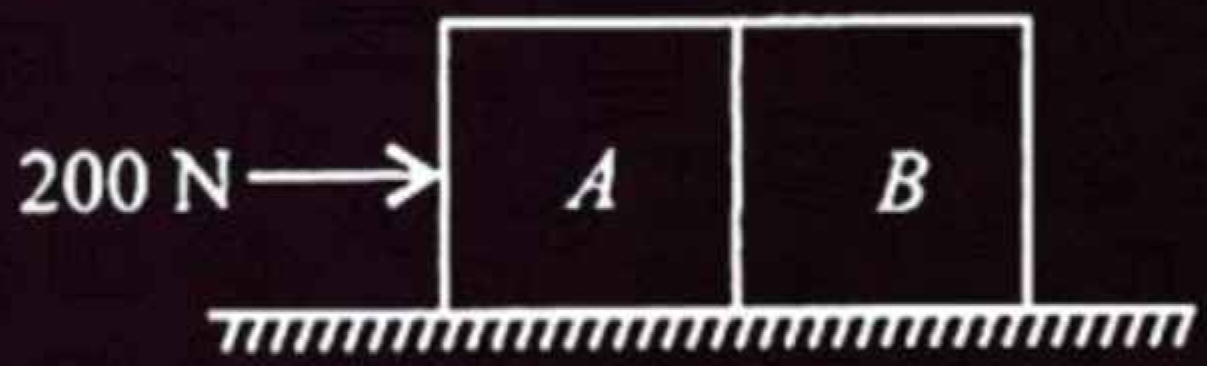
(3) 8 m s^{-2}

(4) 10 m s^{-2}

$$a = \frac{P - f}{m}$$

$$= \frac{200 - 50}{25}$$

$$= \frac{150}{25} = 6 \text{ m/s}^2$$



Difficulty Level : HARD

QUESTION-57

A block of mass m is in contact with the car C as shown in the figure. The coefficient of static friction between the block and the cart is μ. The acceleration α of the cart that will prevent the block from falling satisfies:

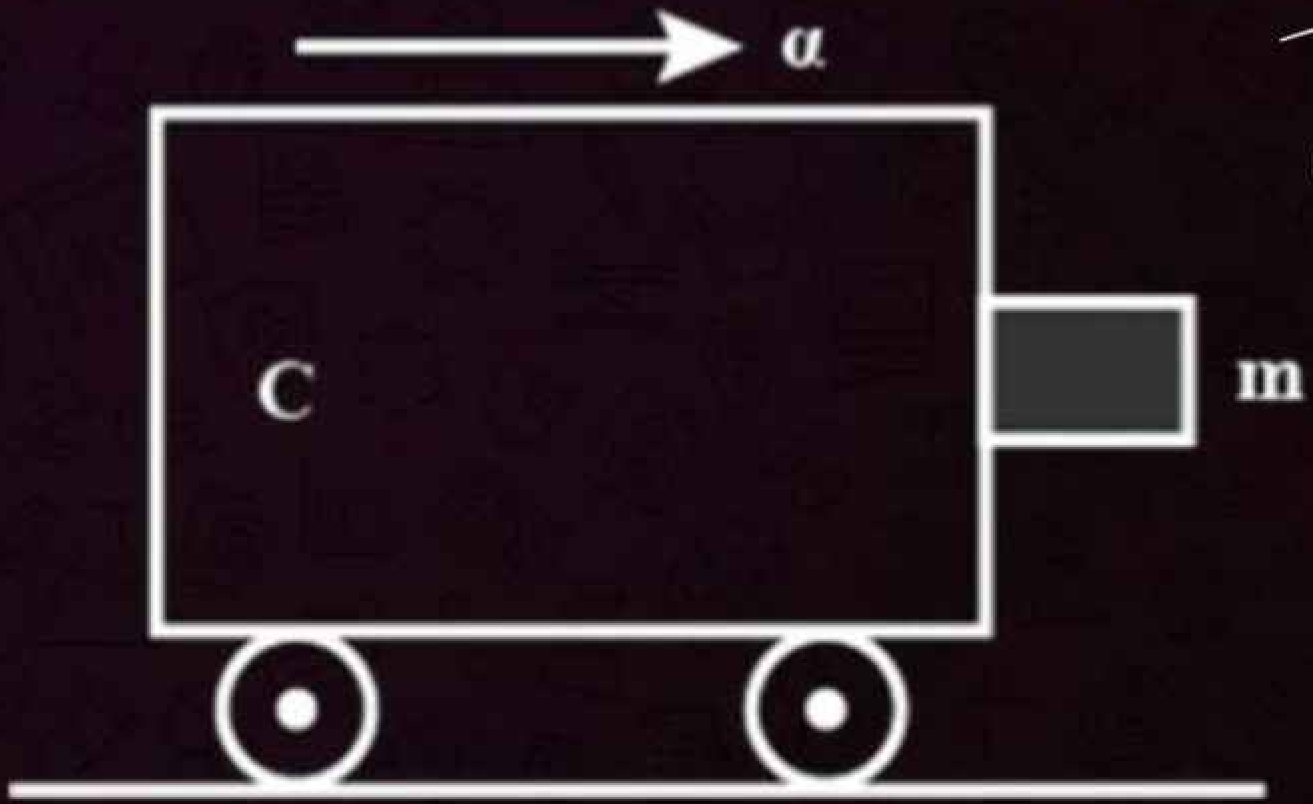
[Pre-2010]

(1) $\alpha < \frac{g}{\mu}$

(2) $\alpha > \frac{g}{\mu}$

(3) $\alpha > \cancel{\frac{g}{\mu m}}$

(4) $\alpha \geq \frac{g}{\mu}$



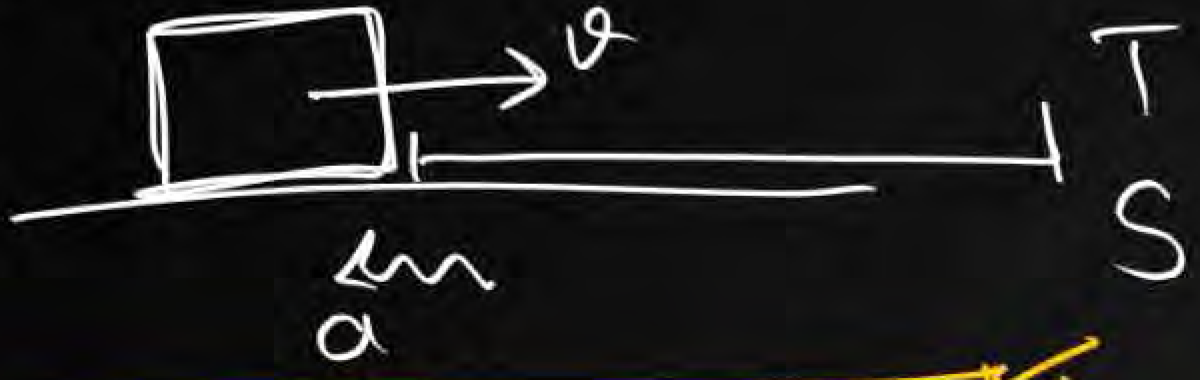
$a_{min} = \frac{g}{\mu}$

$\boxed{a \geq \frac{g}{\mu}}$

Part 6 – μ marna buri baat hai

6.1 Stopping Distance

MISL



$$\boxed{\begin{aligned}\text{Stopping Distance} &= \frac{v^2}{2a}\\ \text{Stopping Time} &= \frac{v}{a}\end{aligned}}$$

$$\cancel{v^2}^{\,0} = u^2 - 2as$$

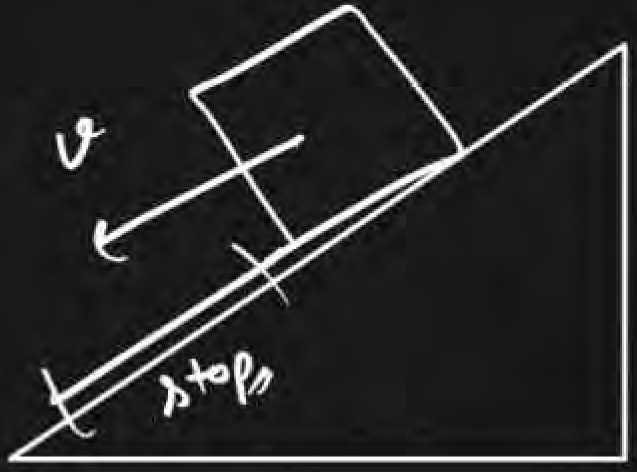
$$\cancel{v} = u - at$$

$\boxed{a = \mu g}$ ✓

$f = \mu mg$

$a = \mu \frac{\cancel{m}g}{\cancel{m}}$

$$S = \frac{v^2}{2\mu g} \qquad T = \frac{v}{\mu g}$$



$$S = \frac{v^2}{2(\mu g\cos\theta - g\sin\theta)} \checkmark$$

$$T = \frac{v}{(\mu g\cos\theta - g\sin\theta)} \checkmark$$

$$a=\frac{\mu \cancel{m} g\cos\theta-\cancel{m}g\sin\theta}{\cancel{m}}$$

$$\boxed{a=\mu g\cos\theta-g\sin\theta}$$

QUESTION-58

Difficulty Level : YODHA

In order to stop a car in shortest distance on a horizontal road, one should

[HCV Objective]

1. apply the brakes very hard so that the wheels stop rotating
2. apply the brakes hard enough to just prevent slipping
3. pump the brakes (press and release)
4. shut the engine off and not apply brakes

~~Slip~~
Rolling f → kinetic f

Difficulty Level : Easy

QUESTION-59

Ans

Two cars of unequal masses use similar tyres. If they are moving at the same initial speed, the minimum stopping distance [HCV Objective]

1. is smaller for the heavier car
2. is smaller for the lighter car
3. is same for both cars
4. depends on the volume of the car

$$S = \frac{v^2}{2\mu g}$$

QUESTION-60

Challenge #1

Difficulty Level : YODHA

The rear side of a truck is open and a box of mass 40 kg is placed 5 m away from the open end. The coefficient of friction between the box and the surface below it is 0.15. The truck starts from rest with an acceleration of 2 m s^{-2} on a straight road. At what distance from the starting point does the box fall off the truck?

[NCERT Based]

(1) 20 m

(2) 30 m

(3) 40 m

(4) 50 m

Difficulty Level : HARD

QUESTION-61

μ v

A bag is gently dropped on a conveyor belt moving at a speed of 2 m/s. The coefficient of friction between the conveyor belt and bag is 0.4. Initially, the bag slips on the belt before it stops due to friction. The distance travelled by the bag on the belt during slipping motion, is: [Take $g = 10\ \text{m/s}^{-2}$]

[Main 27th July 1st Shift 2022]

(1) 2 m

(2) 0.5 m

(3) 3.2 m

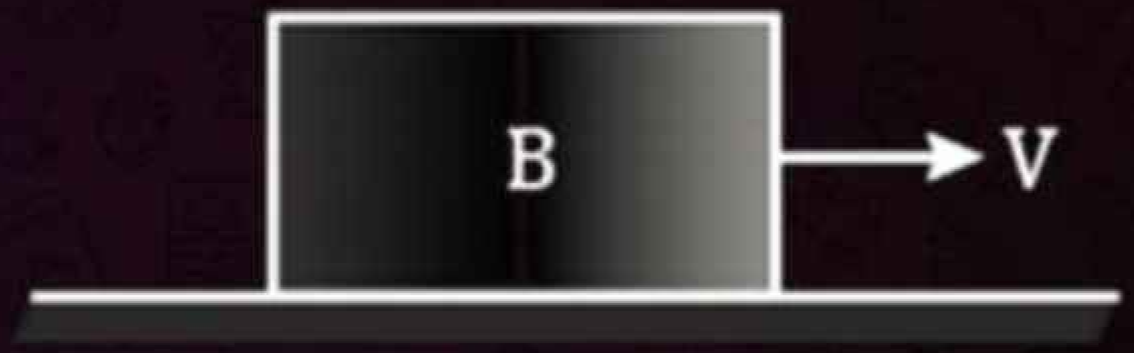
(4) 0.8 m

$$S=\frac{v^2}{2\mu g}=\frac{2\times 2}{2\times 0.4\times 10}$$

Difficulty Level : MEDIUM

QUESTION-62

A block B is pushed momentarily along a horizontal surface with an initial velocity V. If μ is the coefficient of sliding friction between B and the surface, block B will come to rest after a time: [2007]



(1) $g\mu/V$

(2) g/V

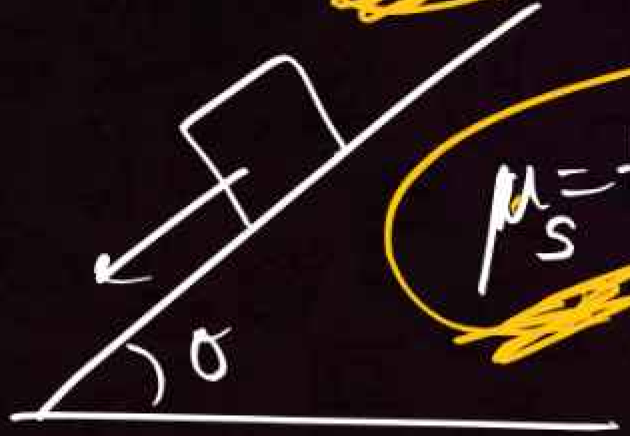
(3) V/g

(4) $V/\mu g$

6.2 Angle of Repose

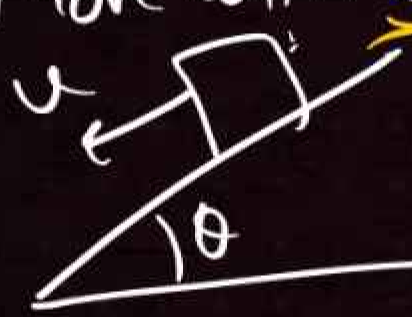
Experimentally

Angle at which
a object just starts to slide

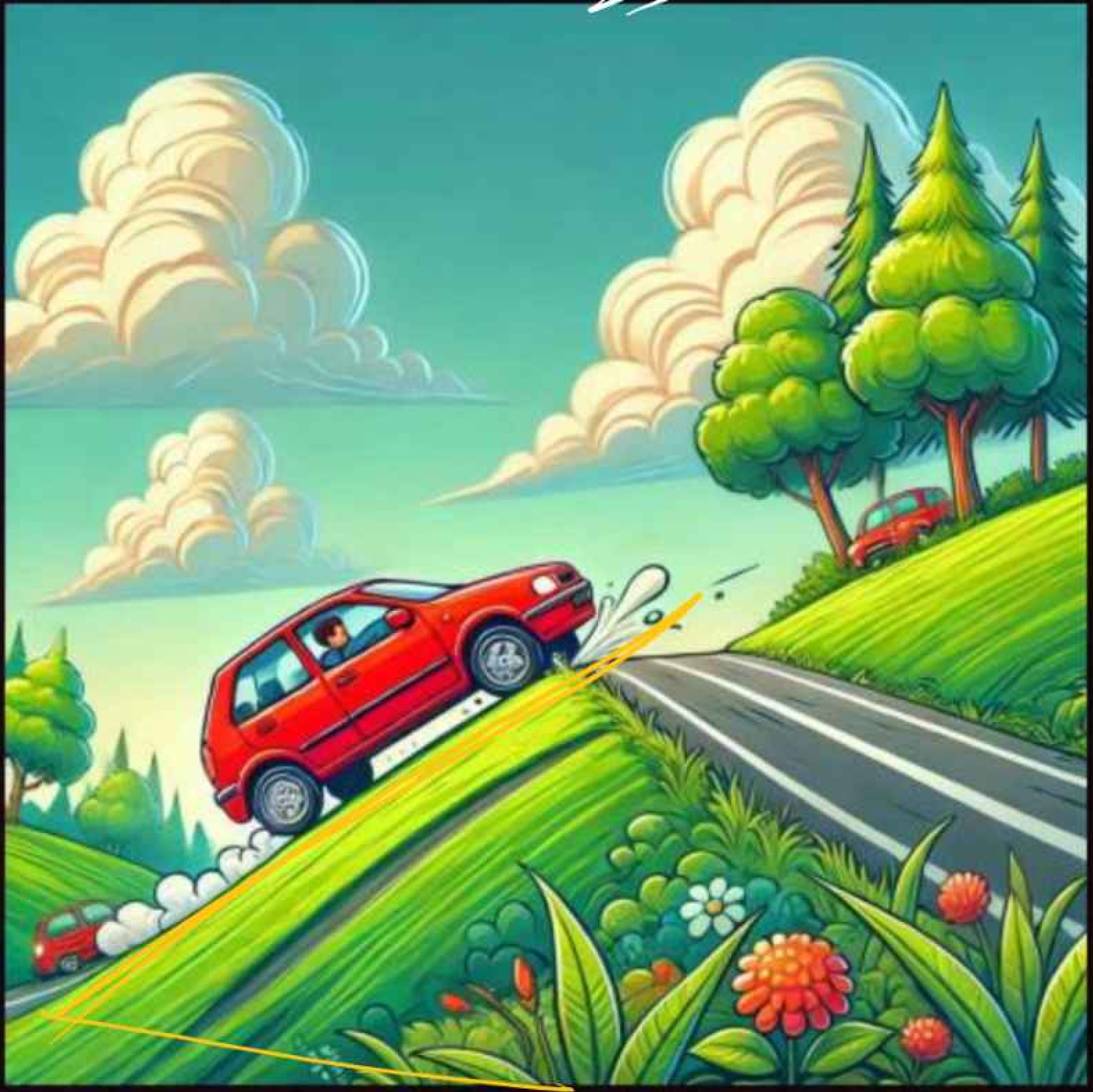


$$\mu_s = \tan\theta$$

Move with constant velocity



$$\mu_k = \tan\theta$$



Difficulty Level : Easy

QUESTION-63

A block of mass m rests on a rough inclined plane. The coefficient of friction between the surface and the block is μ. At what angle of inclination θ of the plane to the horizontal will the block just start to slide down the plane?

[NCERT Based]

$\mu_s = \tan\theta$

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

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

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

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

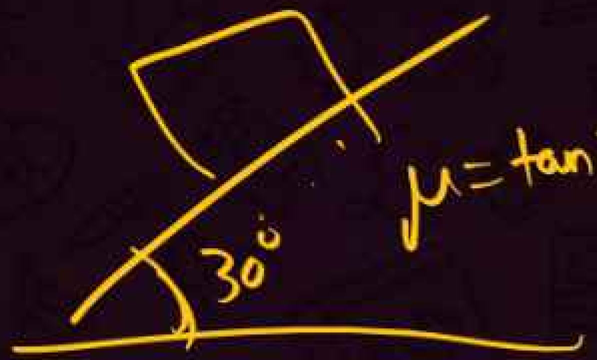
Difficulty Level : Easy

QUESTION-64

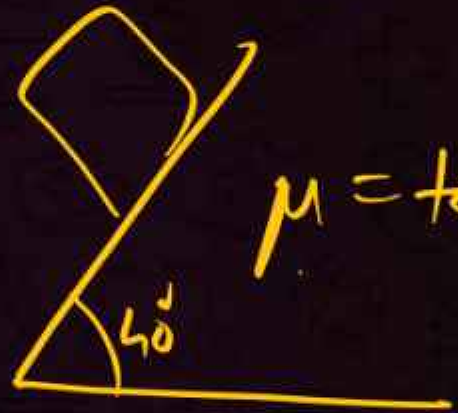
A block A kept on an inclined surface just begins to slide if the inclination is 30°. The block is replaced by another block B and it is found that it just begins to slide if the inclination is 40°.

[HCV Objective]

1. mass of A > mass of B
2. mass of A < mass of B
3. mass of A = mass of B
4. all the three are possible.



$\mu = \tan 30°$



$\mu = \tan 40°$

Difficulty Level : Easy

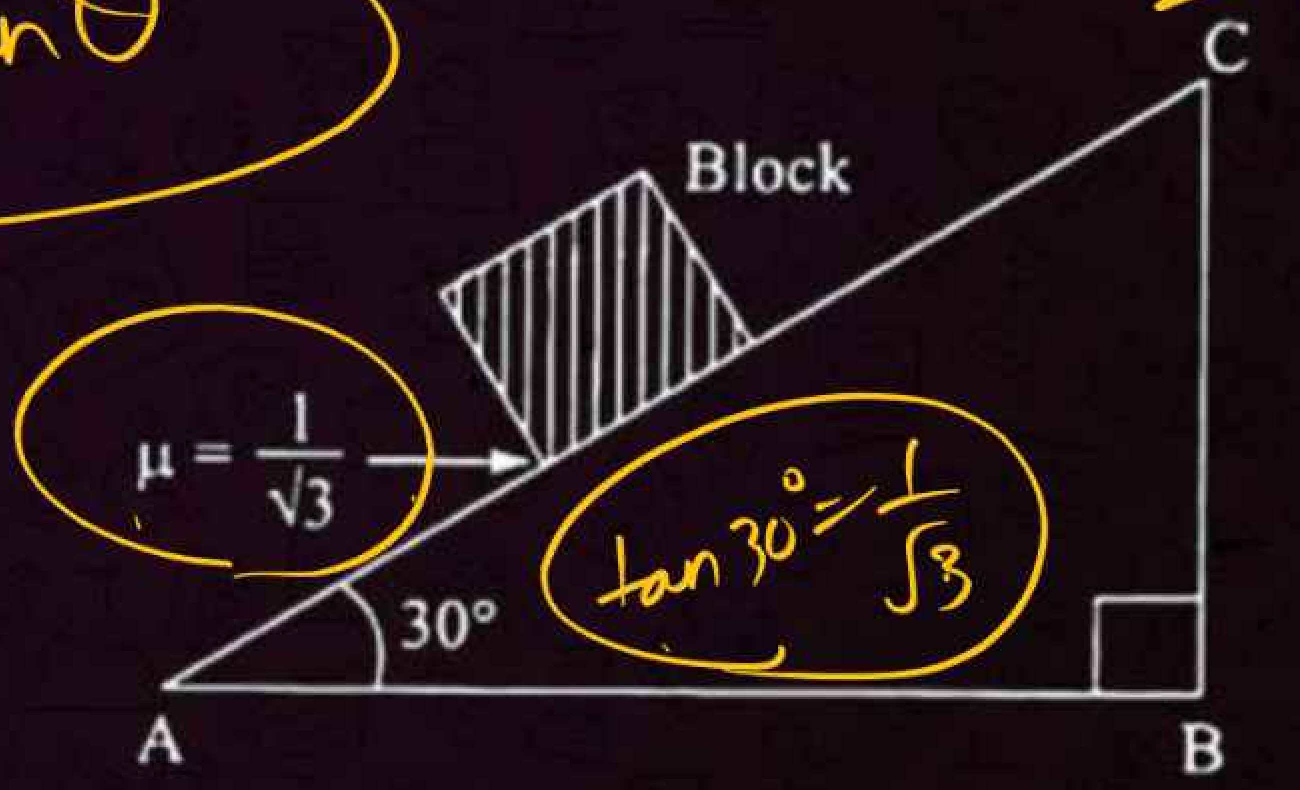
QUESTION-65

nw

A block of mass 2 kg is placed on inclined rough surface AC (as shown in figure) of coefficient of friction μ. If $g = 10\ \text{ms}^{-2}$, the net force (in N) on the block will be:

[Manipur-2023]

$\mu = \tan\theta$



(1) $10\sqrt{3}$

(2) Zero

(3) 10

(4) 20

Difficulty Level : Easy

QUESTION-66

just

A 2 kg brick begins to slide over a surface which is inclined at an angle of 45° with respect to horizontal axis. The co-efficient of static friction between their surfaces is: [Main 4th April 2nd Shift 2024]

(1) $1/\sqrt{3}$

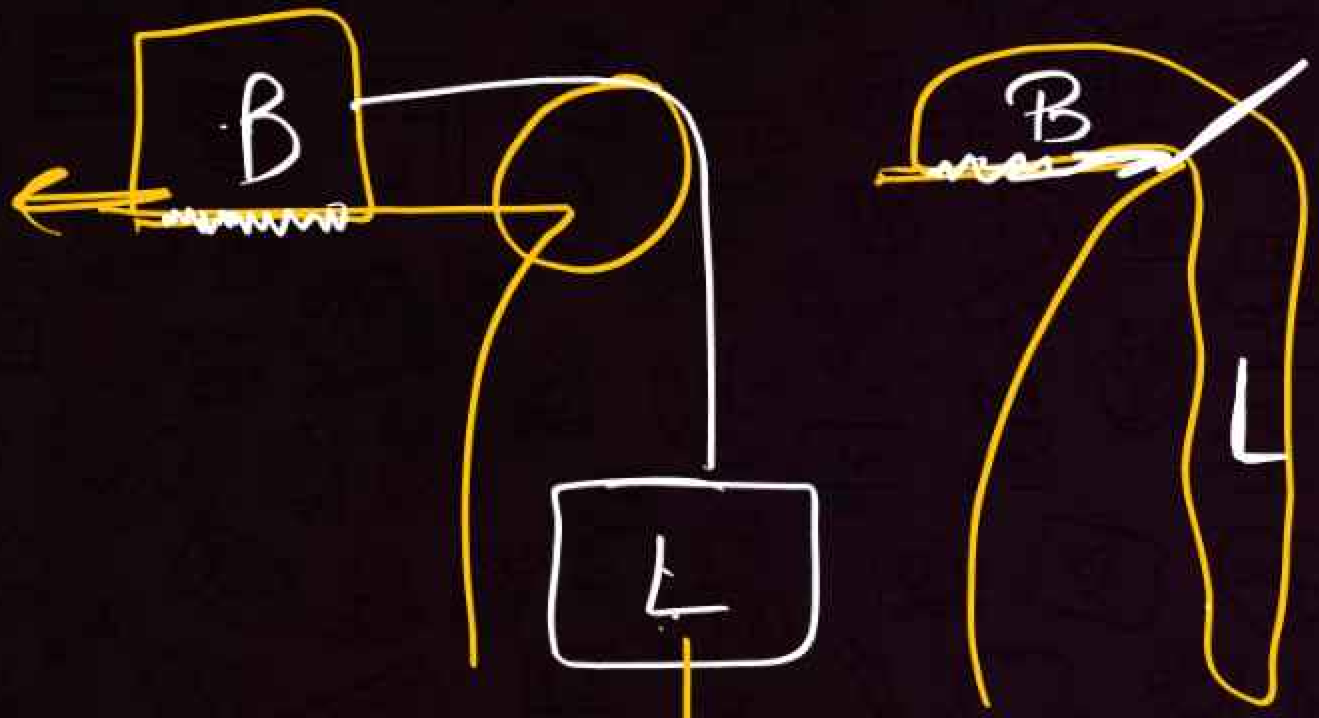
(2) 1 ✓

(3) 0.5

(4) 1.7

$\mu = \tan 45 = 1$

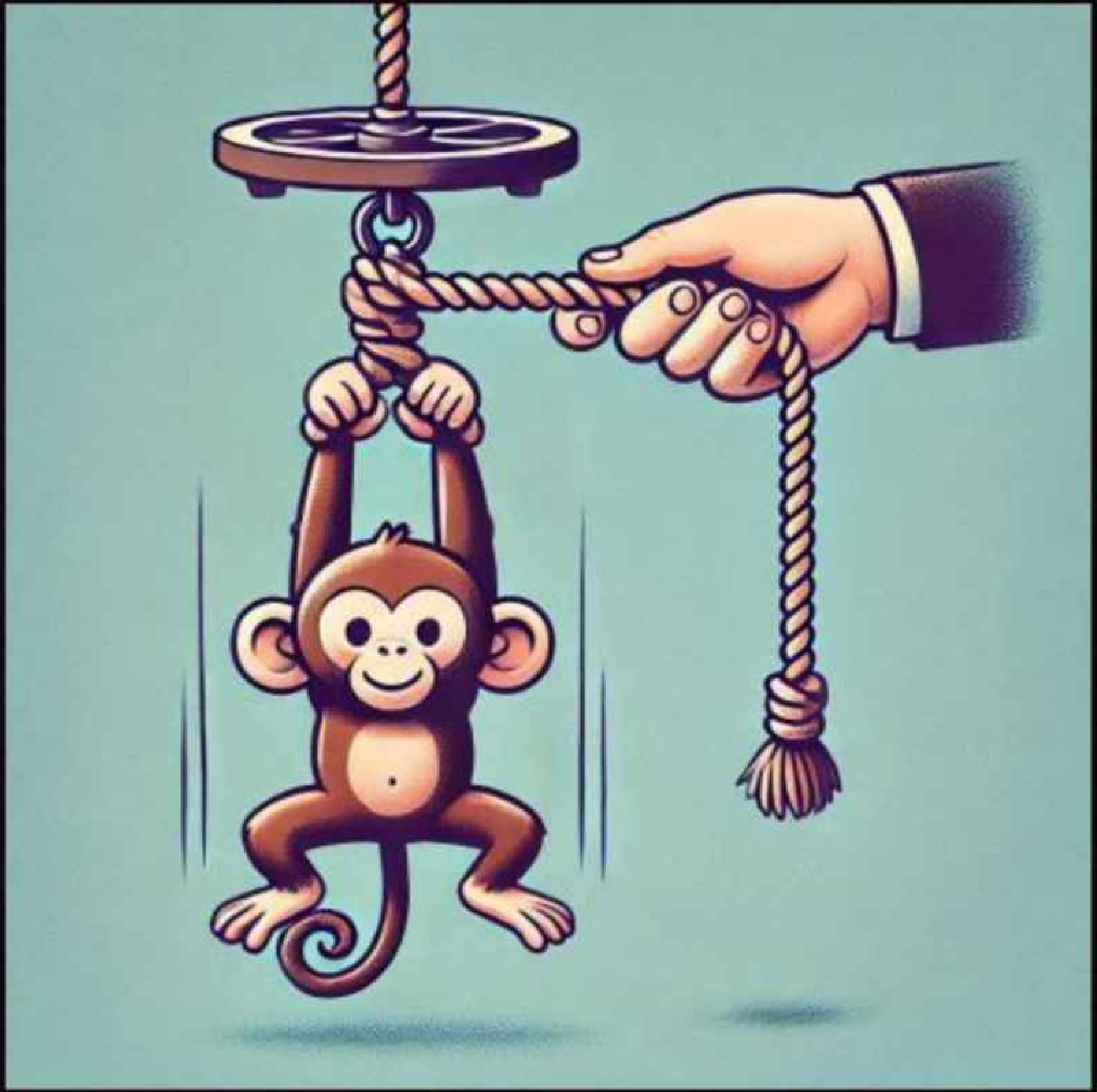
6.3 Lakta hua mass



$$\mu B\cancel{g} = L\cancel{g}$$

$$\boxed{\frac{\mu}{1} = \frac{L}{B} = \frac{\text{Lakta}}{\text{Betha}}}$$

$$\boxed{\%\,\text{Hanging} = \left(\frac{\mu}{1+\mu}\right) \times 100\%}$$



Difficulty Level : HARD

QUESTION-67

A heavy uniform chain lies on horizontal table top. If the coefficient of friction between the chain and the table surface is $\boxed{0.25}$, then the maximum ~~fraction~~ fraction of the length of the chain that can hang over one edge of the table is: [1991]

(1) 20%

(2) 25%

(3) 35%

(4) 15%

$$\left(\text{Hanging}\% = \frac{\mu}{1+\mu} \times 100\%\right) = \frac{0.25}{1.25} = \frac{\cancel{25}}{\cancel{125}} \times \frac{\cancel{100}\%}{\cancel{5}} \quad 20\%$$

Difficulty Level : Easy

QUESTION-68

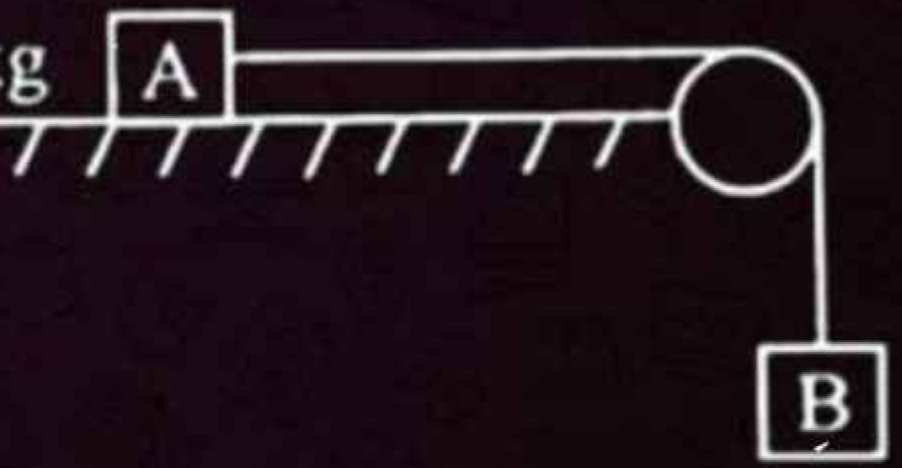
The coefficient of static friction, μ_s, between block A of mass 2 kg and the table as shown in the figure is 0.2. What would be the maximum mass value of block B so that the two blocks do not move? The string and the pulley are assumed to be smooth and massless, ($g = 10\ m/s^2$): [2004]

(1) 4.0 kg

(2) 0.2 kg

(3) 0.4 kg

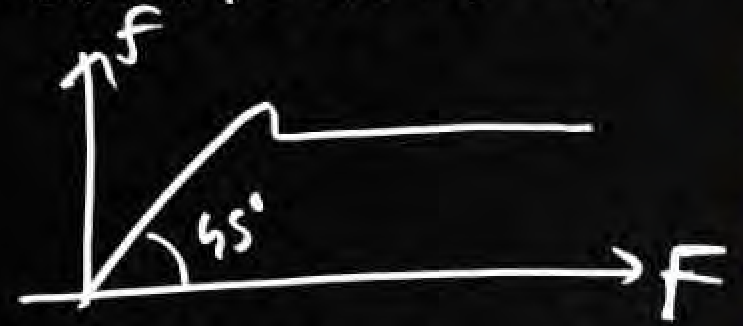
(4) 2.0 kg



$\frac{L}{B} = 0.2$

$\frac{B}{2} = 0.2$

PUPPY POINTS - 2



f opposes rel. motion

f jitni jarurat utna

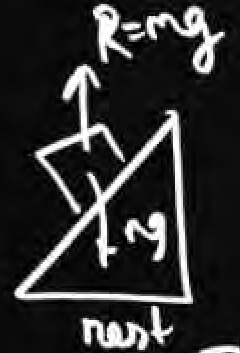
Angle of $F_r = \phi$

$R\cos\phi = N$

$R\sin\phi = f$

$\tan\phi = \frac{f}{N}$

$R = \sqrt{N^2 + f^2}$



For Limiting f

$\tan\phi = \mu$

$\tan\theta = \mu$ *

$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Stopping Distance & Time

$S = \frac{v^2}{2a}$ $\quad T = \frac{v}{a}$

$S = \frac{v^2}{2\mu g}$ $\quad T = \frac{v}{\mu g}$

Angle of Repose

Just ... $\quad$ v constant

$\mu_s = \tan\phi$ $\quad \mu_k = \tan\phi$

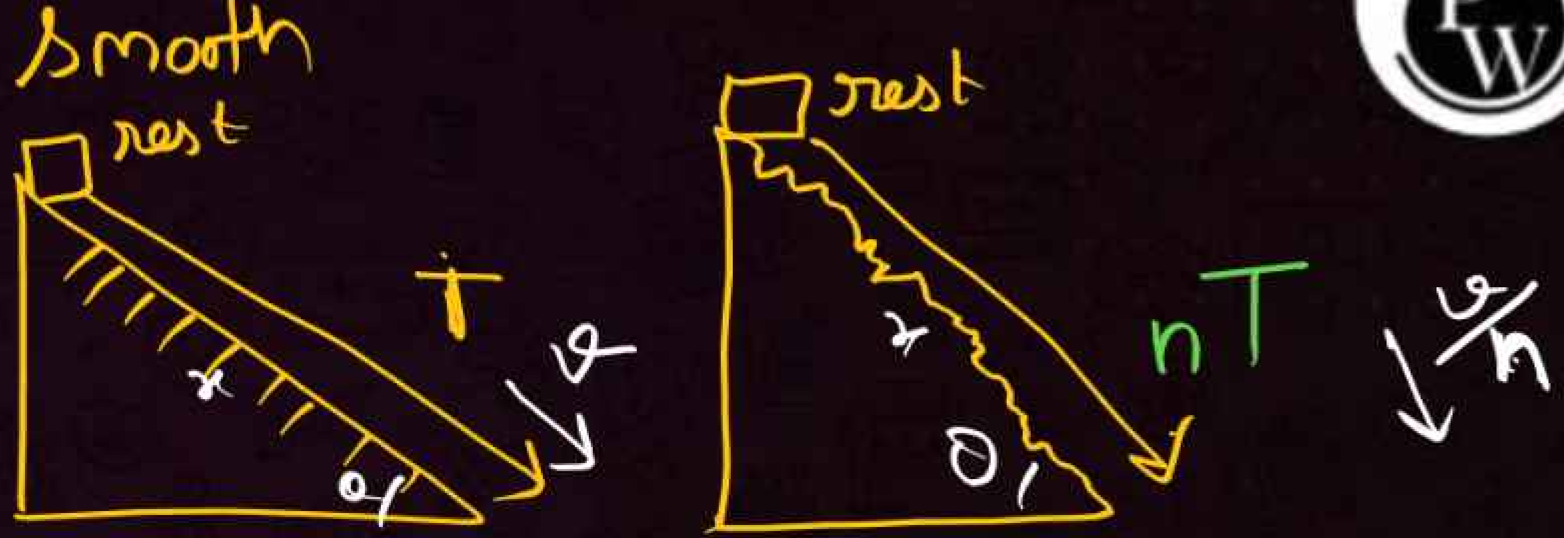
Lakta mass

$\mu = \frac{\text{Latka}}{\text{Betha}} = \frac{L}{B}$

$\%\text{Latka} = \frac{\mu}{1+\mu} \times 100\%$

Part 7 – Approaches in Friction

7.1 Nt on incline



$$\boxed{\mu = \tan\theta\left(1-\frac{1}{n^2}\right)}$$

$a = g\sin\theta$

$x = \frac{1}{2} g \sin\theta\, t^2$

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

$x = \frac{1}{2}(g\sin\theta - \mu g\cos\theta)\, n^2 t^2$

$$\frac{\sin\theta}{\cos} = \left(\frac{\sin\theta}{\cos} - \mu\frac{\cos\theta}{\cos}\right) n^2$$

$$\frac{\tan\theta}{n^2} = (\tan\theta - \mu)$$

$$\boxed{\mu = \tan\theta\left(1-\frac{1}{n^2}\right)}$$

Difficulty Level : YODHA

QUESTION-69

θ $N=2$.

Starting from rest, a body slides down a 45° inclined plane in twice the time it takes to slide down the same distance in the absence of friction. The coefficient of friction between the body and the inclined plane is: **[1988]**

1. 0.80
2. 0.75
3. 0.25
4. 0.33

$$\mu = \tan\theta\left(1-\frac{1}{n^2}\right) = \tan 45^\circ\left(1-\frac{1}{2^2}\right) = 1\left(1-\frac{1}{4}\right)$$

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

$$= 0.75$$

Difficulty Level : YODHA

QUESTION-70

$\angle 30^\circ = \theta$

When a body slides down from rest along a smooth inclined plane making an angle of 30° with the horizontal, it takes time 20 s. When the same body slides down from rest along a rough inclined plane making the same angle and through the same distance, it takes time 20p s, where p is some number greater than 1. The coefficient of friction between the body and the rough plane is

$NT = 20p$. $N = p$

[NCERT Based]

(1) $\mu = \left(1 - \frac{1}{p^2}\right)\frac{1}{\sqrt{3}}$

$\mu = \tan\theta\left(1 - \frac{1}{n^2}\right)$

$= \tan 30^\circ\left(1 - \frac{1}{p^2}\right)$

$= \boxed{\frac{1}{\sqrt{3}}\left(1 - \frac{1}{p^2}\right)}$

(2) $\mu = \sqrt{1 - \frac{1}{9p^2}}$

(3) $\mu = (1 - p^2)\frac{1}{\sqrt{3}}$

(4) $\mu = \sqrt{1 - 9p^2}$

Difficulty Level : YODHA

QUESTION-71

A given object takes n times the time to slide down $45°$ rough inclined plane as it takes the time to slide down an identical perfectly smooth $45°$ inclined plane. The coefficient of kinetic friction between the object and the surface of inclined plane is:

[Main 8th April 2nd Shift 2024, Main 29th Jan 2nd Shift 2023, Main Online 2018, AIEEE 2005]

$\mu = \tan\theta\left(1-\frac{1}{n^2}\right)$

$= \tan 45\left(1-\frac{1}{n^2}\right)$

$\boxed{\mu = \left(1-\frac{1}{n^2}\right)}$

(1) $1-n^2$

(2) $\sqrt{1-\frac{1}{n^2}}$

(3) $1-\frac{1}{n^2}$

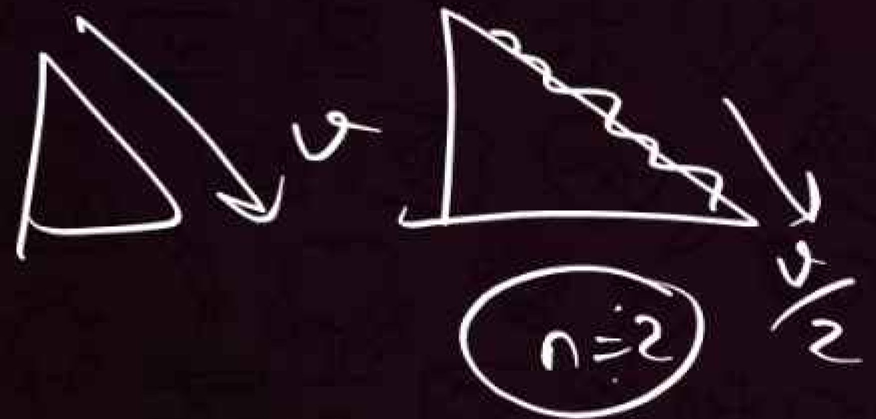
(4) $\sqrt{1-n^2}$

QUESTION-72

Difficulty Level : YODHA

A block is released from the top of an inclined plane of inclination θ. Its velocity at the bottom of plane is v. If it slides down a rough inclined plane of the same inclination., its velocity at bottom is $v/2$. The coefficient of friction is

(1) 3cotθ/4



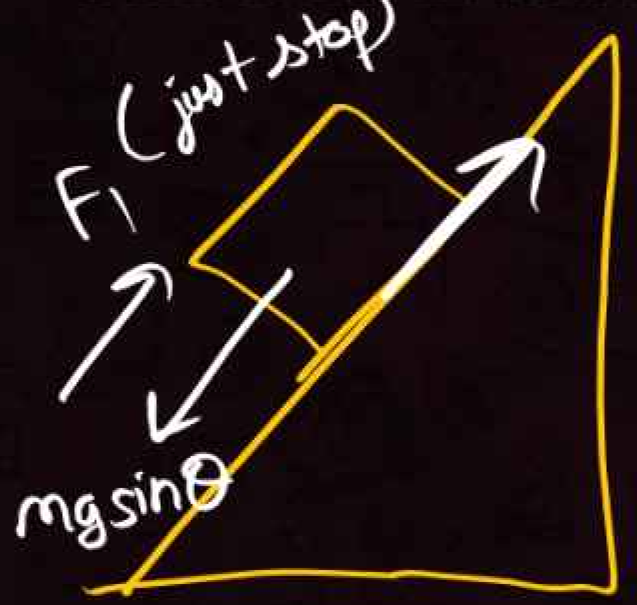
(2) cotθ/4

(3) 3tanθ/4

(4) tanθ/4

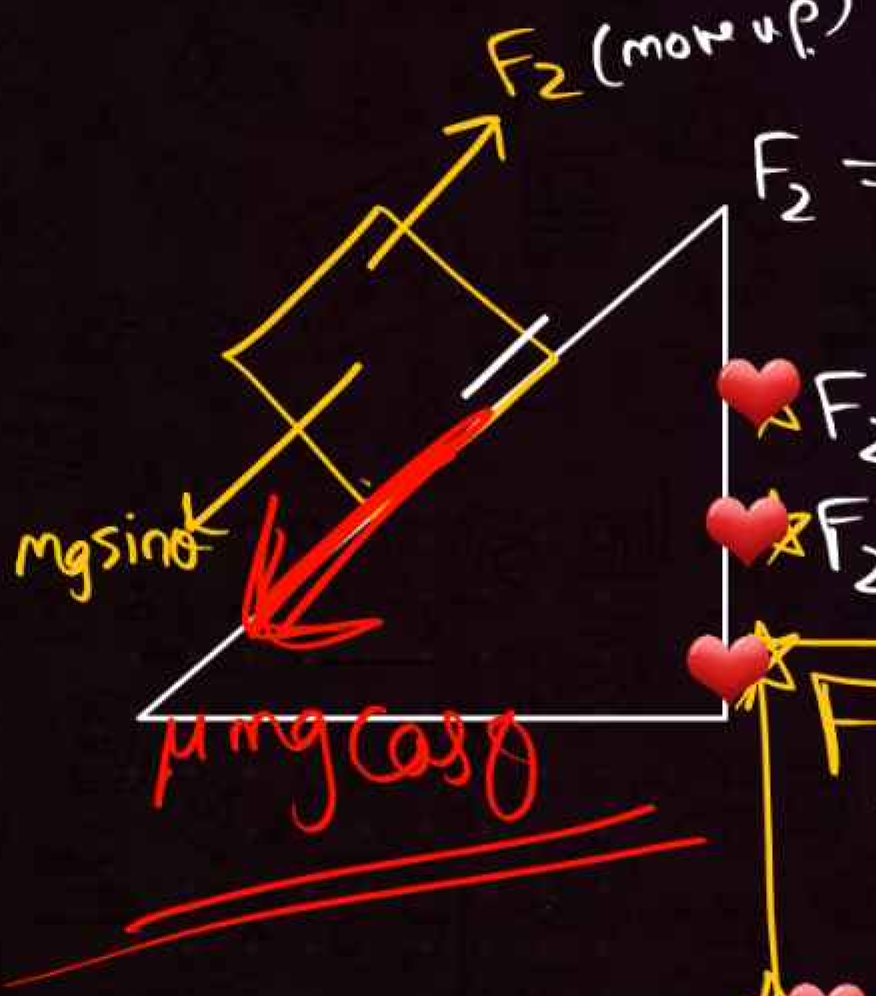
$$\mu = \tan\theta\left(1-\frac{1}{n^2}\right) = \tan\theta\left(1-\frac{1}{4}\right) = \frac{3}{4}\tan\theta$$

7.2 Jara Rok k Dahkka Dena



$\mu mg\cos\theta$

$F_1 = mg\sin\theta - \mu mg\cos\theta$



$F_2 = mg\sin\theta + \mu mg\cos\theta$

$F_2 - F_1 = 2\mu mg\cos\theta$

$F_2 + F_1 = 2mg\sin\theta$

$$\boxed{F_2 = nF_1 \qquad \mu = \tan\theta\left(\frac{n-1}{n+1}\right)}$$

Difficulty Level : YODHA

QUESTION-73

The minimum force required to start pushing a body up a rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2. If the inclined plane makes an angle θ with the horizontal such that $\tan\theta = 2\mu$, then the ratio $\frac{F_1}{F_2}$ is $= n$. [NCERT Based]

(1) 4

(2) 1

(3) 2

(4) 3

$F_1 = (\text{up})$ $F_2 = (\text{just stop})$

$\mu = \tan\theta\left(\frac{n-1}{n+1}\right)$

$\cancel{\mu} = 2\cancel{\mu}\left(\frac{n-1}{n+1}\right)$

$\cancel{n}+1 = \cancel{2}n - 2$

$\boxed{n=3}$

QUESTION-74

Difficulty Level : YODHA

N

Consider a block kept on an inclined plane (incline at 45°) as shown in the figure. If the force required to just push it up the incline is 2 times the force required to just prevent it from sliding down, the coefficient of friction between the block and inclined plane(μ) is equal to: [Main 25th Jan 2nd Shift 2023]

1. 0.50
2. 0.33
3. 0.5
4. 0.60

$N = 2$

$$\boxed{\mu = \tan\theta\left(\frac{N-1}{N+1}\right)} = \tan 45^\circ\left(\frac{2-1}{2+1}\right) = 1\left(\frac{1}{3}\right)$$

Difficulty Level : YODHA

QUESTION-75

hw

A block is moving on an inclined plane making an angle 45° with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is 3 times the force required to just prevent it from sliding down. If we define N = 10 μ, then N is $\boxed{5}$ _____. [IIT-JEE 2011]

$\frac{\cancel{2}}{\cancel{4}}\ \frac{1}{2}$

$\mu = \frac{1}{2}$ $N = 10\mu$

$N = \frac{\cancel{10}\,5}{\cancel{2}}$

Difficulty Level : YODHA

QUESTION-76

hw

A block of mass 5 kg is placed on a rough inclined surface as shown in the figure. If $\vec{F}_1$ is the force required to just move the block up the inclined plane and $\vec{F}_2$ is the force required to just prevent the block from sliding down, then the value of $\left|\vec{F}_1\right| - \left|\vec{F}_2\right|$ is [Use $g = 10\ \text{m/s}^2$] **[Main 31st Jan 2nd Shift 2024]**

(1) $5\sqrt{3}$ N

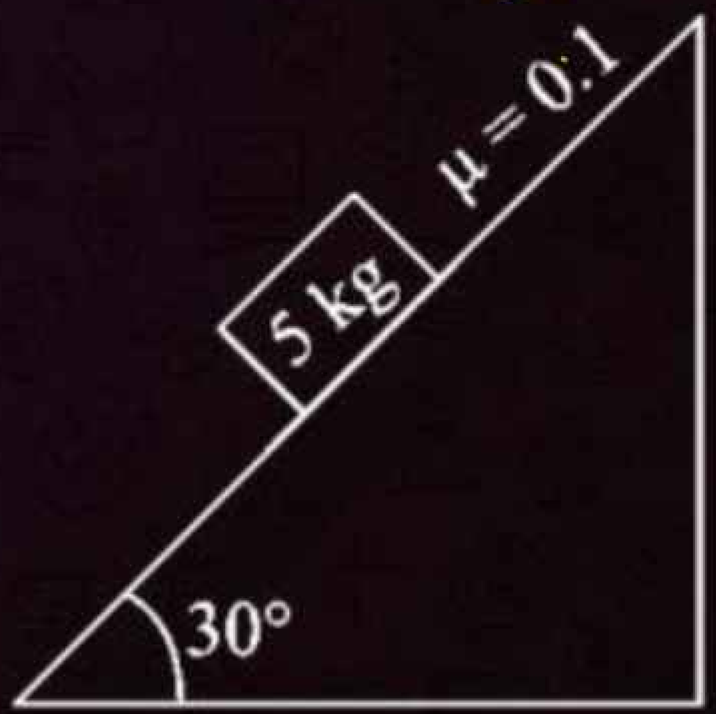
(2) 10 N

(3) $25\sqrt{3}$ N

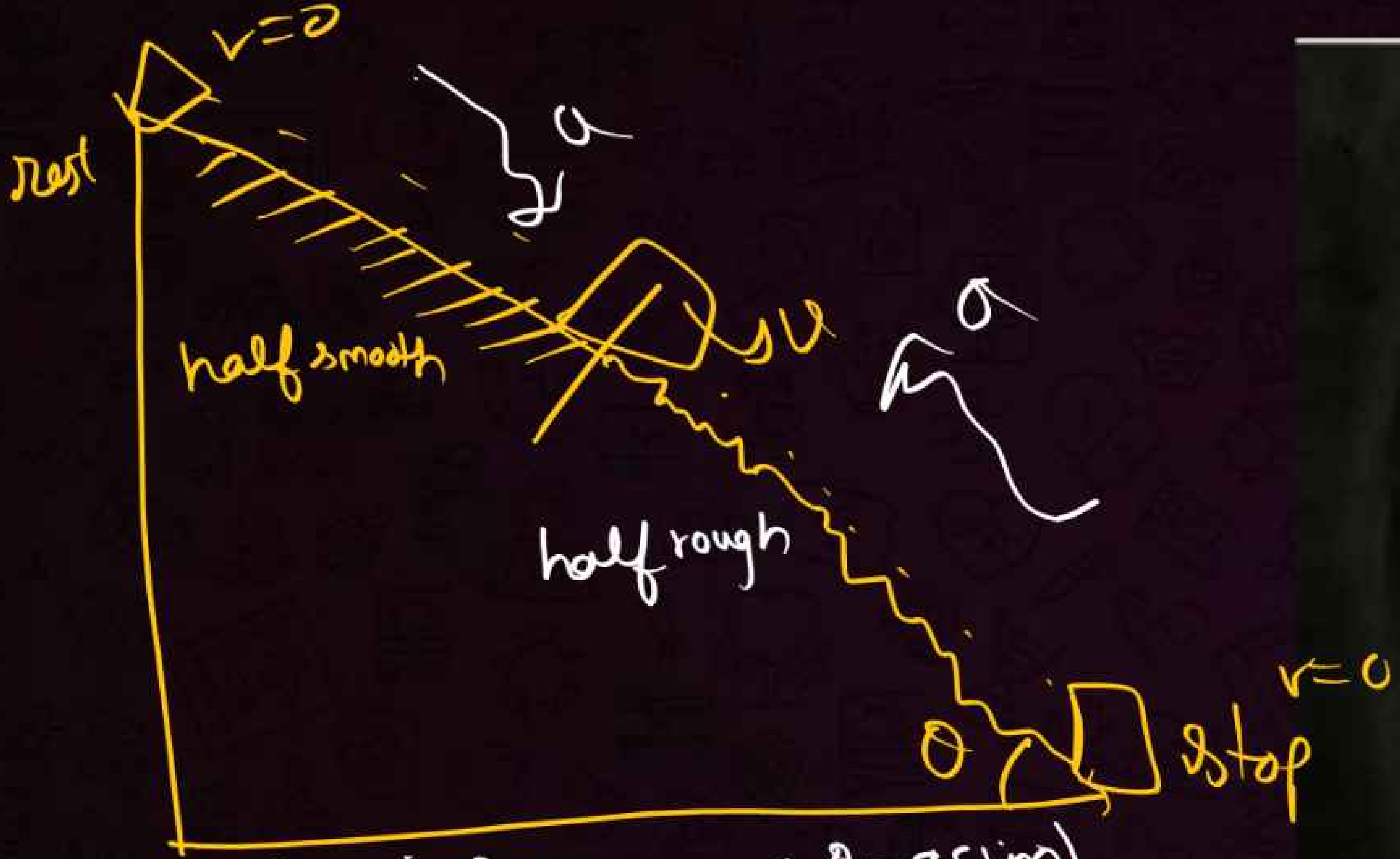
(4) $\frac{5\sqrt{3}}{2}$ N

$F_1 - F_2 = 2\mu mg\cos\theta$

$= \cancel{2} \times 0.1 \times 5 \times 10 \times \frac{\sqrt{3}}{\cancel{2}}$



7.3 Ek Side normal sabun ek Gobar ka tel



$$\left(g\sin\theta = \mu g\cos\theta - g\sin\theta\right)$$

$$\boxed{\mu = 2\tan\theta}$$

QUESTION-77

Difficulty Level : YODHA

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 between the block and lower half of the plane is given by [2013]

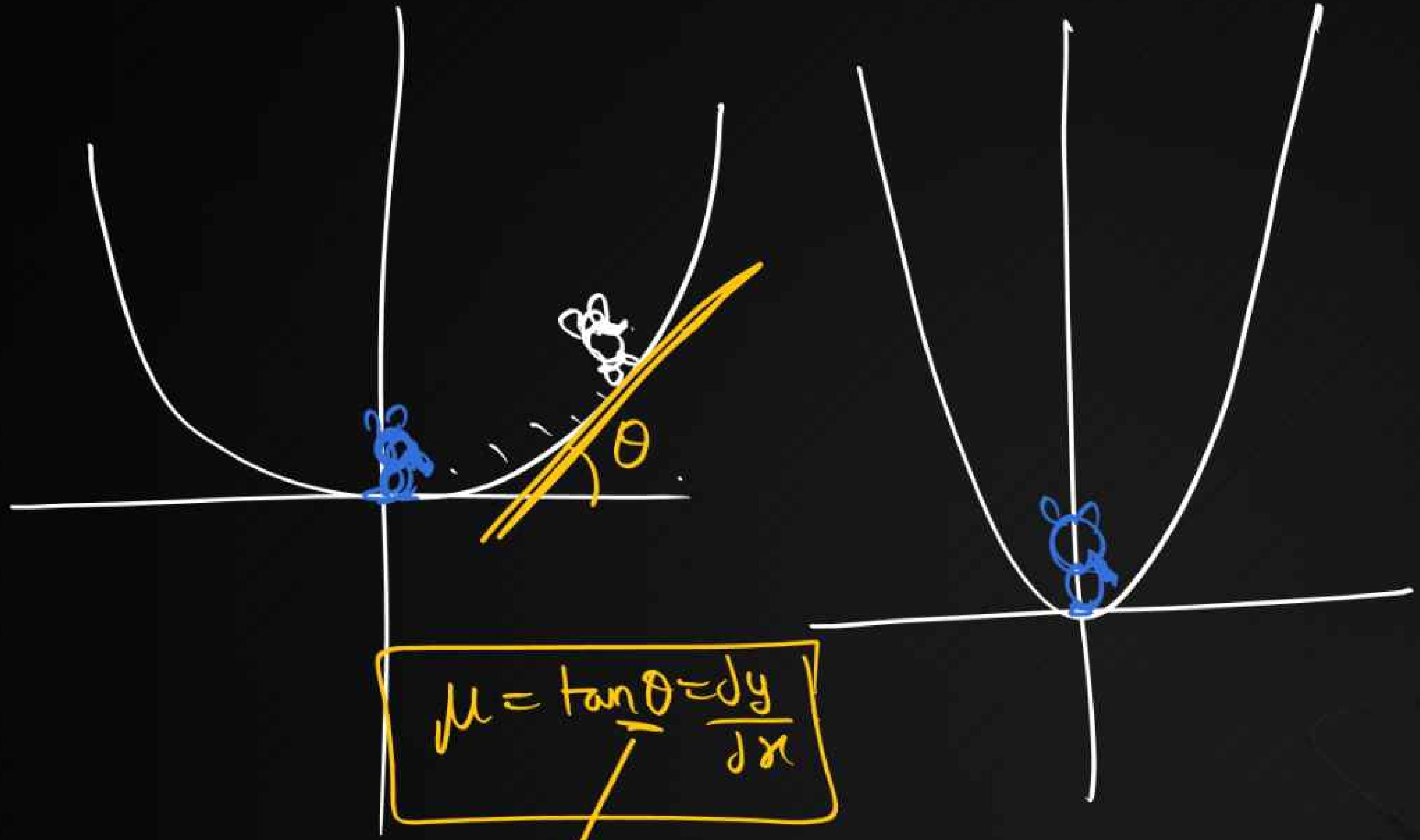
(1) $\mu = 2\tan\theta$

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

(3) $\mu = \dfrac{1}{\tan\theta}$

(4) $\mu = \dfrac{2}{\tan\theta}$

7.4 Gattar k andar fs gaya BANDAR



$$\boxed{\mu = \tan\theta = \frac{dy}{dx}}$$

Maximum ∠ till whic you can Go Up in Gutter

QUESTION-78

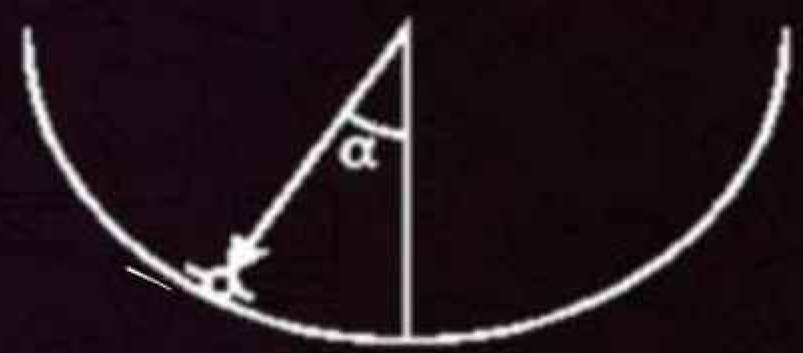
Difficulty Level : YODHA

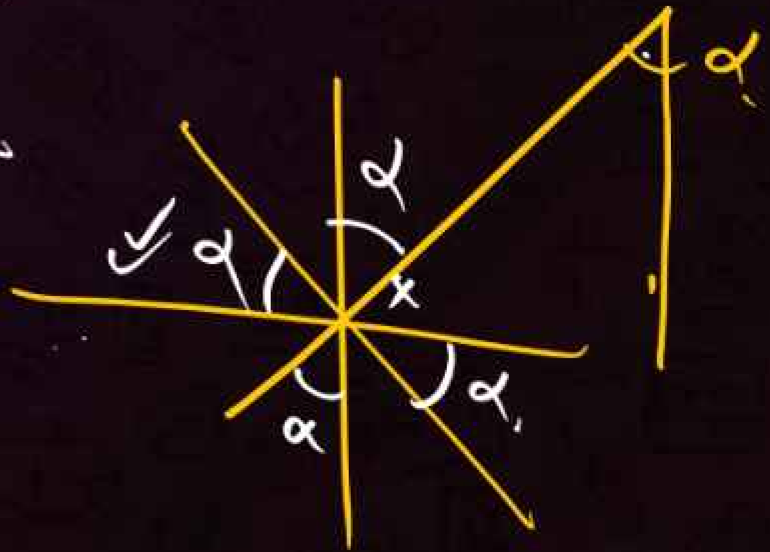
An insect crawls up a hemispherical surface very slowly (see figure) The co-efficient of friction between the insect and the surface is 1/3. If the line joining the center of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α is given by: **[IIT-JEE 2001]**

$\left(\mu = \frac{1}{3}\right)$

$\mu = \tan\alpha = \frac{1}{3}$

$\cot\alpha = 3$



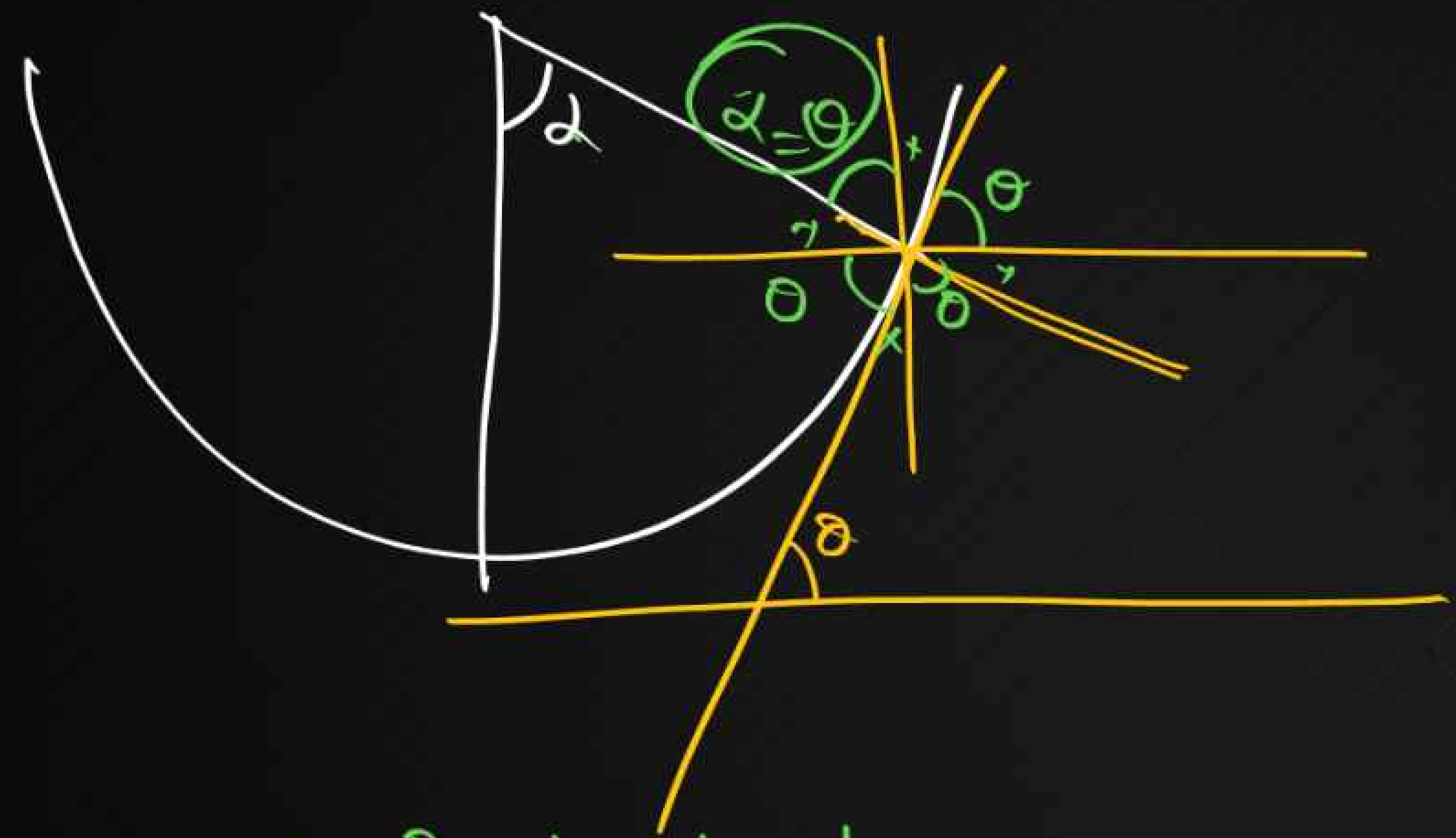


(1) $\cot\alpha = 3$

(2) $\tan\alpha = 3$

(3) $\sec\alpha = 3$

(4) $\operatorname{cosec}\alpha = 3$



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

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

$3 = \frac{1}{\tan\alpha} = \cot\alpha$ //

Difficulty Level : YODHA

QUESTION-79

A block of mass m is placed on a surface with a vertical cross section given by $y = x^3/6$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is:

1. 1/6
2. 2/3
3. 1/2
4. 1/3

$\mu = 0.5 = \frac{1}{2}$

$y = \frac{x^3}{6}$

$\frac{dy}{dx} = \frac{\cancel{3}x^2}{\cancel{6}} = \frac{x^2}{2}$

$\frac{dy}{dx} = \mu$

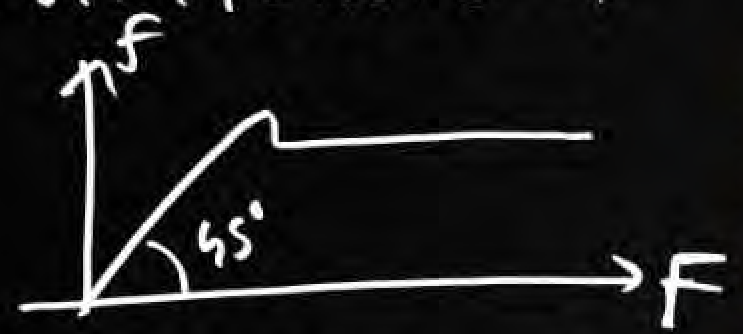
$\frac{x^2}{\cancel{2}} = \frac{1}{\cancel{2}}$

$x = 1$

$\boxed{y = \frac{x^3}{6} = \frac{1^3}{6} = \frac{1}{6}\text{ m}}$

7.5 Stopping Distance on an Incline

PUPPY POINTS - 2



f opposes rel. motion

f jitni jarurat utna

Angle of $F_r = \phi$

$R\cos\phi = N$

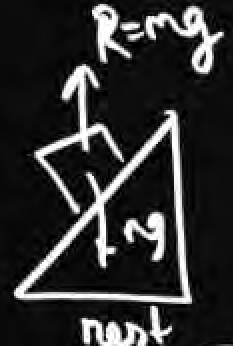
$R\sin\phi = f$

$\tan\phi = \frac{f}{N}$

$R = \sqrt{N^2 + f^2}$

For limiting f

$\tan\phi = \mu$



$\tan\theta = \mu$ *

$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Stopping Distance & Time

$s = \frac{v^2}{2a}$ $\quad T = \frac{v}{a}$

$s = \frac{v^2}{2\mu g}$ $\quad T = \frac{v}{\mu g}$

$s = \frac{v^2}{2(\mu g\cos\theta - g\sin\theta)}$

$T = \frac{v}{(\mu g\cos\theta - g\sin\theta)}$

Angle of Repose

Just ... $\quad$ v constant

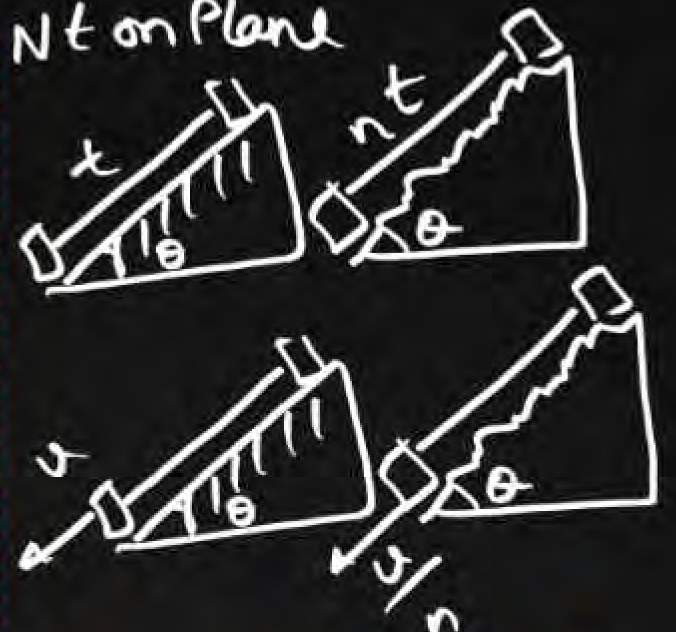
$\mu_s = \tan\phi$ $\quad \mu_k = \tan\phi$

Lakta mass

$\mu = \frac{\text{Latka}}{\text{Betha}} = \frac{L}{B}$

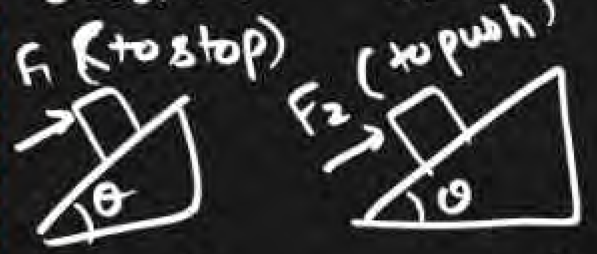
$\%\text{Latka} = \frac{\mu}{1+\mu} \times 100\%$

Nt on Plane



$\mu = \left(1 - \frac{1}{n^2}\right)\tan\theta$

Jana Rok k Dhika



$F_2 = nF_1$ $\quad \mu = \tan\theta\left(\frac{n-1}{n+1}\right)$

$F_1 + F_2 = 2mg\sin\theta$

$F_1 - F_2 = 2\mu mg\cos\theta$

Dove

$\mu = 2\tan\theta$

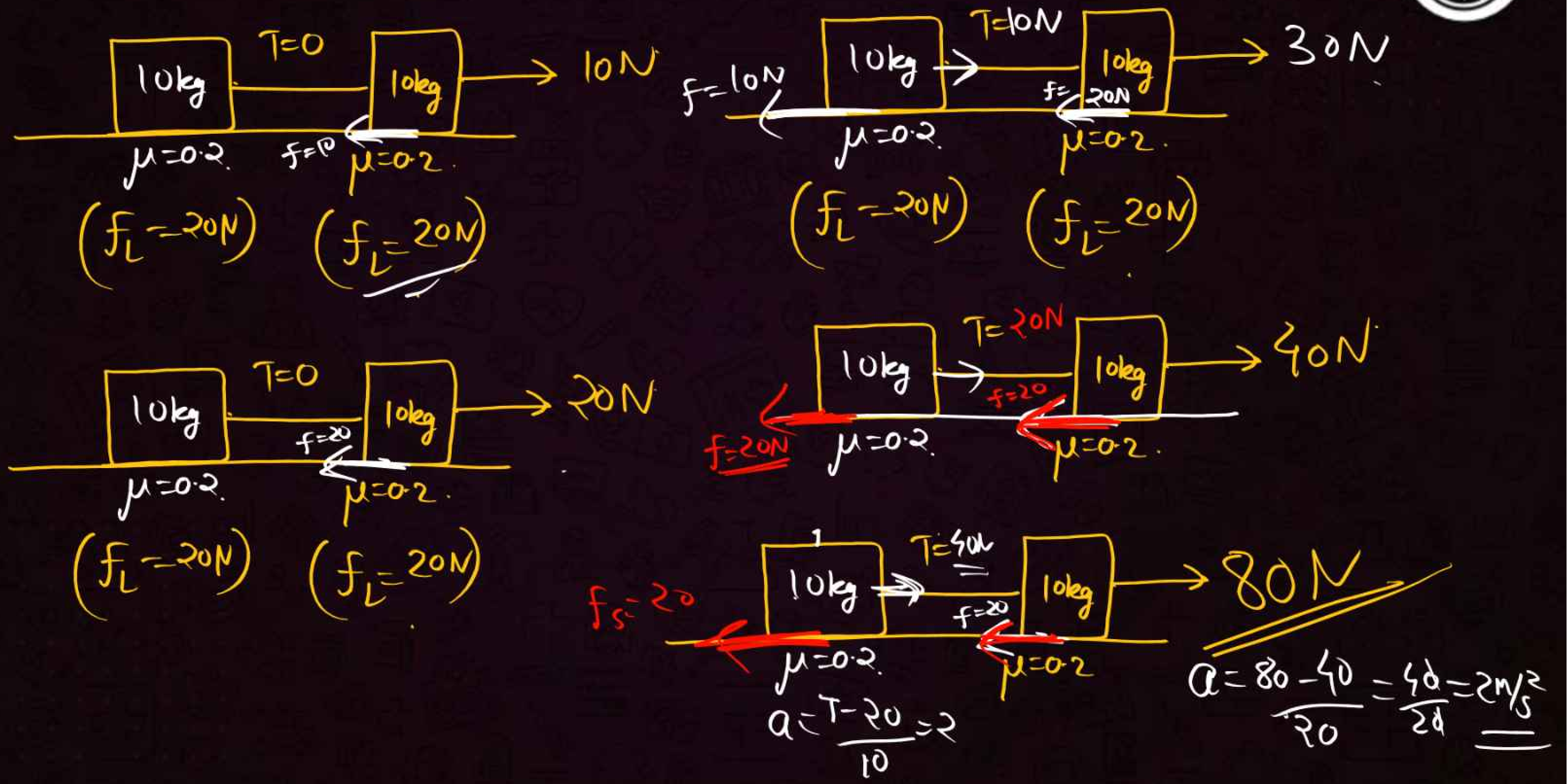
Eattar

$\tan\alpha = \frac{dy}{dx} = \mu$

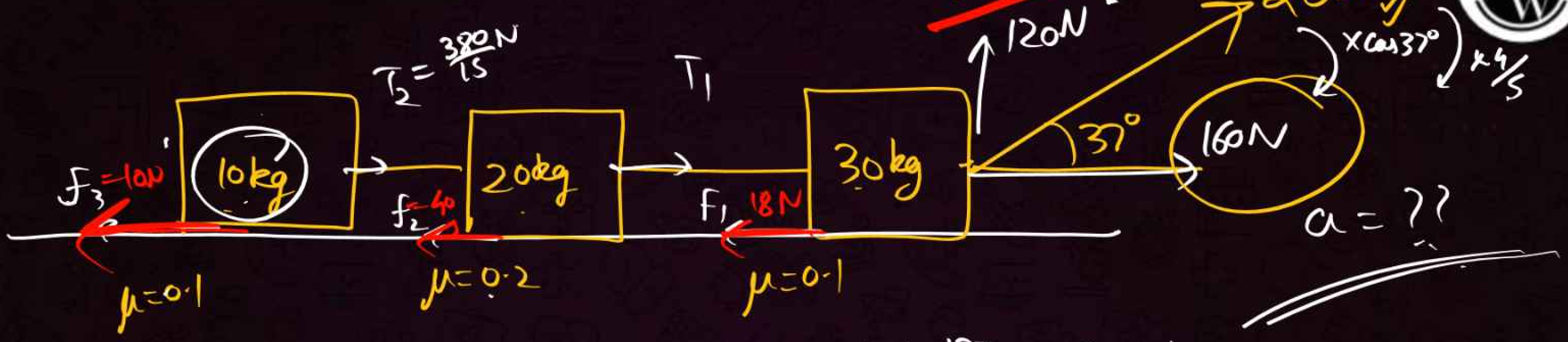
$\mu = \tan\alpha$

Part 8 – Friction in connected bodies

8.1 Push Pull me friction



8.1 Push Pull me friction



$N = 100N$ $\quad$ $N = 200N$ $\quad$ $N = 300 - 120 = 180N$

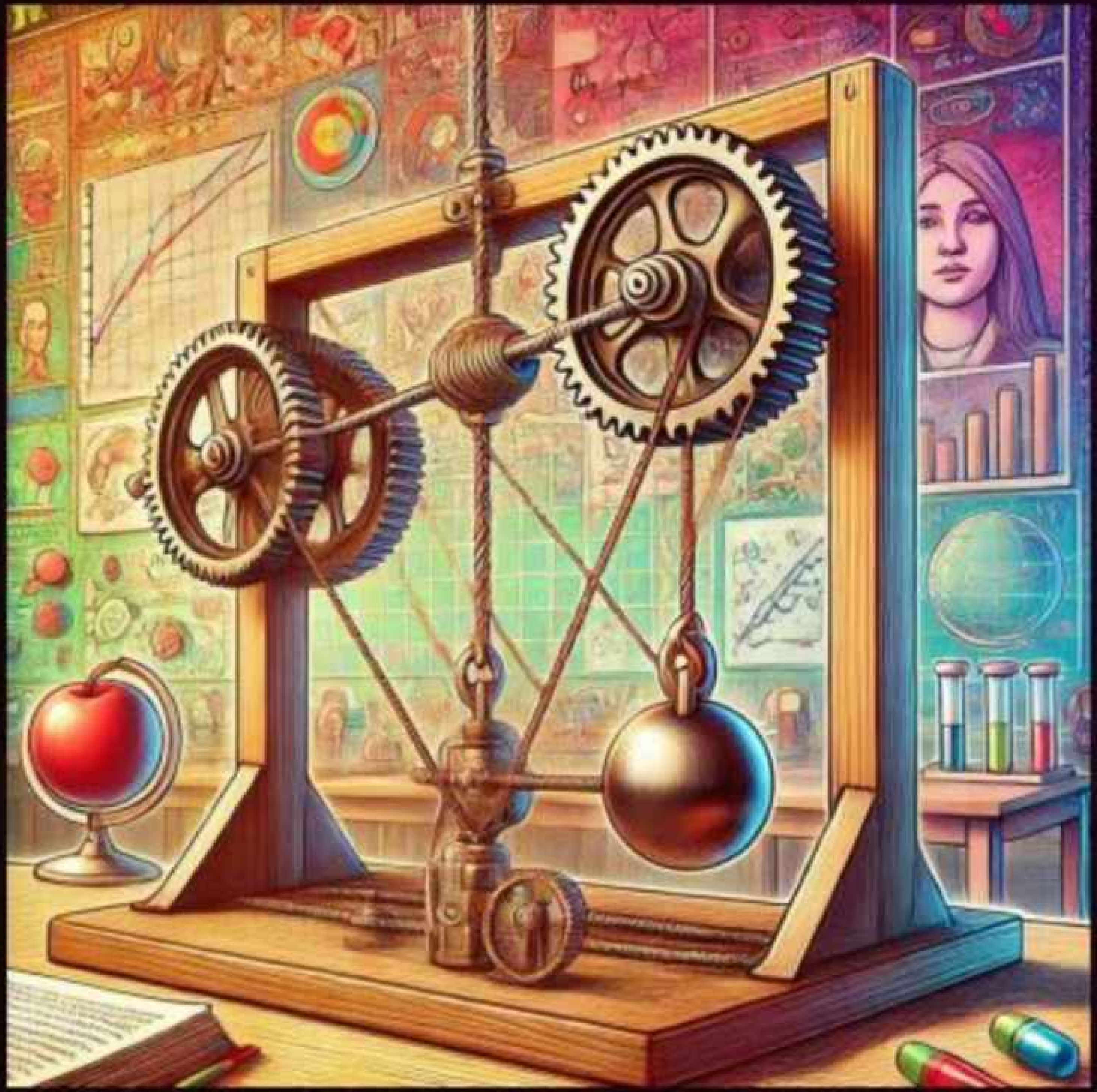
$f_L = 10N$ $\quad$ $f_L = 40N$ $\quad$ $f_L = 18N$

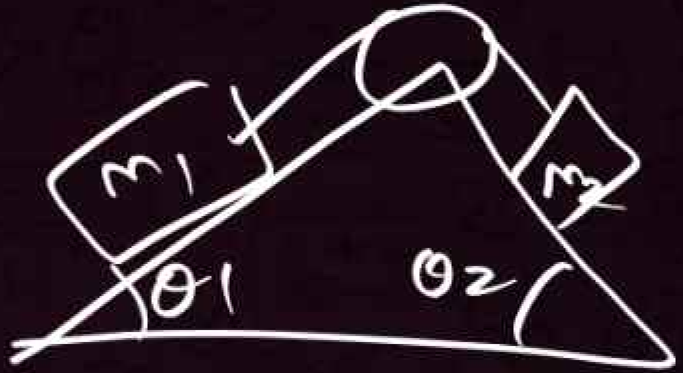
$$\boxed{a = \frac{D - F}{m}} = \frac{160 - 68}{60} = \cancel{\frac{92}{60}} \; \cancel{\frac{46}{30}} \; \frac{23}{15}\ m/s^2$$

$$\frac{T_2 - 10}{10} = \frac{23}{15} \qquad \frac{T_1 - 50}{30} = \frac{23}{15}$$

8.2 Atwood me friction

NLM

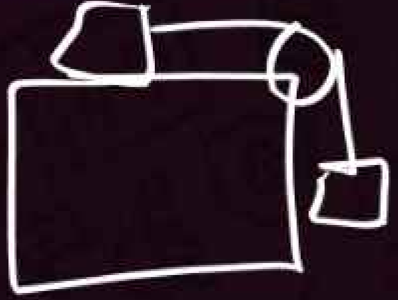




$$T = \left(\frac{m_1 m_2}{m_1+m_2}\right) g(\sin\theta_1+\sin\theta_2)$$

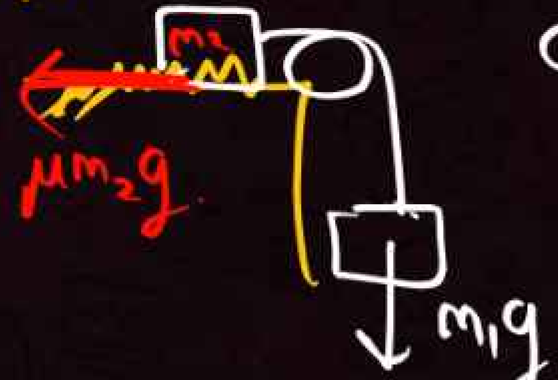
Atwood

a



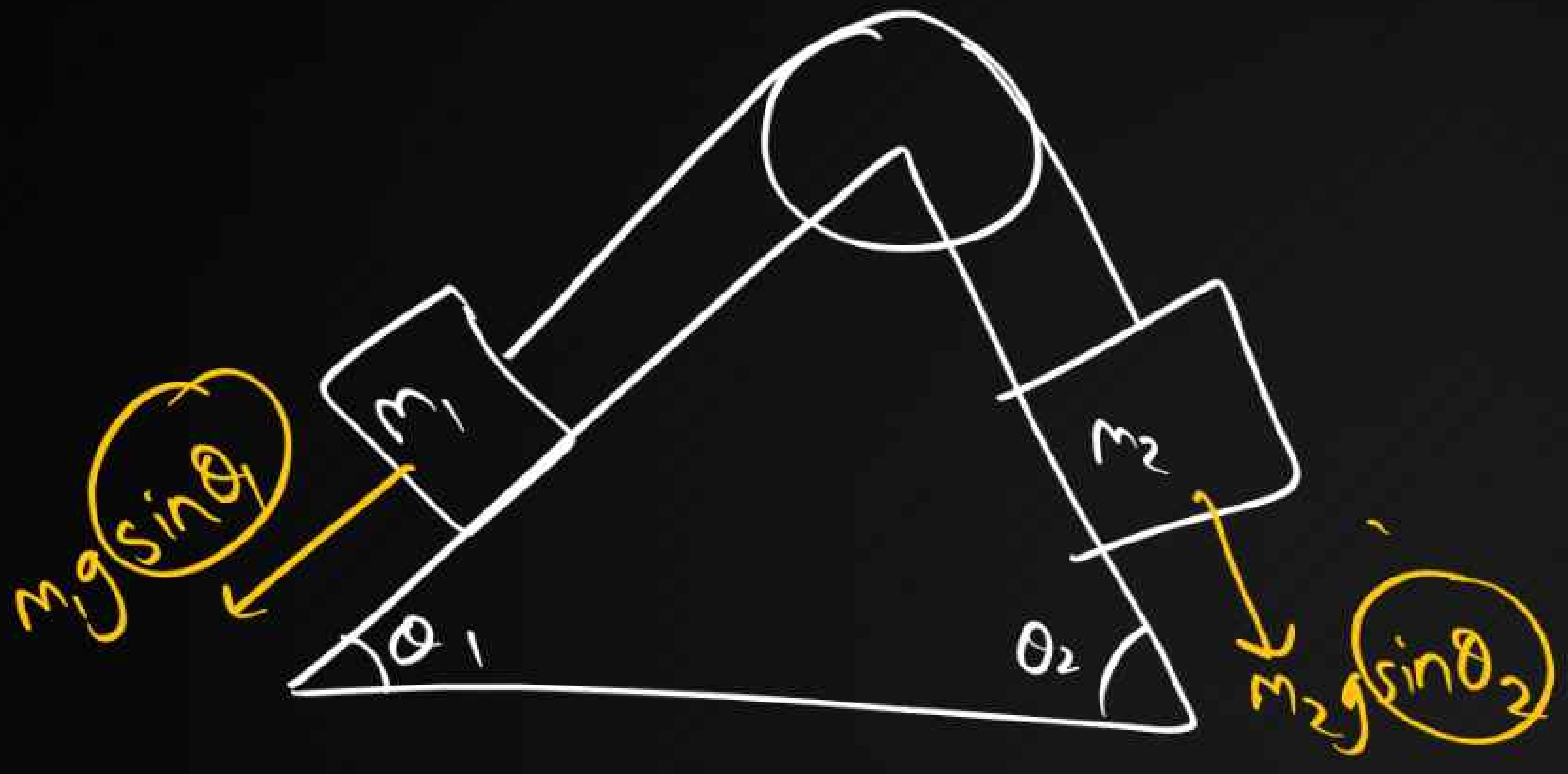
$$T=\frac{m_1 m_2}{m_1+m_2}\,g$$

$$T=\frac{2m_1 m_2}{m_1+m_2}\,g$$



$$\boxed{a=\frac{D-f}{m}=\frac{m_1g-\mu m_2 g}{m_1+m_2}}$$

$$\boxed{T=\frac{m_1 m_2}{m_1+m_2}\,g(1+\mu)}$$



$$a = \frac{m_1 g \sin\theta_1 - m_2 g \sin\theta_2}{m_1 + m_2}$$

$$T = \left(\frac{m_1 m_2}{m_1 + m_2}\right) g \left(\sin\theta_1 + \sin\theta_2\right)$$

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

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

Difficulty Level : HARD

QUESTION-85

A system consists of three masses m_1, m_2 and m_3 is connected by a string passing over a pulley P. The mass m_1 hangs freely and m_2 and m_3 are on a rough horizontal table (the coefficient of friction = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is: (Assume $m_1 = m_2 = m_3 = m$)

[2014]

(1) $\frac{g(1-g\mu)}{9}$

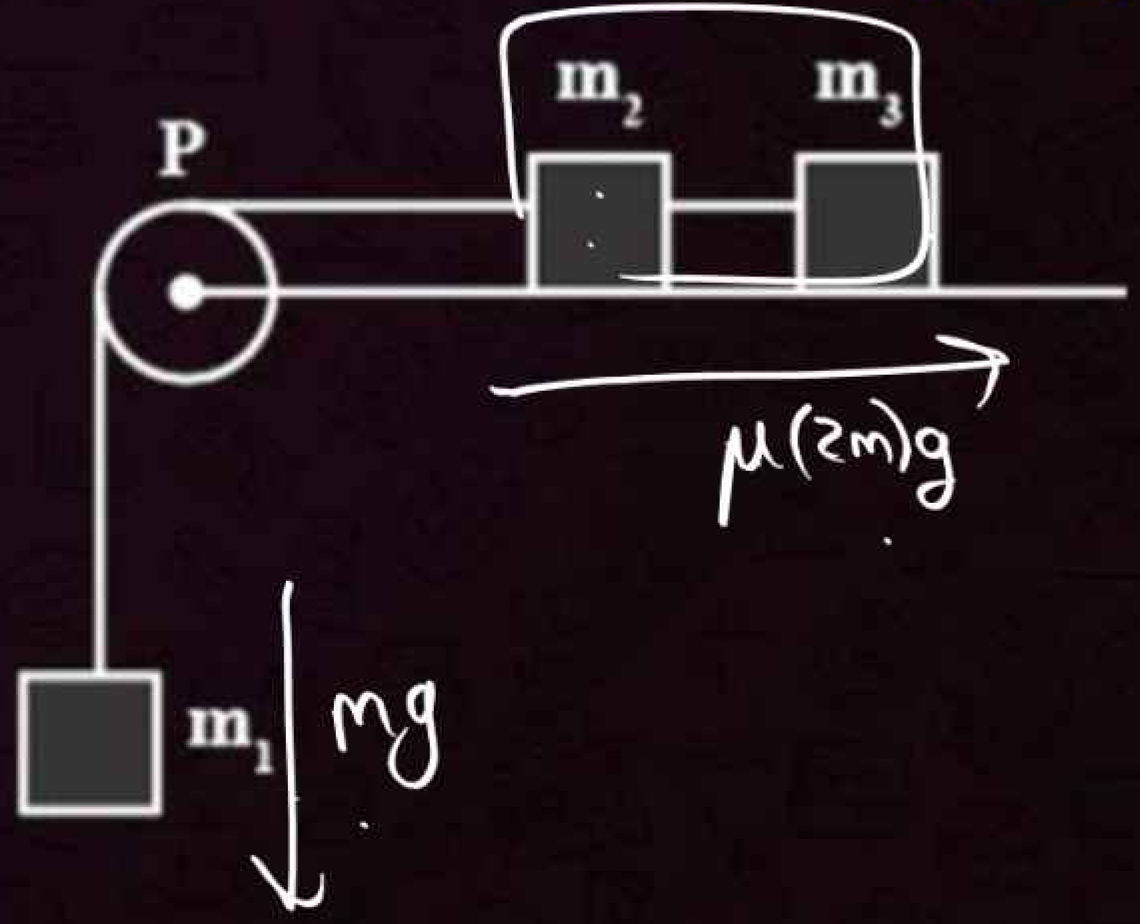
(2) $\frac{2g\mu}{g}$

(3) $\frac{g(1-2\mu)}{3}$

(4) $\frac{g(1-2\mu)}{2}$

$a = \frac{mg - 2\mu mg}{3m}$

$\boxed{a = g\frac{(1-2\mu)}{3}}$



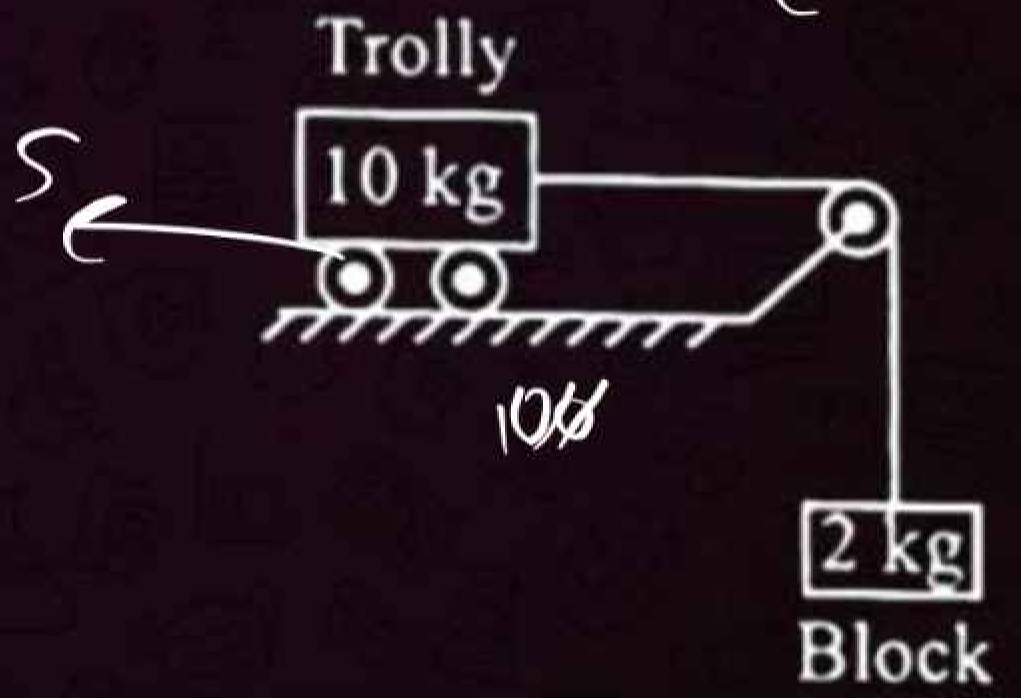
Difficulty Level : HARD

QUESTION-86

nw

Calculate the acceleration of the block and trolly system shown in the figure. The coefficient of kinetic friction between the trolly and the surface is 0.05. ($g = 10\ m/s^2$, mass of the string is negligible and no other friction exists).

[Covid-2020]



(1) $1.50\ m/s^2$

(2) $1.66\ m/s^2$

(3) $1.00\ m/s^2$

(4) $1.25\ m/s^2$

$$a = \frac{20-5}{12} = \frac{\cancel{15}}{\cancel{12}} \frac{5}{4}$$

QUESTION-87

Difficulty Level : YODHA

A block A of mass m_1 rests on a horizontal table. A light string connected to it passes over a frictionless pulley at the edge of table and from its other end another block B of mass m_2 is suspended. The coefficient of friction between the block and table is μ_k. When the block A is sliding on the table, the tension in the string is: [2015]

(1) $\dfrac{(m_2 - \mu_k m_1)g}{(m_1 + m_2)}$

(2) $\dfrac{m_1 m_2 (1 + \mu_k)g}{(m_1 + m_2)}$

(3) $\dfrac{m_1 m_2 (1 - \mu_k)g}{(m_1 + m_2)}$

(4) $\dfrac{(m_2 + \mu_k m_1)g}{(m_1 + m_2)}$

Difficulty Level : HARD

QUESTION-88

A trolley of mass 20 kg is attached to a block of mass 4 kg by a massless string passing over a frictionless pulley as shown in the figure. If the coefficient of kinetic friction between trolley and the surface is 0.02, then the acceleration of the trolley and block system is (Take $g = 10\ m\ s^{-2}$) **[NCERT Based]**

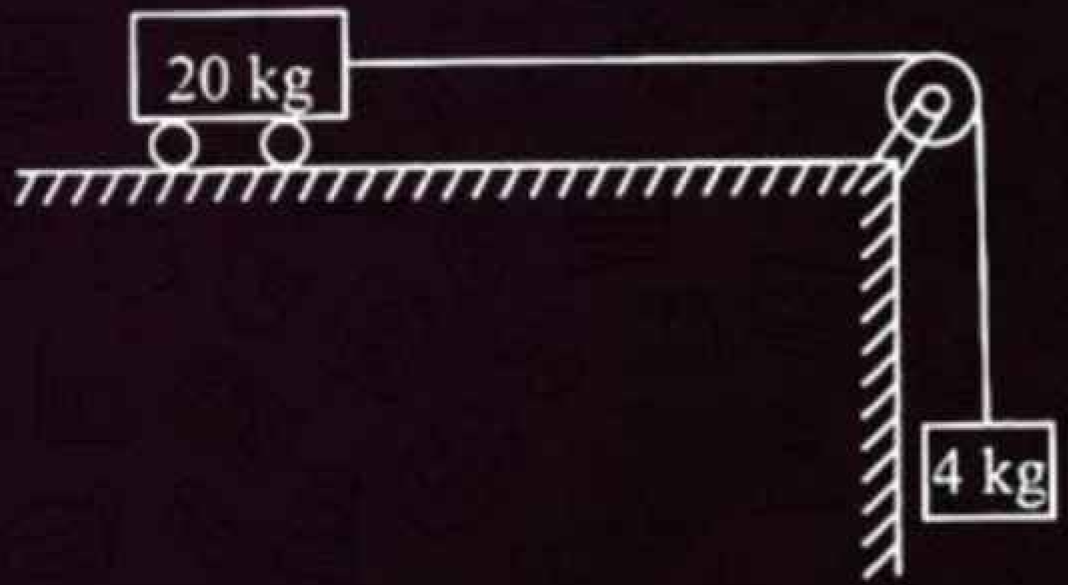
hw

(1) $1\ m\ s^{-2}$

(2) $2\ m\ s^{-2}$

(3) $1.5\ m\ s^{-2}$

(4) $2.5\ m\ s^{-2}$



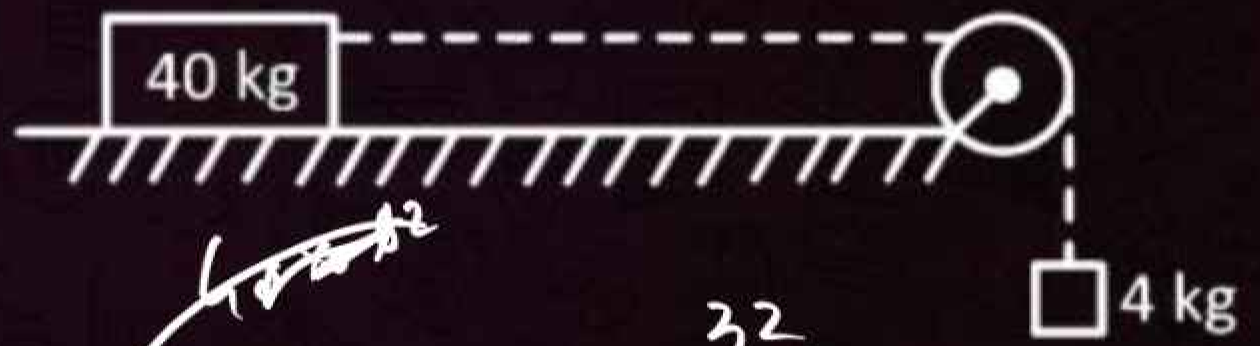
Difficulty Level : HARD

QUESTION-91

hw

A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below. The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is. (Given $g = 10\ \text{ms}^{-2}$)

[Main 29th June 2nd Shift 2022]



$\frac{32}{44}$

(1) $1\ \text{ms}^{-2}$

(2) $1/5\ \text{ms}^{-2}$

(3) $4/5\ \text{ms}^{-2}$

(4) $8/11\ \text{ms}^{-2}$

QUESTION-92

Challenge #2

Difficulty Level : YODHA

In the given arrangement of a doubly inclined plane V two blocks of masses M and m are placed. The blocks are connected by a light string passing over an ideal pulley as shown. The coefficient of friction between the surface of the plane and the blocks is 0.25. The value of m, for which M = 10 kg will move down with an acceleration of $2\ m/s^2$ is (Take $g = 10\ m/s^2$ and $\tan 37° = \frac{3}{4}$)

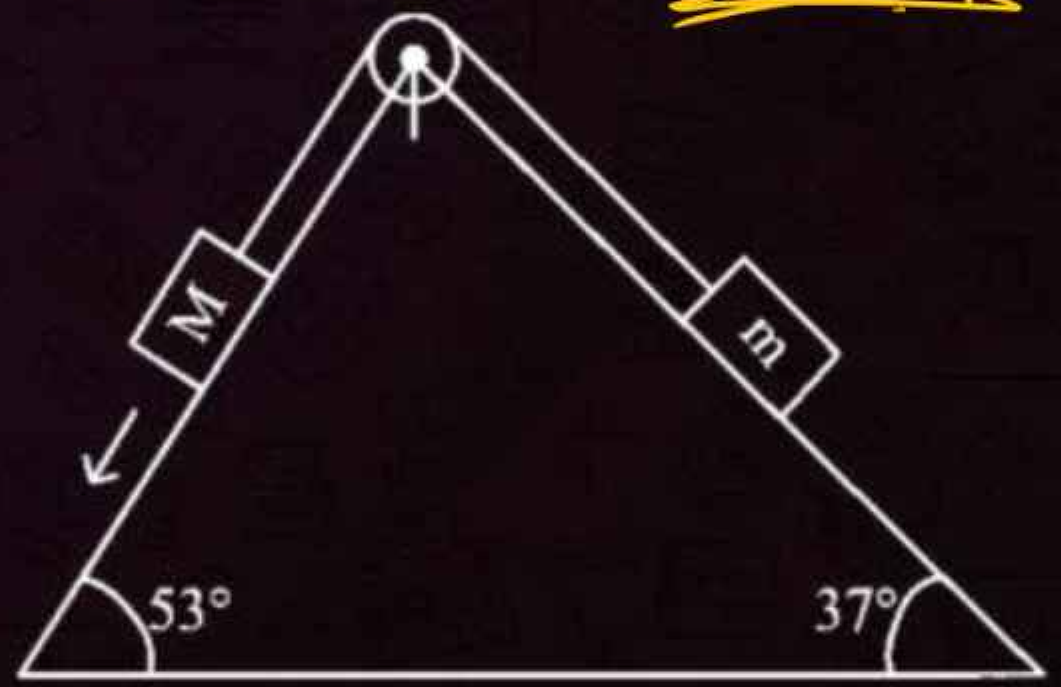
[Main 31st Jan 1st Shift 2024]

(1) 6.5 kg

(2) 2.25 kg

(3) 4.5 kg

(4) 9 kg



PUPPY POINTS - 2

f opposes rel. motion

f jitni jarurat utna

Angle of $F_r = \phi$

$R\cos\phi = N$

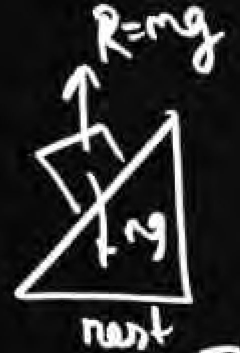
$R\sin\phi = f$

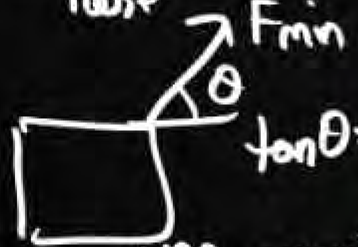
$\tan\phi = \frac{f}{N}$

$R = \sqrt{N^2+f^2}$

For Limiting f

$\tan\phi = \mu$





$\tan\theta = \mu$*

$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Stopping Distance & Time

$s = \frac{v^2}{2a}$ $T = \frac{v}{a}$

$s = \frac{v^2}{2\mu g}$ $T = \frac{v}{\mu g}$

$s = \frac{v^2}{2(\mu g\cos\theta - g\sin\theta)}$

$T = \frac{v}{(\mu g\cos\theta - g\sin\theta)}$

Angle of Repose

Just ... $\mu_s = \tan\phi$

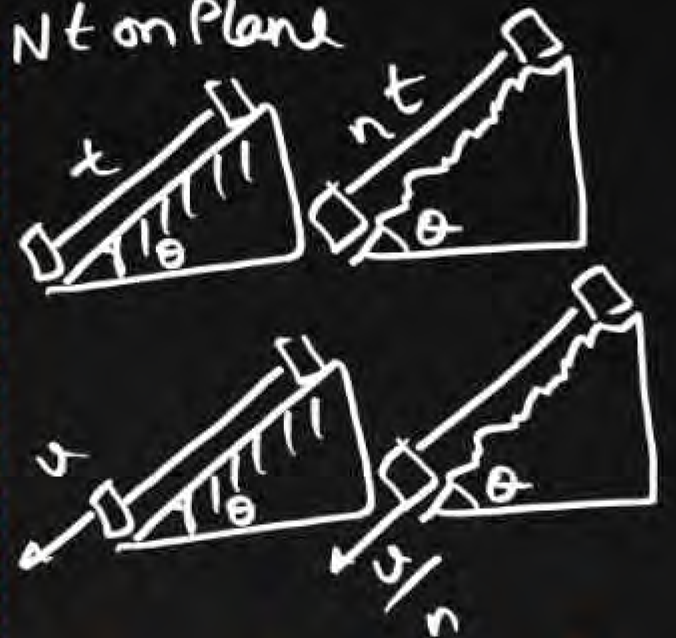
v constant $\mu_k = \tan\phi$

Lakta mass

$\mu = \frac{Latka}{Betha} = \frac{L}{B}$

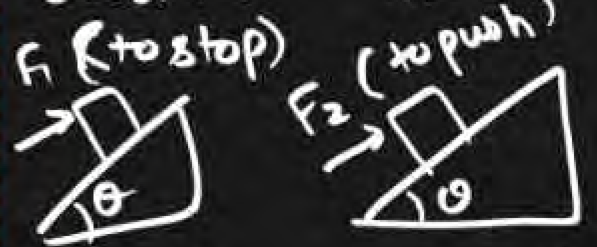
$\%\,Latka = \frac{\mu}{1+\mu} \times 100\%$

Nt on Plane



$\mu = \left(1 - \frac{1}{n^2}\right)\tan\theta$

Jana Rok k Dhika



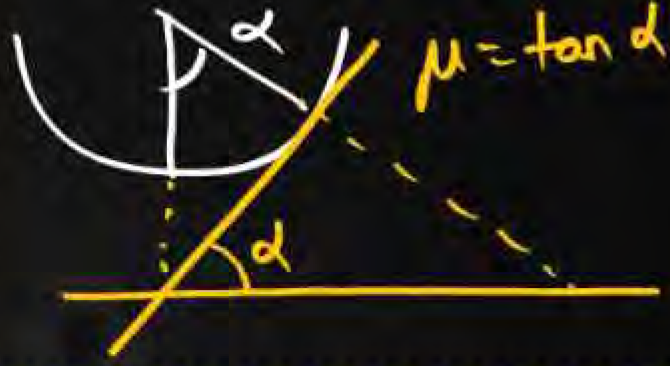
$F_2 = nF_1$ $\mu = \tan\theta\left(\frac{n-1}{n+1}\right)$

Dove

$\mu = 2\tan\theta$

Sattar

$\tan\alpha = \frac{dy}{dx} = \mu$



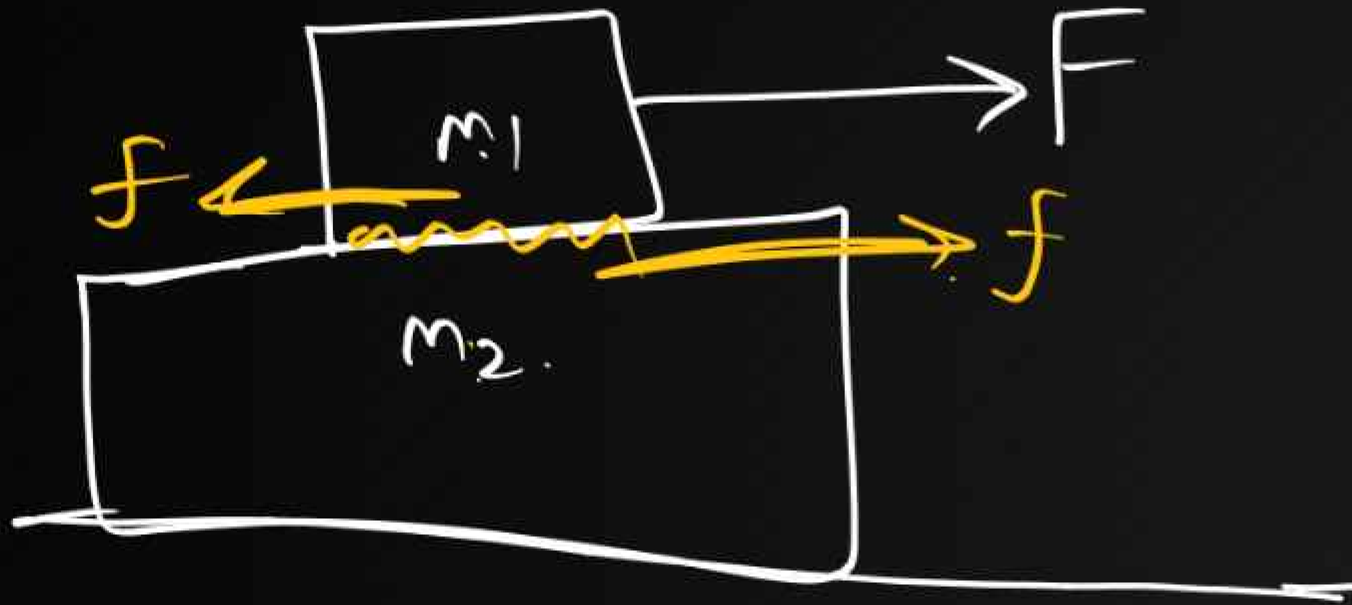
$\mu = \tan\alpha$

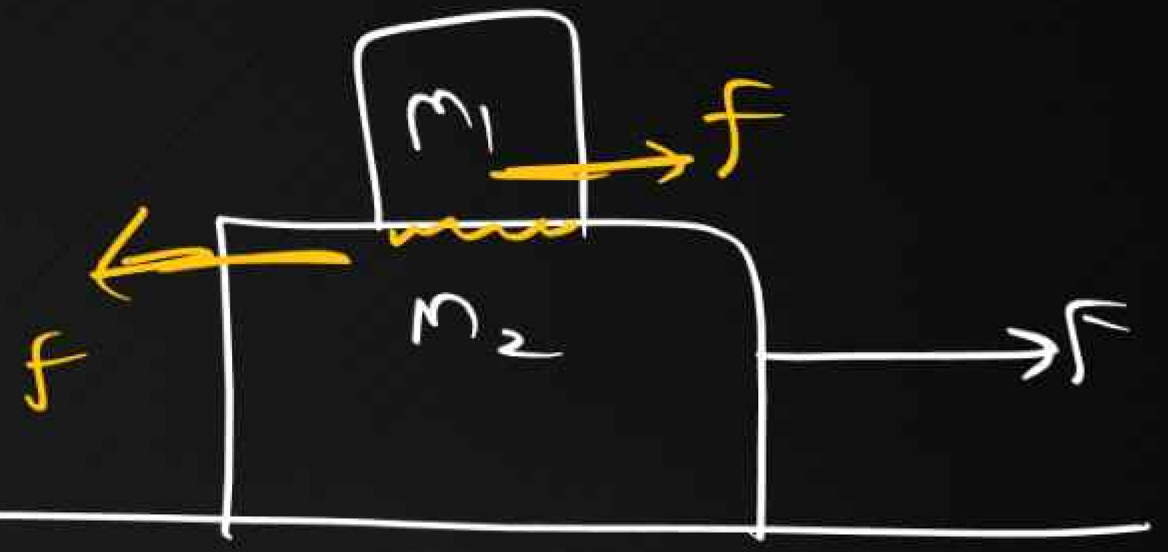
$a = \frac{m_1 g - \mu m_2 g}{m_1+m_2}$

$T = \frac{m_1 m_2 g}{m_1+m_2}(1+\mu_k)$

Part 9 – Multiple Block System

2 block system





$$F_{daddy} = \mu\left(\frac{m_1}{m_2}\right)(m_1+m_2)g$$

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

$F < F_{daddy}$ (move together)

$\left(a = \frac{F}{m_1+m_2}\right)$ $\boxed{f = m_2 a}$

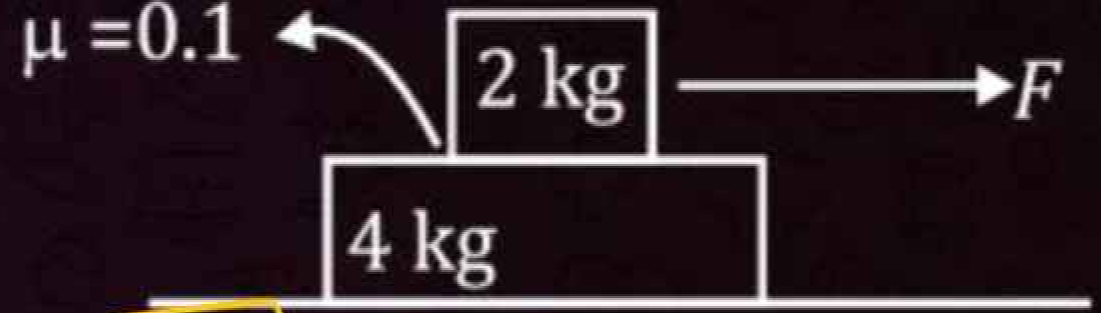
$F < F_{daddy}$ (move together)

$\left(a = \frac{F}{m_1+m_2}\right)$ $f = m_1 a$.

Difficulty Level : HARD

QUESTION-93

Find F_{max} for which blocks will move together.



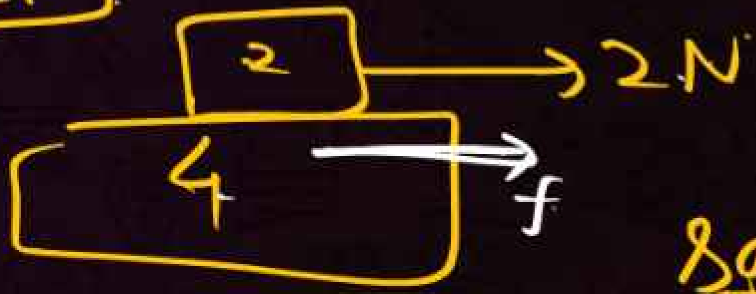
$$F_{daddy} = \mu\left(\frac{m_1}{m_2}\right)(m_1+m_2)g$$

$$= 0.1\times\left(\frac{2}{4}\right)(2+4)10$$

$$= 0.1\times\frac{1}{2}\times 6\times 10$$

$$\boxed{F_{daddy} = 3N}$$

I $\boxed{F = 2N}$



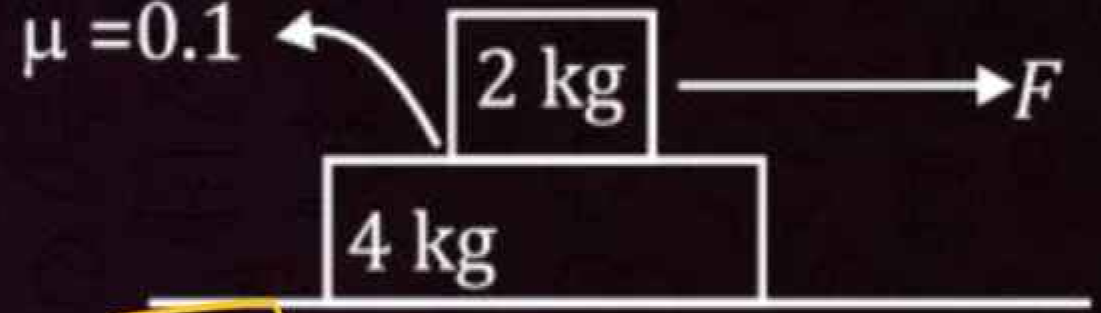
Saath

$a = \frac{2}{6} = \frac{1}{3} m/s^2$ $f = 4\times a = 4\times\frac{1}{3} = \frac{4}{3}N$

Difficulty Level : HARD

QUESTION-93

Find F_{max} for which blocks will move together.



$$F_{daddy} = \mu \left(\frac{m_1}{m_2}\right)(m_1+m_2)\, g$$

$$= 0.1 \times \left(\frac{2}{4}\right)(2+4)10$$

$$= 0.1 \times \frac{1}{2} \times 6 \times 10$$

$$\boxed{F_{daddy} = 3N}$$

(I) $\boxed{F = 2N}$

6N

f

$N = 20$

$f_L = \mu N = 0.1 \times 20 = 2N$

2 → 6N

2N

$a_1 = \frac{F}{m} = \frac{6-2}{2} = 2\, m/s^2$

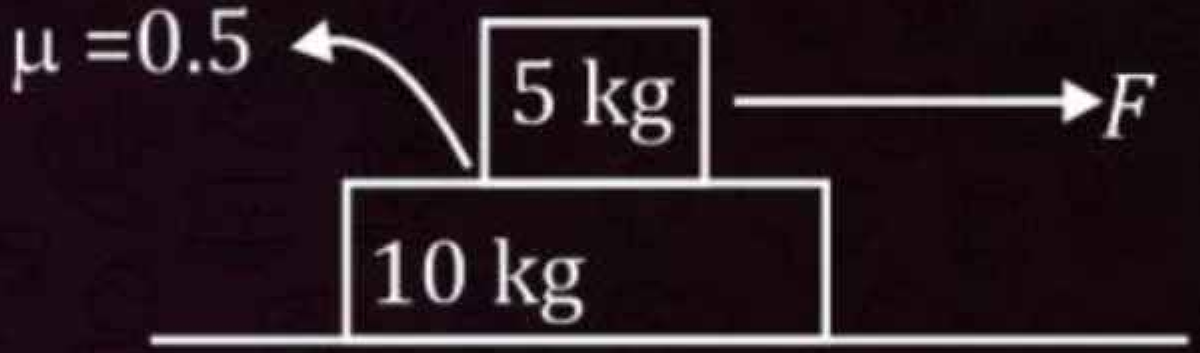
4 → 2N

$a = \frac{F}{m} = \frac{2}{4} = \frac{1}{2}\, m/s^2$

Difficulty Level : Easy

QUESTION-94

Find F_{max} for which blocks will move together.

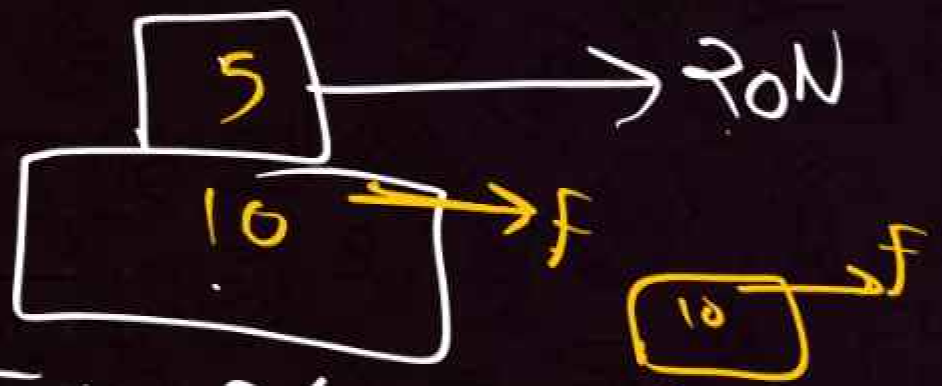


$$F_{daddy} = \mu(m_1+m_2)\left(\frac{m_1}{m_2}\right)g$$

$$= 0.5(5+10)\left(\frac{5}{10}\right)\cancel{\times 10}$$

$$= \frac{5\times15\times\cancel{5}}{\cancel{10}\,2} = \frac{75}{2} = 37.5\,N$$

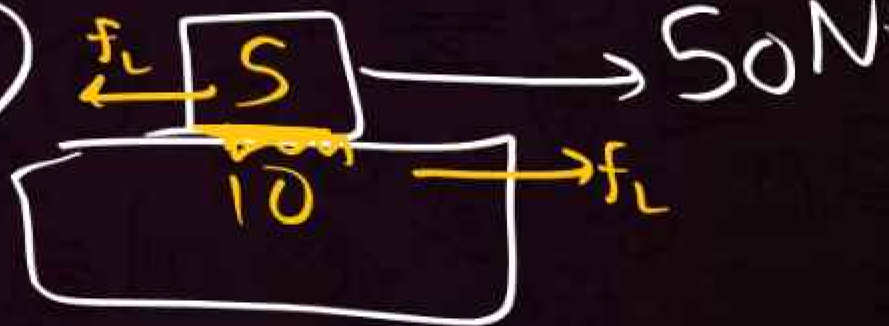
I



$$a = \frac{F_{net}}{m_{total}} = \frac{\cancel{20}}{\cancel{15}} = \frac{4}{3}$$

$$f = 10a = 10\times\frac{4}{3} = \frac{40}{3}\,N$$

II



$N = 50$

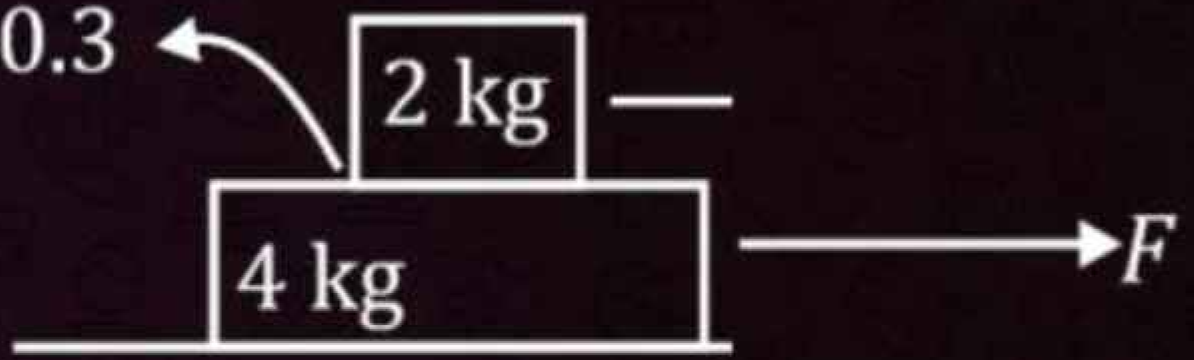
$f_L = 0.5\times50 = 25N$

$$a_1 = \frac{50-25}{5} = 5\,m/s^2 \qquad a_2 = \frac{25}{10} = 2.5\,m/s^2$$

Difficulty Level : HARD

QUESTION-96

Find F_{max} for which blocks will move together.



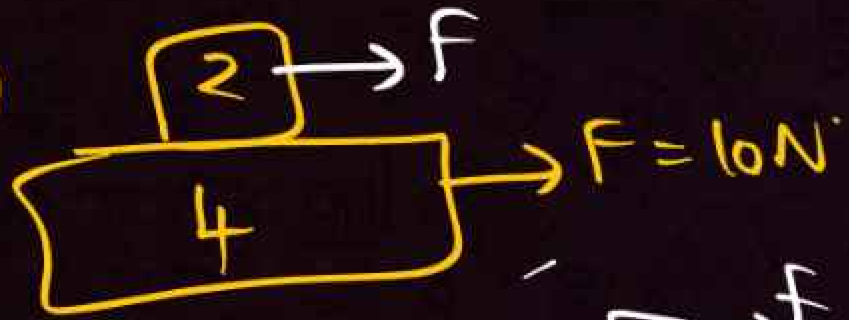
$F_{daddy} = \mu(m_1+m_2)g$

$= 0.3(2+4)\times10$

$= 0.3\times6\times10$

$= 18N$

(I)

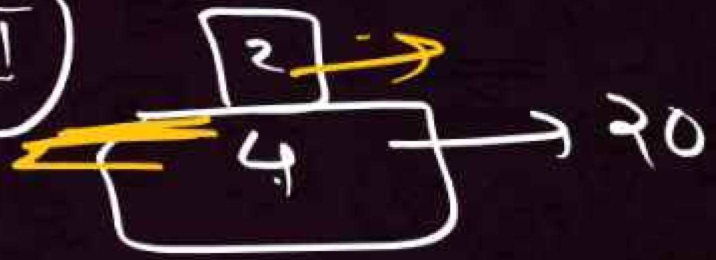


$a = \frac{F}{m} = \frac{10}{6} = \frac{5}{3}$

$f = ma$

$f = 2\times\frac{5}{3} = \frac{10}{3}N$

(II)



$N = 20$

$f_L = \mu N = 0.3\times20$

$= 6N$

$a_1 = \frac{6}{2} = 3 m/s^2$

$a_2 = \frac{14}{4} = 7/2\ m/s^2.$

Difficulty Level : HARD

QUESTION-99

In figure, the coefficient of friction between the floor and the block B is 0.1. The coefficient of friction between the blocks B and A is 0.2. The mass of A is m/2 and of B is m. What is the maximum horizontal force F which can be applied to the block B so that two blocks move together?

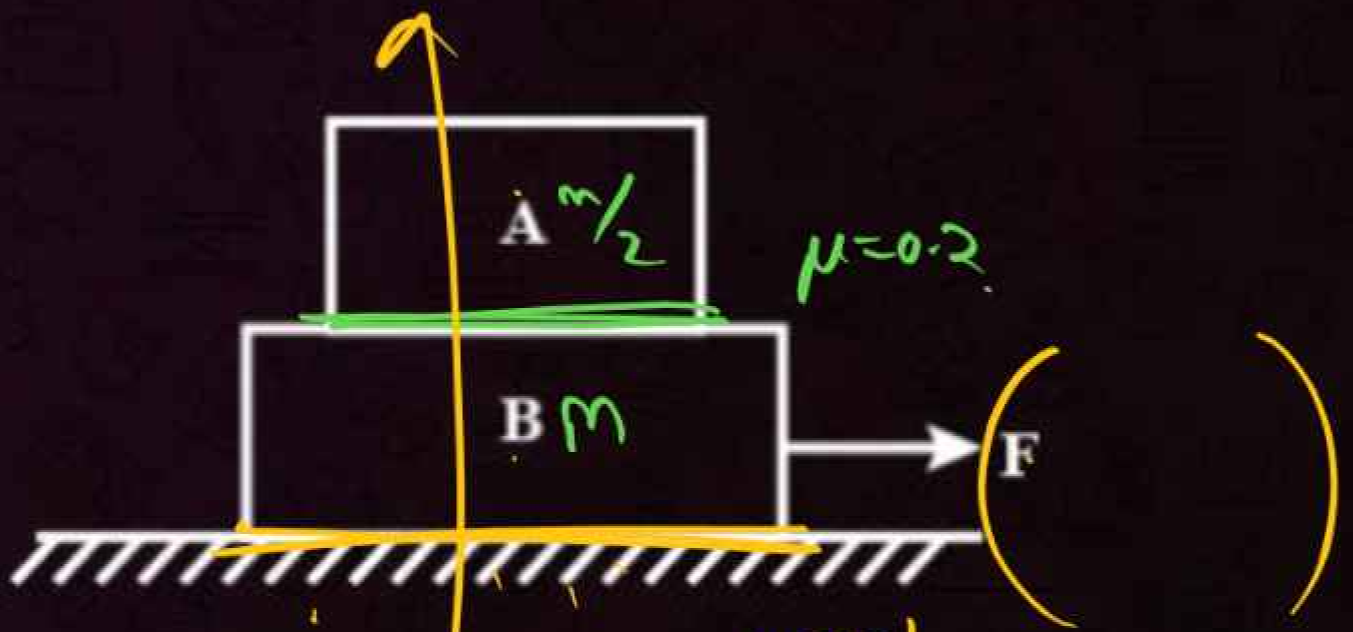
[NCERT Based]

(1) 0.15 mg

(2) 0.05 mg

(3) 0.1 mg

(4) 0.45 mg



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

$= 0.2\left(m + \frac{m}{2}\right)g$

$= 0.2 \times \frac{3m}{2} g$

$\boxed{F_{daddy} = 0.3\,mg}$

$N = \frac{3m}{2}g$

$\left(f_L = \mu N = 0.3\frac{mg}{2}\right)$

$F_{max} = 0.3mg + \frac{0.3}{2}mg$

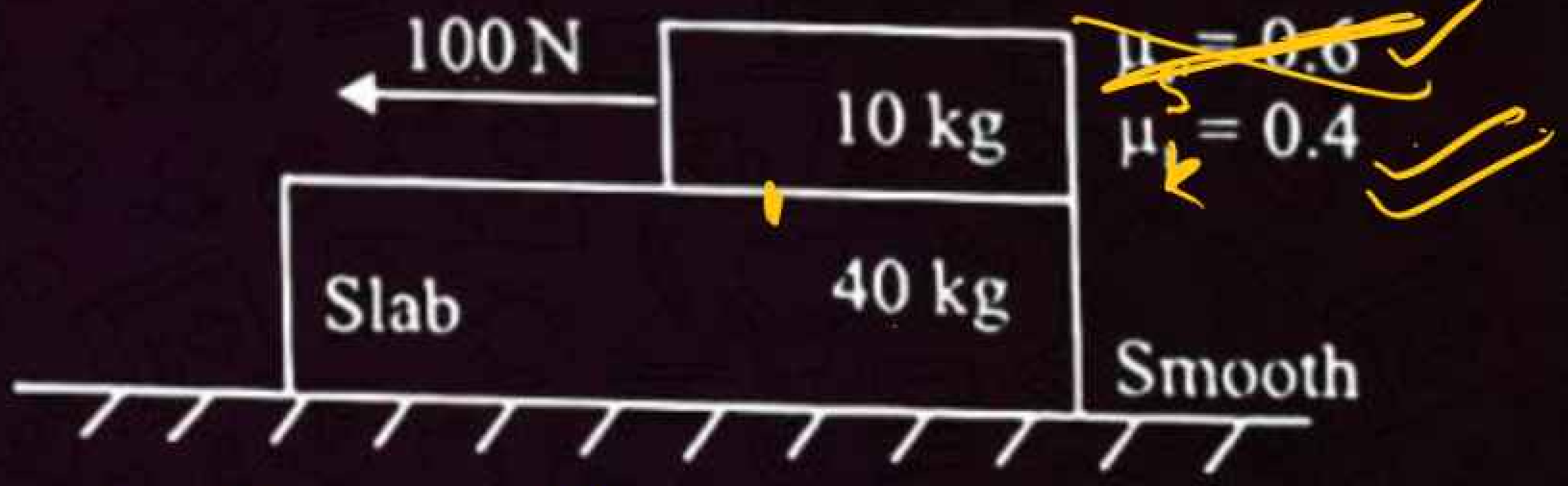
$= \frac{0.9mg}{2} = \frac{9}{20}mg = \frac{4.5}{10}mg = 0.45mg$

Difficulty Level : YODHA

QUESTION-100

If 100 N force is applied to 10 kg block as shown in diagram, then acceleration produced for slab: [1999]

1. $1.65\ m/s^2$
2. $0.98\ m/s^2$
3. $1.2\ m/s^2$
4. $0.25\ m/s^2$



$\cancel{F_{daddy} = \mu_s (m_1+m_2)\left(\frac{m_1}{m_2}\right) g = 0.6(50)\left(\frac{1}{4}\right)10 = \frac{25}{2} = 12.5\,N}$

100

$f_k = 0.4 \times 10 \times 9.8$

40N

40kg

$a = \frac{4 \times 9.8}{40}$

Difficulty Level : YODHA

QUESTION-101

A boy of mass M is applying a horizontal force to slide a box of mass M' on a rough horizontal surface. The coefficient of friction between the shoes of the boy and the floor is μ and that between the box and the floor is μ'. In which of the following cases it is certainly not possible to slide the box? **[HCV Objective]**

(1) $\mu < \mu'$, $M < M'$

(2) $\mu > \mu'$, $M < M'$

(3) $\mu < \mu'$, $M > M'$

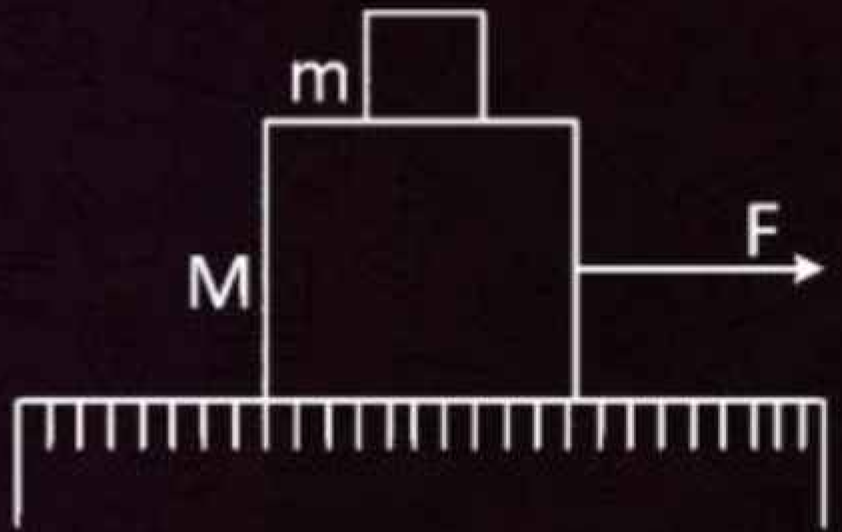
(4) $\mu > \mu'$, $M > M'$

HW

Difficulty Level : HARD

QUESTION-102

A system of two blocks of masses $m = 2$ kg and $M = 8$ kg is placed on a smooth table as shown in figure. The coefficient of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be: **[Main 27th June 1st Shift 2022]**



(1) 9.8 N

(2) 39.2 N

(3) 49 N

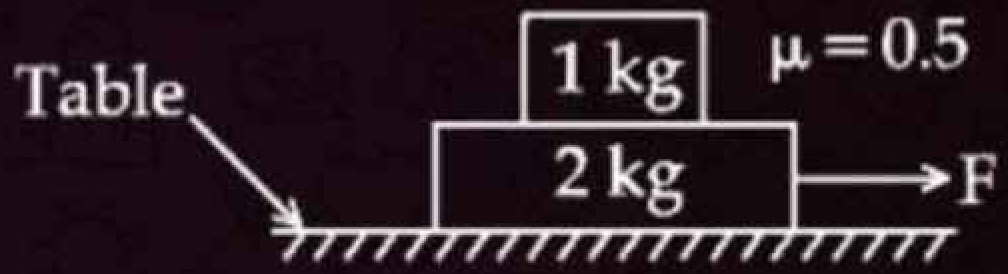
(4) 78.4 N

Difficulty Level : HARD

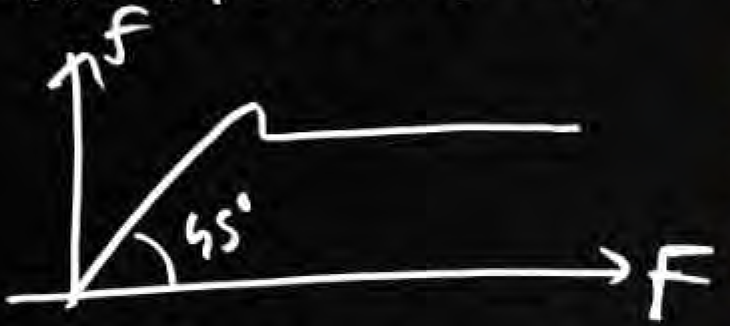
QUESTION-103

The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is ________ N.

[Main 26th Aug 2nd Shift 2021]



PUPPY POINTS - 2



f opposes rel. motion

f jitni jarurat utna

Angle of $F_r = \phi$

$R\cos\phi = N$

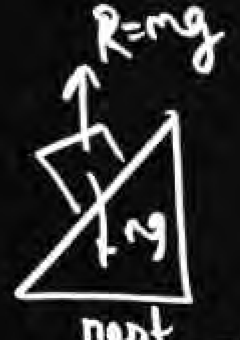
$R\sin\phi = f$

$\tan\phi = \dfrac{f}{N}$

$R = \sqrt{N^2 + f^2}$

For Limiting f

$\tan\phi = \mu$



$\tan\theta = \mu$

$F_{min} = \dfrac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Stopping Distance & Time

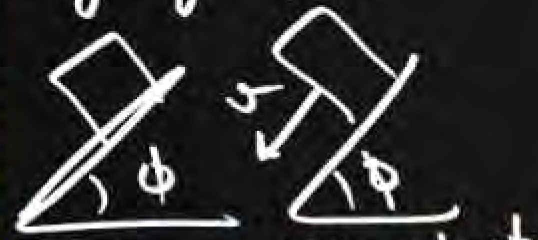
$S = \dfrac{v^2}{2a}$ $T = \dfrac{v}{a}$

$S = \dfrac{v^2}{2\mu g}$ $T = \dfrac{v}{\mu g}$

$S = \dfrac{v^2}{2(\mu g\cos\theta - g\sin\theta)}$

$T = \dfrac{v}{(\mu g\cos\theta - g\sin\theta)}$

Angle of Repose



Just ... v constant

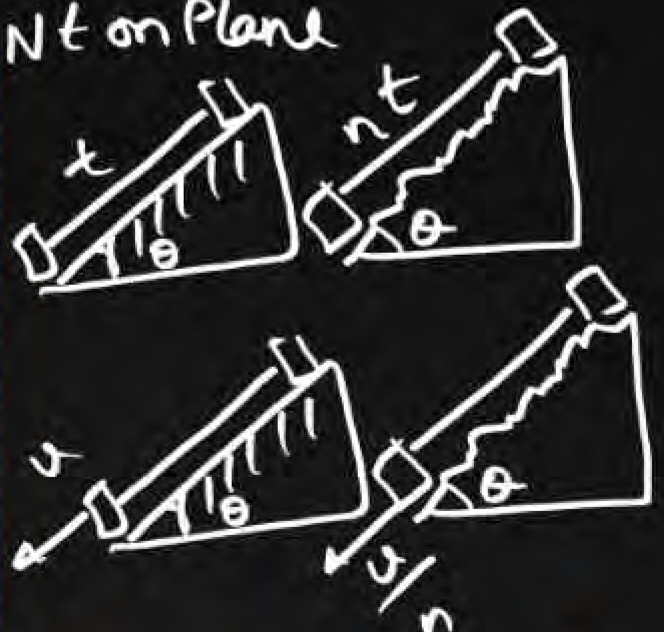
$\mu_s = \tan\phi$ $\mu_k = \tan\phi$

Lakta mass

$\mu = \dfrac{Latka}{Betha} = \dfrac{L}{B}$

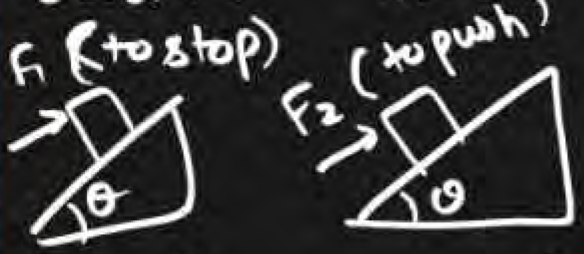
$\% Latka = \dfrac{\mu}{1+\mu} \times 100\%$

Nt on Plane



$\mu = \left(1 - \dfrac{1}{n^2}\right)\tan\theta$

Jana Rok k Dhika



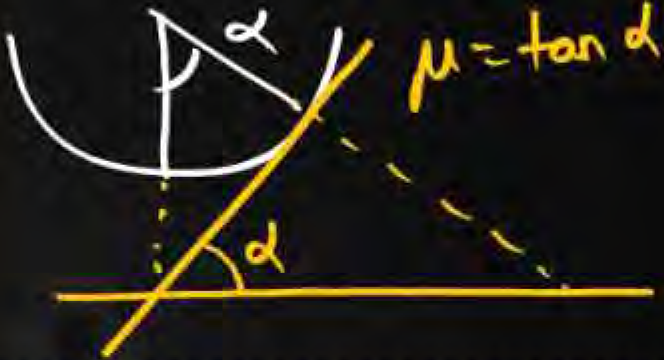
$F_2 = nF_1$ $\mu = \tan\theta\left(\dfrac{n-1}{n+1}\right)$

Dove

$\mu = 2\tan\theta$

Sattar

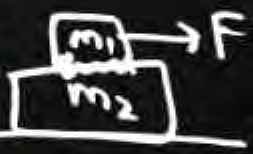
$\tan\alpha = \dfrac{dy}{dx} = \mu$



$\mu = \tan\alpha$

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

$T = \dfrac{m_1 m_2 g}{m_1 + m_2}(1 + \mu_k)$



$F_{papa} = \mu\left(\dfrac{m_1}{m_2}\right)(m_1 + m_2)g$

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

$F < F_{papa}$

$a = F/(m_1 + m_2)$

$F > F_{papa}$

Seperate a

Part 17 – Kinectic Friction

Difficulty Level : Easy

QUESTION-104

A block has been placed on a inclined plane with the slope angle θ, block slides down the plane at constant speed. The coefficient of kinetic friction is equal to:

[1993]

(1) $\sin\theta$

(2) $\cos\theta$

(3) g

(4) $\tan\theta$ ✓

$\mu = \tan\theta$ ✓

Difficulty Level : MEDIUM

QUESTION-106

nw//

A heavy box of mass 50 kg is moving on a horizontal surface. If co-efficient of kinetic friction between the box and horizontal surface is 0.3 then force of kinetic friction is: **[Main 5th April 2nd Shift 2024]**

(1) 1470 N

(2) 1.47 N

(3) 147 N

(4) 14.7 N

Difficulty Level : MEDIUM

QUESTION-107

A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30 N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10 s. Coefficient of kinetic friction is (given, $g = 10\ ms^{-2}$): **[Main 1st Feb 1st Shift 2023]**

(1) 0.50

(2) 0.60

(3) 0.75

(4) 0.25

QUESTION-105

Black → 10–15 min → Ganda

Difficulty Level : YODHA

A plank with a box on it at one end is gradually raised about the other end. As the angle of inclination with the horizontal reaches 30°, the box starts to slip and slides 4.0 m down the plank in 4.0 s. The coefficients of static and kinetic friction between the box and the plank will be, respectively: **[Re-2015]**

(1) 0.4 and 0.3

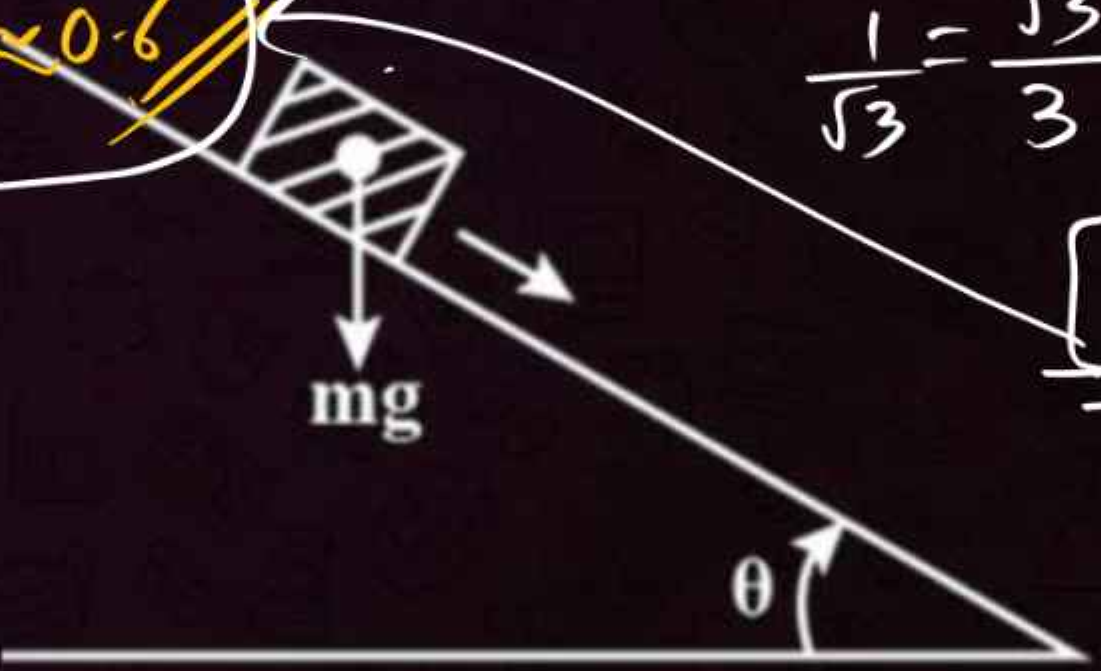
(2) 0.6 and 0.6

(3) 0.6 and 0.5

(4) 0.5 and 0.6

$\mu_s = \tan 30^\circ = \frac{1}{\sqrt{3}} = \frac{1}{1.73} = 0.578 \approx 0.6$

$\frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3} = \frac{1.73}{3} = 0.58$



$S = \cancel{ut} + \frac{1}{2}at^2$

$4 = \frac{1}{2}(g\sin 30 - \mu g\cos 30^\circ)\, 4\times4$

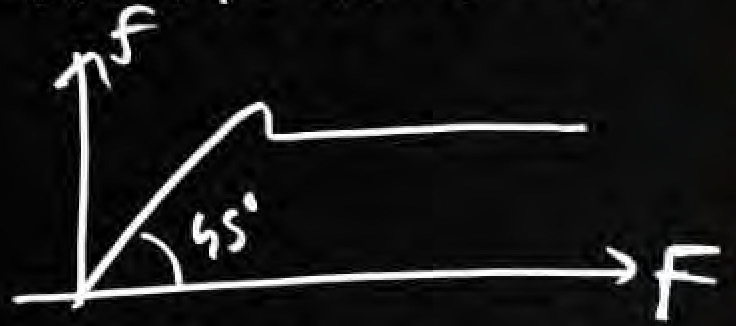
$\frac{1}{2} = g\left(\frac{1}{2} - \frac{\mu\sqrt{3}}{2}\right)$

$\frac{1}{g} = 1 - \sqrt{3}\mu$

$\sqrt{3}\mu = 1 - \frac{1}{g}$

$\mu = \frac{1 - 0.1}{\sqrt{3}} = \frac{0.9}{\sqrt{3}} = 0.520 = 0.9 \times 0.58 = 0.522$

PUPPY POINTS - 2



f opposes rel. motion

f jitni jarurat utna

Angle of $F_r = \phi$

$R\cos\phi = N$

$R\sin\phi = f$

$\tan\phi = \frac{f}{N}$

$R = \sqrt{N^2 + f^2}$

For Limiting f

$\tan\phi = \mu$

$\tan\theta = \mu$*

$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Stopping Distance & Time

$s = \frac{v^2}{2a}$ $T = \frac{v}{a}$

$s = \frac{v^2}{2\mu g}$ $T = \frac{v}{\mu g}$

$s = \frac{v^2}{2(\mu g\cos\theta - g\sin\theta)}$

$T = \frac{v}{(\mu g\cos\theta - g\sin\theta)}$

Angle of Repose

Just ... v constant

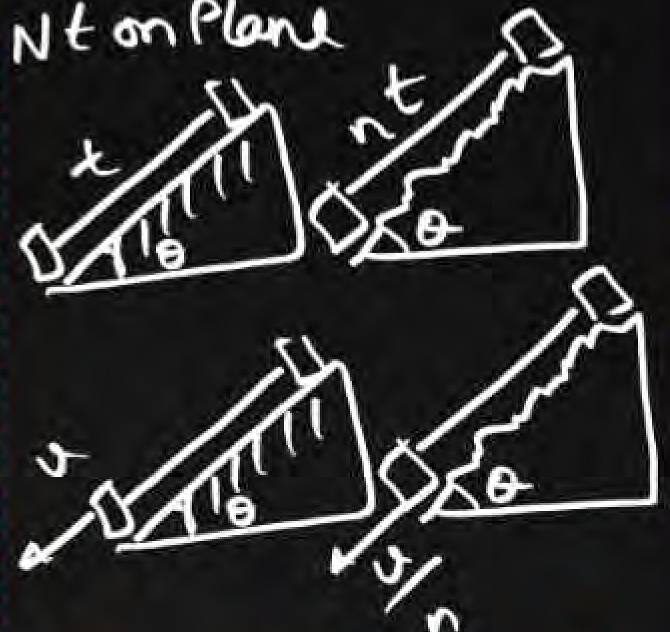
$\mu_s = \tan\phi$ $\mu_k = \tan\phi$

Laktamass

$\mu = \frac{Latka}{Betha} = \frac{L}{B}$

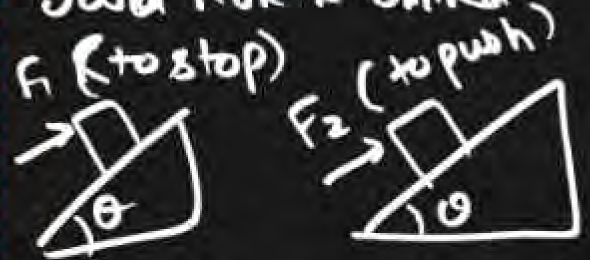
$\%\,Latka = \frac{\mu}{1+\mu} \times 100\%$

Nt on Plane



$\mu = \left(1 - \frac{1}{n^2}\right)\tan\theta$

Jana Rok k Dhika



$F_2 = nF_1$ $\mu = \tan\theta\left(\frac{n-1}{n+1}\right)$

$\mu_s \rightarrow$ Just about to move

$\mu_k \rightarrow$ moving (v, a) ...

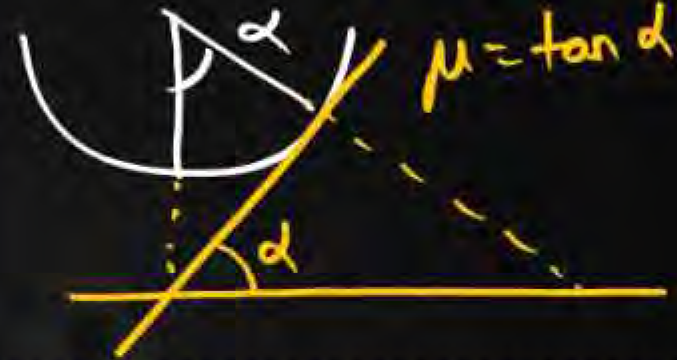
$f_L = \mu_s N$ $f_k = \mu_k N$ $\mu_s \geq \mu_k$

Dove

$\mu = 2\tan\theta$

Sattar

$\tan\alpha = \frac{dy}{dx} = \mu$



$\mu = \tan\alpha$

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

$T = \frac{m_1 m_2 g}{m_1 + m_2}(1 + \mu_k)$

$F_{papa} = \mu\left(\frac{m_1}{m_2}\right)(m_1 + m_2)g$

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

$F < F_{papa}$: $a = F/(m_1 + m_2)$

$F > F_{papa}$: Seperate a

Part 18 – Theory and AR Questions

QUESTION-108 (Assertion and Reason)

Assertion: Friction opposes relative motion and thereby dissipates power in the form of heat.

Reason: Friction is always an undesirable force.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-109 (Assertion and Reason)

Assertion: On a rainy day, it is difficult to drive a car or bus at high speed.

Reason: The value of coefficient of friction is lowered due to wetting of the surface.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (1)

QUESTION-110 (Assertion and Reason)

Assertion: Static friction is a self-adjusting force upto its limit μ_s, N where μ_s is the coefficient of S static friction.

Reason: One can use the equation $f_s = \mu_s$ N only when the maximum value of static friction comes into play.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (2)

QUESTION-111 (Assertion and Reason)

Assertion: The work done in bringing a body down from the top to the base along a frictionless inclined plane is the same as the work done in bringing it down the vertical side.

Reason: The gravitational force on the body along the inclined plane is the same as that along the vertical side.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

QUESTION-112 (Assertion and Reason)

Assertion: On a rainy day, it is difficult to drive a car or bus at high speed.

Reason: The value of coefficient of friction is lowered due to wetting of the surface.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-113 (Assertion and Reason)

Assertion: When a bicycle is in motion, the force of friction exerted by the ground on the two wheels is always in the for- ward direction.

Reason: The frictional force acts in the direction of motion of the bicycle.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (4)

QUESTION-114 (Assertion and Reason)

Assertion: Angle of repose is equal to angle of limiting friction.

Reason: When the body is just at the point of motion, the force of friction at this stage is called limiting friction.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (2)

QUESTION-115 (Assertion and Reason)

Assertion: Friction is a self-adjusting force.

Reason: does not depend upon the mass of the body.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (4)

QUESTION-116 (Assertion and Reason)

Assertion: Pulling a lawn roller is easier than pushing it.

Reason: Pushing increases the apparent weight and hence the force of friction.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-117 (Assertion and Reason)

Assertion: The value of dynamic friction is less than the limit- ing friction.

Reason: Once the motion has started, the inertia of rest has been overcome.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-118 (Assertion and Reason)

Assertion: When two surfaces are highly polished, the coefficient of friction between them increases.

Reason: When two surfaces are highly polished, intermolecular forces come into play and increase friction,

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (1)

QUESTION-119 (Assertion and Reason)

Assertion: Coefficient of friction can be greater than unity.

Reason: Force of friction is dependent on normal reaction and ratio of frictional force and normal reaction cannot exceed anity.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-120 (Assertion and Reason)

Assertion: Coefficient of friction can be greater than unity.

Reason: Force of friction is dependent on normal reaction and ratio of frictional force and normal reaction cannot exceed anity.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-121 (Assertion and Reason)

Assertion: In tug of war, the team which presses ground hard has probability to win.

Reason: The team which presses ground hard has less frictional force.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-122 (Assertion and Reason)

Assertion: If a body on a rough surface has acceleration in the forward direction, it may experience frictional force in the forward direction.

Reason: Motion is in the direction of acceleration.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (4)

QUESTION-123 (Assertion and Reason)

Assertion: Friction force between tyres and road is independent of normal speed of automobile.

Reason: Coefficient of friction is independent of normal speed.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (1)

QUESTION-124 (Assertion and Reason)

Assertion: Force of friction always opposes relative motion.

Reason: Friction force is a contact force.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (1)

QUESTION-125 (Assertion and Reason)

Assertion: Frictional forces are conservative forces.

Reason: Potential energy can be associated with frictional forces.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (4)

QUESTION-126 (Assertion and Reason)

Assertion: It is difficult to move a cycle along the road with its brakes on.

Reason: Sliding friction is greater than rolling friction.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-127 (Assertion and Reason)

Assertion: A massless inextensible string passes over a frictionless light pulley. The tension on both the sides of the string will be different.

Reason: The acceleration of the blocks connected to both the ends of strings is different.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (4)

QUESTION-128 (Assertion and Reason)

Assertion: Static friction is a self-adjusting force.

Reason: The direction of static frictional force is opposite to the tendency of relative motion.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (2)

QUESTION-129 (Assertion and Reason)

Assertion: Practically, force is required to make a body move with uniform speed along a straight line on a surface.

Reason: Force of friction has to be neutralised.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (1)

QUESTION-130 (Assertion and Reason)

Assertion: A car accelerates forward because of the force of friction.

Reason: Engine converts heat energy into useful work which rotates the wheels.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-131 (Assertion and Reason)

Assertion: Proper use of lubricants cannot reduce inertia.

Reason: Proper use of lubricants reduces friction.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (2)

QUESTION-132 (Assertion and Reason)

Assertion: Value of frictional force as seen from an inertial frame for a pair of solids, may change if it is observed from a non-inertial frame.

Reason: Coefficient of friction u depends on the frame of reference.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (3)

QUESTION-133 (Assertion and Reason)

Assertion: Friction may help in the motion of a body.

Reason: Friction is an electromagnetic force.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (2)

QUESTION-134 (Assertion and Reason)

Assertion: When two surfaces are highly polished, the coefficient of friction between them increases.

Reason: When two surfaces are highly polished, intermolecular forces come into play and increase friction,

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-135 (Assertion and Reason)

Assertion: Wheels of automobiles are made circular in shape.

Reason: Rolling friction is the least among all type of frictions.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-136 (Assertion and Reason)

Assertion: Without friction between our feet and the ground, it will not be possible to walk.

Reason: Frictional force is necessary to start motion.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-137 (Assertion and Reason)

Assertion: Force is required to move a body uniformly along a circle.

Reason: When the motion is uniform, acceleration is zero.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (2)

QUESTION-138 (Assertion and Reason)

Assertion: Linear momentum of a body changes even when it is moving uniformly in a circle.

Reason: In uniform circular motion, velocity remains constant.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-139 (Assertion and Reason)

Assertion: Linear momentum of a body changes even when it is moving uniformly in a circle.

Reason: Force required to move a body uniformly along a straight line is zero.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (2)

QUESTION-140 (Assertion and Reason)

Assertion: If the speed of a body is constant, the body can have a path other than a circular or straight line path.

Reason: It is not possible for a body to have a constant speed in an accelerated motion.

(1) If both A and R are true and reason is the correct explanation of assertion.

(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

Ans: (3)

QUESTION-141 (Assertion and Reason)

Assertion: A cyclist always bends inwards while negotiating a curve.

Reason: By bending, cyclist lowers his centre of gravity.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (3)

QUESTION-142 (Assertion and Reason)

Assertion: A cyclist negotiating a sharp turn is a non-inertial observer.

Reason: The accelerating frames are non-inertial frames of reference.

1. If both A and R are true and reason is the correct explanation of assertion.
2. If both A and R are true but reason is not the correct explanation of assertion.
3. If assertion is true but reason is false.
4. If both assertion and reason are false.

Ans: (1)

QUESTION-143 (Assertion and Reason)

Assertion: An electric fan continues to rotate for some time after the current is switched off.

Reason: Inertia of rest is more than inertia of motion.

(1) If both A and R are true and reason is the correct explanation of assertion.

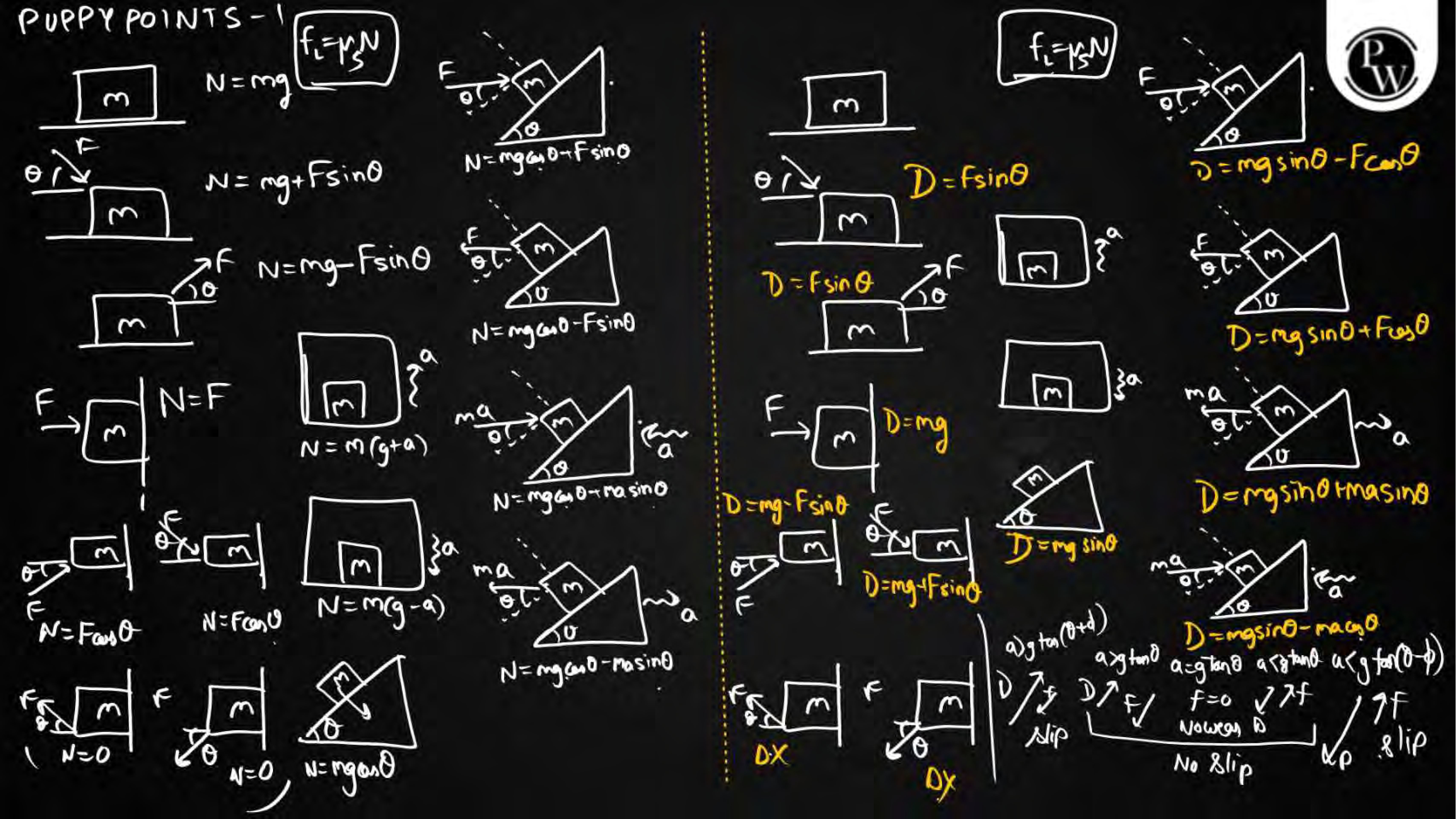
(2) If both A and R are true but reason is not the correct explanation of assertion.

(3) If assertion is true but reason is false.

(4) If both assertion and reason are false.

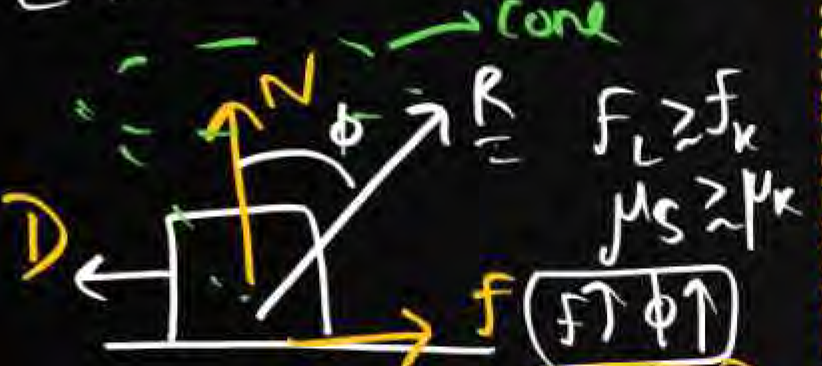
Ans: (2)

Part 19 – Revision and PUPPY POINTS


PUPPY POINTS - 1
f_L = μ_s N
N = mg
N = mg cos θ + F sin θ
N = mg + F sin θ
N = mg − F sin θ
N = mg cos θ − F sin θ
N = F
N = m(g + a)
N = mg cos θ + ma sin θ
N = F cos θ
N = F cos θ
N = m(g − a)
N = mg cos θ − ma sin θ
N = 0
N = 0
N = mg cos θ
f_L = μ_s N
D = mg sin θ − F cos θ
D = F sin θ
D = F sin θ
D = mg sin θ + F cos θ
D = mg
D = mg sin θ + ma sin θ
D = mg − F sin θ
D = mg + F sin θ
D = mg sin θ
D = mg sin θ − ma cos θ
DX
DX
a ≥ g tan(θ + α)
D ↗ f ↙ slip
a > g tan θ
D ↗ f ↙
a = g tan θ
f = 0
a < g tan θ
↙ ↗ f
Nowear D
No slip
a < g tan(θ − φ)
↗ f
↙ D
slip

PUPPY POINTS - 2

f opposes rel. motion
f jitni jarurat utna



$f_L \geq f_k$

$\mu_s \geq \mu_k$

$f \uparrow \ \phi \uparrow$

Angle of $F_r = \phi$

$f = 0, N = R$

$R\cos\phi = N$

$R\sin\phi = f$

$\tan\phi = \dfrac{f}{N}$

$R = \sqrt{N^2 + f^2}$

For Limiting f

$\tan\phi = \mu$

$\tan\theta = \mu$

$F_{min} = \dfrac{\mu mg}{\sqrt{1+\mu^2}} = mg\sin\theta$

Stopping Distance & Time

$s = \dfrac{v^2}{2a}$ $\quad T = \dfrac{v}{a}$

$s = \dfrac{v^2}{2\mu g}$ $\quad T = \dfrac{v}{\mu g}$

$s = \dfrac{v^2}{2(\mu g\cos\theta - g\sin\theta)}$

$T = \dfrac{v}{(\mu g\cos\theta - g\sin\theta)}$

Angle of Repose

Just ... $\quad$ v constant

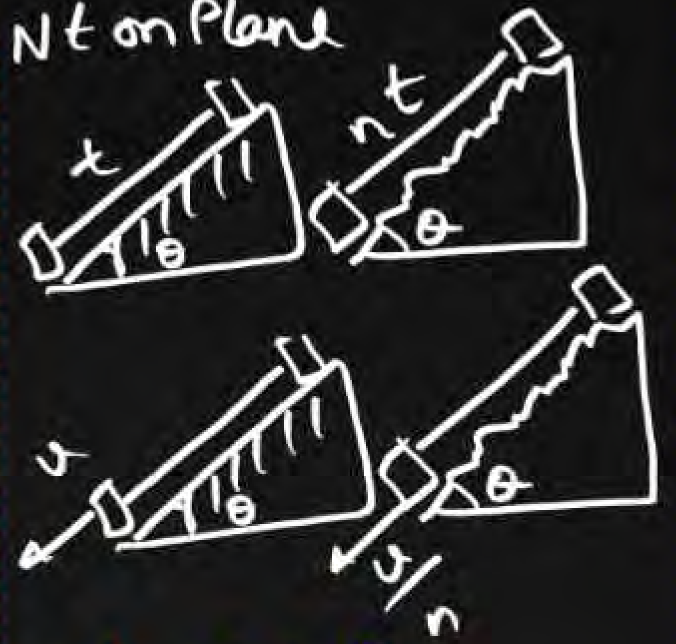
$\mu_s = \tan\phi$ $\quad \mu_k = \tan\phi$

Latkamass

$\mu = \dfrac{\text{Latka}}{\text{Betha}} = \dfrac{L}{B}$

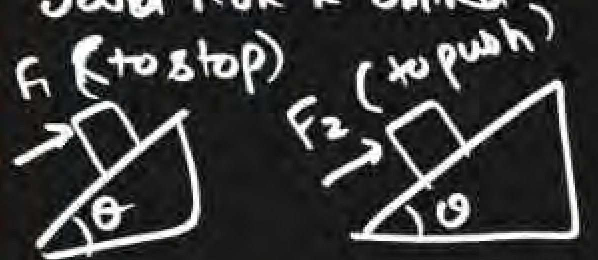
$\%\text{Latka} = \dfrac{\mu}{1+\mu} \times 100\%$

N t on Plane



$\mu = \left(1 - \dfrac{1}{n^2}\right)\tan\theta$

Jana Rok k Dhika



$F_2 = nF_1$ $\quad \mu = \tan\theta\left(\dfrac{n-1}{n+1}\right)$

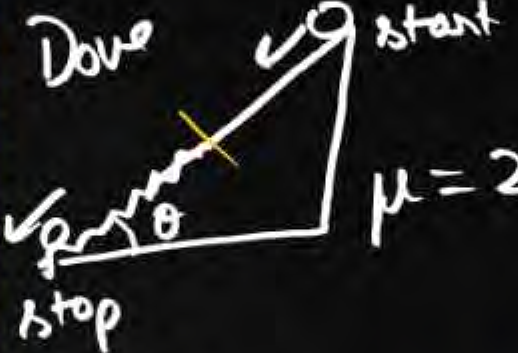
$F_1 + F_2 = 2mg\sin\theta$ $\quad F_1 - F_2 = 2\mu mg\cos\theta$

$\mu_s \rightarrow$ Just about to move

$\mu_k \rightarrow$ moving (v, a)

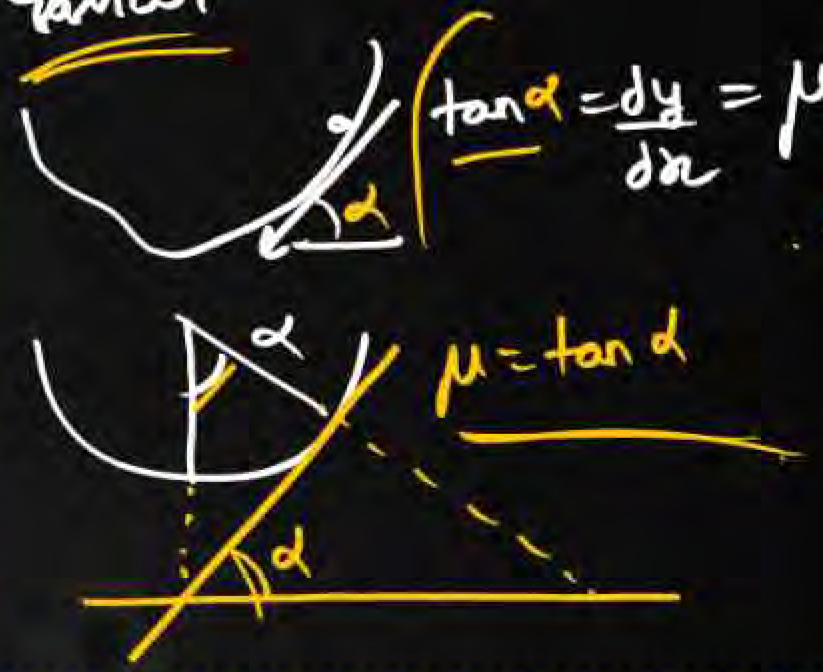
$f_L = \mu_s N$, $\quad f_k = \mu_k N$ $\quad \mu_s \geq \mu_k$

Dove



$\mu = 2\tan\theta$

Sattar

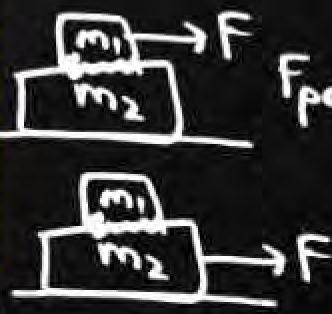


$\tan\alpha = \dfrac{dy}{dx} = \mu$

$\mu = \tan\alpha$

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

$T = \dfrac{m_1 m_2 g}{m_1 + m_2}(1 + \mu_k)$



$F_{papa} = \mu\left(\dfrac{m_1}{m_2}\right)(m_1 + m_2)g$

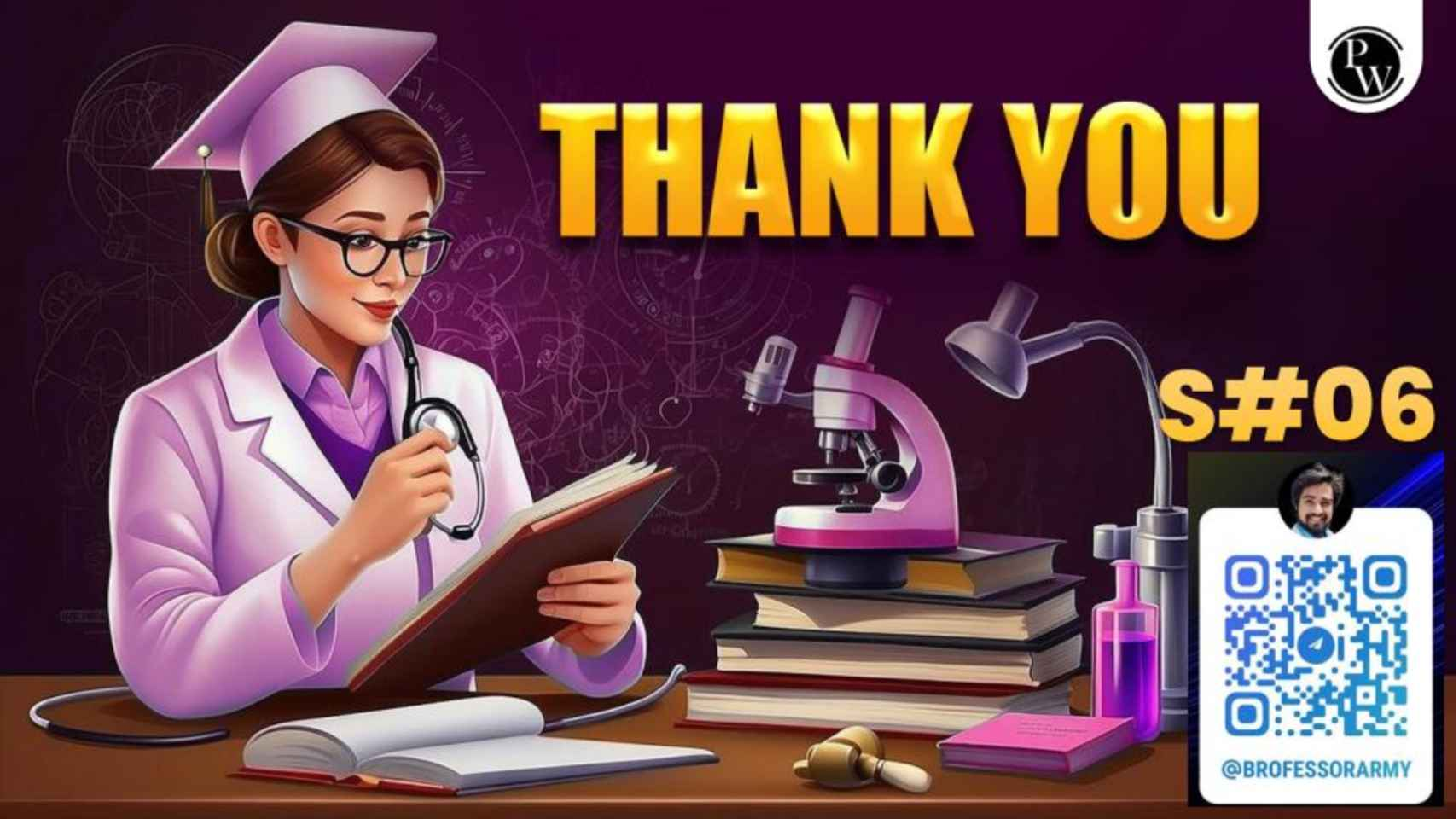
$F_{papa} = \mu(m_1 + m_2)g$

$F < F_{papa}$

$a = F/(m_1 + m_2)$

$F > F_{papa}$

Seperate a


THANK YOU
S#06
@BROFESSORARMY