Date: 24/08/2022

Subject: Physics

Class: Standard XI

Topic : Friction

Time: 00:20 hrs

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

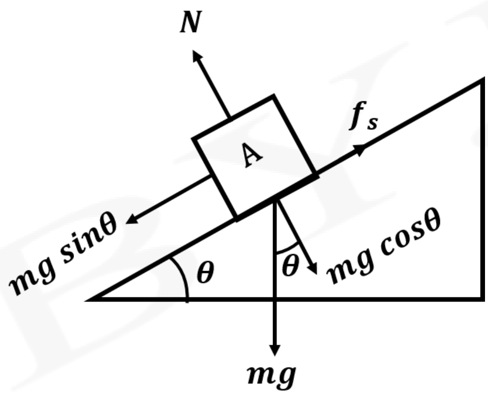
   A. 30°

   B. 45°

   C. 60° ✓

   D. 75°

$I-$ Method



The block will have force $mg \sin \theta$ along the incline plane and the frictional force will have $f_s = \mu N$

where $N = mg \cos \theta$

$f_s = mg \sin \theta$

For equilibrium

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

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

$\theta = 60^\circ$

$II-$ Method

This is the case of angle of repose. Angle of repose is defined as the minimum angle of the inclined plane and we have the formulae as $\tan \theta = \mu$ by putting the value of $\mu = \sqrt{3}$ we get $\theta = 60^\circ$

2. A body of mass $2 \mathrm{~kg}$ is kept on a rough horizontal surface. If $\mu_s = 0.5$ and an external force of $F = 5 \mathrm{~N}$ is applied on the body, find the angle of friction. (Take $g = 10 \mathrm{~m/s^2}$)

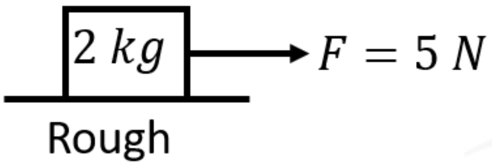
A. $\tan^{-1}\left(\frac{1}{2}\right)$ ✔

B. $\tan^{-1}(2)$ ✘

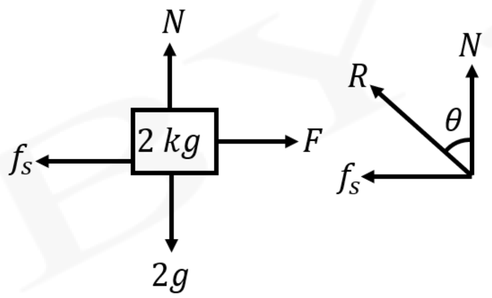
C. $\cot^{-1}(2)$ ✘

D. $\cot^{-1}\left(\frac{1}{2}\right)$ ✘

The given situation can be shown as



The FBD of the block is

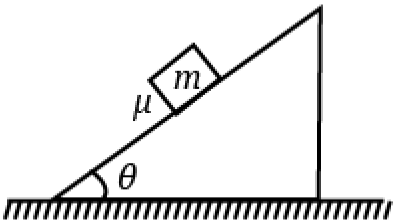


We have angle of friction as

$$\tan\theta = \frac{f_s}{N} = \frac{\mu_s mg}{mg} = \mu_s$$

$$\Rightarrow \theta = \tan^{-1}(0.5)$$

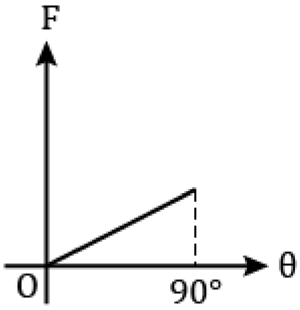
3. A body is placed on an inclined plane. The coefficient of friction between the body and the plane is μ. The plane is gradually tilted up. If θ is the inclination of the plane, then frictional force on the body is

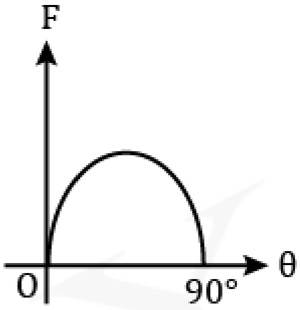


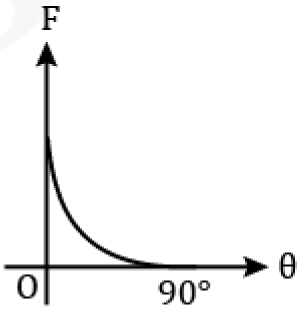
- ✗ **A.** constant upto $\theta = \tan^{-1}(\mu)$ and decrease after that
- ✓ **B.** increases upto $\theta = \tan^{-1}(\mu)$and decrease after that
- ✗ **C.** decreases upto $\theta = \tan^{-1}(\mu)$ and constant after that
- ✗ **D.** Increases upto $\theta = \tan^{-1}(\mu)$ and constant after that

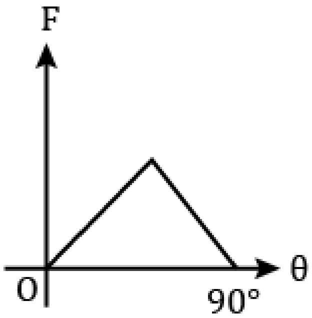
As θ increases, frictional force $(f = mg\sin\theta)$ will increase upto limiting value i.e. $\theta = \tan^{-1}(\mu)$
Here, from the FBD of block we can say that
$N = mg\cos\theta$, After limiting value, while θ will increase, the value of $\cos\theta$ will decrease which will result in decreasing the normal value and simultaneously the frictional force value.
Hence, the frictional force on the body will decrease after $\theta = \tan^{-1}(\mu)$

4. A block rests on a rough plane whose inclination θ to the horizontal can be varied. Which of the following graphs indicates how the frictional force F between the block and the plane varies as θ is increased?

A.


B. ✔


C.


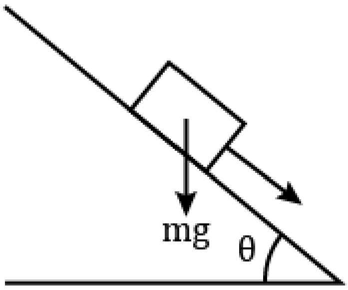
D.


When the plane is horizontal there will be no frictional force acting as there will be no driving force. The maximum angle for the which the block remains stationary is called the angle of repose

Let $\alpha =$ angle of repose
For $\theta \leq \alpha$, block is stationary and force of friction,
$f = mg\sin\theta$
or $f \propto \sin\theta$
i.e., it is sine graph
For $\theta \geq \alpha$ Block slides downwards
$\therefore f = \mu mg\cos\theta$
or $f \propto \cos\theta$
i.e, now it is cosine graph.

Hence option b will be the correct answer

5. 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 $4.0 \mathrm{~m}$ down the plank in $4.0 \mathrm{~s}$. The coeffficient of static and kinetic friction between the box and the plank will respectively be



A. 0.4 and 0.3

B. 0.6 and 0.6

C. 0.6 and 0.5

D. 0.5 and 0.6

Static friction
$\mu_s=\tan \theta$ [θ-At which it starts to slide]
$\mu_s=\tan 30^{\circ}=\frac{1}{\sqrt{3}}=0.6$
Now as the body slips down, acceleration $=g \sin \theta-\mu_k g \cos \theta$
$=g \sin 30^{\circ}-\mu_k g \cos 30^{\circ}$
$s=u t+\frac{1}{2} a t^2$
$4=0+\frac{1}{2}\left[g\left(\frac{1}{2}\right)-\frac{\mu \times g \sqrt{3}}{2}\right] t^2$
$4=\frac{1}{2}\left[\frac{g}{2}-\frac{\mu_k g \sqrt{3}}{2}\right] 16$
$\frac{1}{2}=\frac{1}{2}(g)[1-\sqrt{3} \mu_k]$
$1-\sqrt{3} \mu_k=\frac{1}{10}$
$1-\sqrt{3} \mu_k=0.1$
$\mu_k=\frac{0.9}{\sqrt{3}}=0.52$