FRICTION

PREVIOUS EAMCET QUESTIONS

ENGINEERING

1. A bullet of mass 0.02 kg traveling horizontally with velocity $250ms^{-1}$ strikes a block of wood of mass 0.23 kg which rests on a rough horizontal surface. After the impact, the block and bullet move together and come to rest after traveling a distance of 40m. The coefficient of sliding friction of the rough surface is : ($g = 9.8ms^{-2}$) **(2009 E)**

1) 0.75 2) 0.61 3) 0.51 4) 0.30

Ans : 3

Sol: After the collision the bullet and block move combinedly and comes to rest after covering a distance of 40m.

From law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 0.02 \times 250 + 0.23 \times 0 = (0.02 + 0.23)\, v$$

$$\Rightarrow v = \frac{500}{25} = 20ms^{-1}$$

From law of conservation of energy

$$\Rightarrow \frac{1}{2}Mv^2 = \mu(Mg)S$$

$$\Rightarrow \frac{1}{2} \times 0.25 \times 400 = \mu \times 0.25 \times 9.8 \times 40$$

$$\Rightarrow \mu = 0.51$$

2. Starting from rest, the time taken by a body sliding down on a rough inclined plane at 45^0 with the horizontal is, twice the time taken to travel on a smooth plane of same inclination and same distance. Then the coefficient of kinetic friction is **(2008 E)**

1) 0.25 2) 0.33 3) 0.50 4) 0.75

Ans : 4

Sol: Time taken to travel from the top to bottom of rough inclined plane

$$t_R = \sqrt{\frac{2L}{g(\sin\theta - \mu\cos\theta)}} \quad \text{……………….(1)}$$

Time taken to travel from the top to bottom of smooth inclined plane

$$t_S = \sqrt{\frac{2L}{g\sin\theta}} \quad \text{………………………..….(2)}$$

Given $t_R = 2t_S$

$$\Rightarrow \sqrt{\frac{2L}{g(\sin\theta - \mu\cos\theta)}} = 2\sqrt{\frac{2L}{g\sin\theta}}$$

Squaring on both sides

$$4[\sin\theta - \mu\cos\theta] = \sin\theta$$

$$3\sin\theta = 4\mu\cos\theta$$

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

$$\mu = 0.75$$

3. When the angle of inclination of an inclined plane is θ, an object slides down with uniform velocity. If the same object is pushed up with an initial velocity u on the same inclined plane; it goes up the plane and stops at a certain distance on the plane. Thereafter the body: **(2006 E)**

1. slides down the inclined plane reaches the ground with velocity 'u'
2. slides down the inclined plane and reaches the ground with velocity less than 'u'
3. slides down the inclined plane and reaches the ground with velocity greater than 'u'
4. stays at rest on the inclined plane and will not slide down

Ans:4

Sol: We know that $\mu = \tan\theta$

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

$$o^2 - u^2 = -2g\left[\sin\theta + \mu\cos\theta\right]l$$

$$u^2 = 2gl\left[\sin\theta + \mu\cos\theta\right]$$

$$u^2 = 2gl\left[\sin\theta + \tan\theta.\cos\theta\right]$$

$$\Rightarrow u^2 = 4gl\sin\theta$$

From here it will not slide down

4. The minimum force required to move a body up an inclined plane is three times the minimum force required to prevent it from sliding down the plane. If the coefficient of friction between the body and the inclined plane is $\frac{1}{2\sqrt{3}}$, the angle of the inclined plane is [2005 E]

1. 60º 2. 45º 3. 30º 4.15º

Ans : 3

Sol: Minimum force required to move a body up an inclined plane $mg\left[\sin\theta + \mu\cos\theta\right]$

Minimum force required to prevent it from sliding down the plane

$$= mg\left[\sin\theta - \mu\cos\theta\right]$$

but given $mg\left[\sin\theta + \mu\cos\theta\right] = 3\,mg\left[\sin\theta - \mu\cos\theta\right]$

on solving $\theta = 30^0$

5. Consider the following statements A and B and identify the correct answer:**(2004 E)**

A: When a person walks on a rough surface the direction of frictional force exerted by the surface on the person is opposite to the direction of his motion.

B: When a cycle is in motion, the force of friction exerted by the ground on the front wheel is in the backward direction.

1. A and B are correct 2. A is correct B is wrong
3. A and B are wrong 4. A is wrong B is correct

Ans: 4

Sol: A) When a person walks on a rough surface the direction of frictional force exerted by the surface on the person is in the same direction of his motion but not in the opposite direction.

b) When a cycle is in motion, the force of friction exerted by the ground on the front wheel in the backward direction.

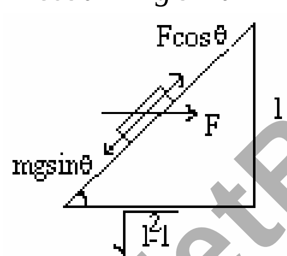
6. The horizontal acceleration that should be given to a smooth inclined plane of angle $\sin^{-1}\left(\frac{1}{l}\right)$ to keep an object stationary on the plane, relative to the inclined plane is

[2003 E]

1) $\frac{g}{\sqrt{l^2-1}}$ 2) $g\sqrt{l^2-1}$ 3) $\frac{\sqrt{l^2-1}}{g}$ 4) $\frac{g}{\sqrt{l^2+1}}$

Ans : 1

Sol: from the figure : $F\cos\theta = mg\sin\theta$



but F = ma

$\therefore ma\cos\theta = mg\sin\theta$

a =g tan θ = $\frac{g}{\sqrt{l^2-1}}$

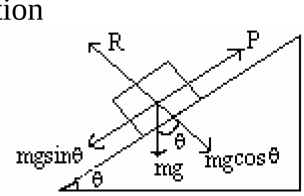
7. A body is moving up an inclined plane of angle θ with an initial kinetic energy E. The coefficient of friction between the plane and the body is μ. The work done against friction before the body comes to rest is **[2002E]**

1) $\frac{\mu\cos\theta}{E\cos\theta+\sin\theta}$ 2) 2μE Cosθ 3) $\frac{\mu E\cos\theta}{\mu\cos\theta-\sin\theta}$ 4) $\frac{\mu E\cos\theta}{\mu\cos\theta+\sin\theta}$

Ans: 4

Sol: acceleration of a body moving up the rough inclined plane is $a = g\left[\sin\theta+\mu\cos\theta\right]$

From equation of motion



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

$$\Rightarrow o^2 - u^2 = -2as$$
$$\Rightarrow u^2 = 2as \text{ ....(1)}$$

Initial KE, $E = \frac{1}{2}mu^2$ ....(2)

$$E = \frac{1}{2}m(2as)$$
$$\therefore S = \frac{E}{ma} = \frac{E}{mg[\sin\theta + \mu\cos\theta]}$$

We know that work done W = F.S

$$\therefore W = (\mu_k\, mg\cos\theta).S$$
$$\therefore W = \mu\, mg\cos\theta.\frac{E}{mg[\sin\theta + \mu\cos\theta]}$$
$$\therefore W = \frac{\mu E\cos\theta}{\mu\cos\theta + \sin\theta}$$

8. A body is sliding down a rough inclined plane. The coefficient of friction between the body and the plane is 0.5. The ratio of the net force required for the body to slide down and the normal reaction on the body is 1:2. Then, the angle of the inclined plane is **[2002 E]**

1. 15º 2.30º 3.45º 4.60º

Ans : 3

Sol: Given $\frac{F}{R} = \frac{1}{2}$, $\mu = 0.5$

F = mg $(\sin\theta - \mu\cos\theta)$ = Net force acting down ward

R = Normal reaction = mg $\cos\theta$

$$\therefore \frac{mg(\sin\theta - \mu\cos\theta)}{mg\cos\theta} = \frac{1}{2}$$

On solving $\theta = 45^0$

9. A body of weight "64 N" is pushed with just enough force to start it moving across a horizontal floor and the same force continues to act afterwards. If the coefficients of static and dynamic friction are 0.6 and 0.4 respectively. The acceleration of the body will be (acceleration due to gravity = g) [2001-E]

1) $\frac{g}{2}$ 2) 0.64g 3) $\frac{g}{32}$ 4) 0.2g

Ans : 4

Sol: acceleration of the body = $(\mu_S - \mu_K)g$

$= (0.6 - 0.4) \times g$

= 0.2 g

10. A particle is projected up along a rough plane of inclination 45º with the horizontal. If the coefficient of friction is 0.5, the retardation is (g = acceleration due to gravity)

[2001-E]

1) $\frac{g}{2}$ 2) $\frac{g}{2\sqrt{2}}$ 3) $\frac{3g}{2\sqrt{2}}$ 4) $\frac{g}{\sqrt{2}}$

Ans : 3

Sol: acceleration of an object up a rough inclined

plane = a = $g\left(\sin\theta+\mu\cos\theta\right)$

$$= g\left(\sin 45^0+\frac{1}{2}\cos 45^0\right)$$

$$= g\left(\frac{1}{\sqrt{2}}+\frac{1}{2\sqrt{2}}\right)$$

$$= \frac{3g}{2\sqrt{2}}$$

11. A body is sliding down an inclined plane having coefficient of friction 0.5. If the normal reaction is twice that of the resultant downward force along the incline, the angle between the inclined plane and horizontal is [2000 E]

1. 15º 2. 30º 3. 45º 4. 60º

Ans: 3

Sol: Given N = 2F

$$mg\cos\theta = 2mg\left(\sin\theta-\mu\cos\theta\right)$$

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

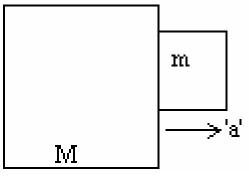
$$2\sin\theta = \cos\theta+2\times 0.5\times\cos\theta$$

$$2\sin\theta = 2\cos\theta$$

$$\tan\theta = 1 \;\Rightarrow\; \theta = 45^0$$

MEDICAL

12. Consider a mass 'M' moving in the positive X-direction with an acceleration 'a' as shown below. The minimum acceleration needed to hold a smaller mass 'm' stationary with respect to 'M' on the vertical side on M is : (Assume that the surfaces of M and m in contact are rough) **(2009 M)**



1) $\frac{g}{m}$ 2) $\frac{g}{M}$ 3) 3g 4) $\frac{g}{\mu}$

Ans : 4

Sol: Frictional force = f = mg, F = ma = N

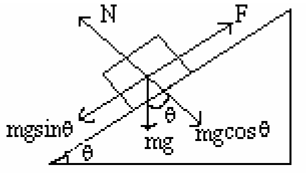
$\therefore$ f = μN $\Rightarrow$ mg = μma $\Rightarrow$ a = $\frac{g}{\mu}$

13. A body of mass 'm' is placed on a rough wooden plank.. One end of the wooden plank raised from the surface of horizontal plane keeping other end in contact with the surface. The body just starts slide down when angle of the plank with horizontal is 30^0. At that instant how much force parallel to the plank is required to stop the slides down of the mass? **(2008 M)**

1) mg 2) $\frac{mg}{2}$ 3) $\frac{\sqrt{m}}{2}mg$ 4) $\frac{1}{\sqrt{3}}mg$

Ans : 2

Sol:



From the figure

Force required to stop the body = mg sin θ

= mg $\sin 30^0$

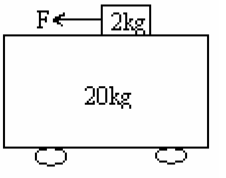
= $\frac{mg}{2}$

14. A block of 2kg is placed on the surface of a trolley of mass 20kg which is on a smooth surface. The value of $\mu = 0.25$. If a horizontal force 2N acts on the block, the acceleration of the system is ($g=10ms^{-2}$) **(2007 M)**

1.0.04 ms^{-2} 2. 0.02 ms^{-2} 3. 0.01 ms^{-2} 4. 0.09 ms^{-2}

Ans:4

Sol: F L = the force of limiting friction between the block and trolley = μmg



= $0.25 \times 2 \times 10$

= 5N

But applied force = 2N

As F < F_L

$\therefore$ both will move together with same acceleration

$\therefore\ a = \frac{2}{20+2} = \frac{2}{22}$ = $0.09ms^{-2}$

15. A block of wood resting on an inclined plane of angle 30^0, just starts moving down. If the coefficient of friction is 0.2, its velocity (in ms^{-1}) after 5 seconds is : ($g=10ms^{-2}$)

[2006 M]

1. 12.75 2. 16.35 3. 18.25 4. 20

Ans : 2

Sol: From $V = u + at \;\Rightarrow V = at$ as u = 0

$$\therefore \text{ v} = \left[g\left(\sin\theta - \mu\cos\theta\right)\right]t$$

$$= 10\left[\sin 30^0 - \frac{1}{5}\cos 30^0\right]\times 5$$

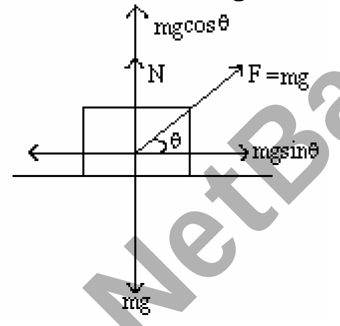
$$= 16.35 \text{ ms}^{-1}$$

16. A cubical block of mass 'm' rests on a rough horizontal surface 'μ' is the coefficient of static friction between the block and the surface. A force mg acting on the cube at an angle 'θ' with the vertical side of the cube pulls the block. If the block is to be pulled along the surface then the value cot (θ/2) is **(2005 M)**

1. Less than μ 2. Greater than μ 3. *Equal to* μ 4. Not dependent on μ

Ans: 2

Sol: If mg sin θ >f then the block moves along the horizontal surface.



Frictional force = f = μN

But N + mg cos θ = mg $\Rightarrow$ N = mg [1- cosθ]

$$\therefore \text{ f} = \mu mg\left(1-\cos\theta\right)$$

$$\Rightarrow mg\sin\theta > \mu mg\left[1-\cos\theta\right]$$

$$\Rightarrow 2\sin\frac{\theta}{2}\cos\frac{\theta}{2} > \mu\sin^2\frac{\theta}{2}$$

$$\therefore \cot\frac{\theta}{2} > \mu$$

17. The minimum force required to move a body up an inclined plane of inclination 300 is found to be thrice the minimum force required to prevent it from sliding down the plane. The coefficient of friction between the body and the plane is **[2004 E]**

1) $\frac{1}{\sqrt{3}}$ 2) $\frac{1}{2\sqrt{3}}$ 3) $\frac{1}{3\sqrt{3}}$ 4) $\frac{1}{4\sqrt{3}}$

Ans : 2

Sol: Force required to move a body up an inclined plane = $mg\left[\sin\theta + \mu\cos\theta\right]$

Force required to move a body down an inclined plane = $\therefore mg\left[\sin\theta - \mu\cos\theta\right]$

$$\therefore mg\left[\sin\theta + \mu\cos\theta\right] = 3mg\left[\sin\theta - \mu\cos\theta\right]$$

$$\therefore \mu = \frac{\tan\theta}{2} = \frac{\tan 30^0}{2} = \frac{1}{2\sqrt{3}}$$

18. A horizontal force, just sufficient to move a body of mass 4k gms lying on a rough horizontal surface is applied on it. The coefficients of static and kinetic friction between the body and the surface are 0.8 and 0.6 respectively. If the force continues to act even after the block has started moving, the acceleration of the block in metres per Sec^2 is ($g=10m/s^2$) **[2003 E]**

1) $\frac{1}{4}$ 2) $\frac{1}{2}$ 3) 2 4) 4

Ans: 3

Sol: The static frictional force F = $\mu_s mg$ ……………..(1)

$F - \mu_k mg = ma$ …………..(2)

Sub (1) in (2)

$\mu_s mg$ - $\mu_k mg = ma$

$\therefore$ a = $(\mu_s - \mu_k)g$

= (0.8-0.6)10 = $2ms^{-2}$

19. A body moves along a circular path of radius 5m. The coefficient of friction between the surface of the path and body is 0.5. The angular velocity, in rad/s with which the body should move so that it does not leave the path is (g = $10m/s^2$)

[2002 – M]

1. 4 2. 3 3. 2 4. 1

Ans : 4

Sol: Centripetal force = Frictional force

$mr\omega^2 = \mu kg$

$\omega = \sqrt{\frac{\mu g}{r}}$

$= \sqrt{\frac{(0.5)(10)}{5}}$ = 1 $rads^{-1}$

20. A block of weight 200N is pulled along a rough horizontal surface at constant speed by a force 100N acting at an angle 30º above the horizontal. The coefficient of kinetic friction between the block and the surface is [2001 – M]

1. 0.43 2.0.58 3.0.75 4.0.83

Ans : 2

Sol: Normal reaction acting on the body

R = mg –F sinθ = 200 – 50 = 150 N

$\therefore$ Force on friction f = $\mu R = \mu$ (150)

But f = F cosθ

$$\mu(150) = 50\sqrt{3}$$

$$\Rightarrow \mu = \frac{1}{\sqrt{3}} = 0.58$$

21. Consider the following two statements A and B, and identify the correct choice in the given answer

A. For a body resting on a rough horizontal table, it is easier to pull at an angle than push at the same angle to cause motion

B. A body sliding down a rough inclined plane of inclination equal to angle of friction has non–zero acceleration [2001 – M]

1. Both A & B are true
2. A is true but B is false
3. A is false but B is true
4. Both A & B are false

Ans : 2

Sol: A) It is easier to pull at an angle than push at the same angle to cause the motion. This is because the normal reaction in pulling is less than in pushing

B) If angle of inclination is equal to angle of friction then the body moves down with zero acceleration.

22. A body of mass 5kg rests on a rough horizontal surface of coefficient of friction 0.2. The body is pulled through a distance of 10m by a horizontal force 25N. The K.E. acquired by it is [2000 – E] 1. 200J

2. 150J 3.100J 4.50J

Ans: 2

Sol: From work – energy theorem

K.E = work done = (F-f)s but f = μmg

= [F - $\mu(mg)$]s

= [25 –(0.2)(5)(10)]10

= 150 J

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