Inclined Plane

1. A given object takes n times as much time to slide down a 45^0 rough inclined plane as it takes to slide down a perfectly smooth 45^0 incline. The coefficient of kinetic friction between the object and the incline is

(1) $1-\frac{1}{n^2}$ (2) $\frac{1}{1-n^2}$ (3) $\sqrt{1-\frac{1}{n^2}}$ (4) $\sqrt{\frac{1}{1-n^2}}$

2. A block of mass M is resting on an inclined plane. When the angle of inclination is gradually increased to θ, the block just begins to slide down the plane. What minimum force applied parallel to the plane on the block would just make the block move up the plane?

(1) $Mg\sin\theta$ (2) $Mg\cos\theta$ (3) $2Mg\cos\theta$ (4) $2Mg\sin\theta$

3. A cylinder rolls up an inclined plane, reaches some height and then rolls down (without slipping through out these motions). The directions of frictional force acting on the cylinder are

1) Up the incline while ascending and down the incline while descending

2) Up the incline while ascending as well as descending

3) Down the incline while ascending and up the incline while descending

4) Down the incline while ascending as well as descending

4. Consider the following A and B, and identify the correct choice in the given answers.

A) For a body resting on a rough horizontal table, it is easier to pull at angle that pushes 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.

1) Both A and B are true.

2) A is true but B is false.

3) A is false but B is true.

4) Both A and B are false.

5. (A): The time of ascent for a body projected to move up a rough inclined plane is less than the time of descent.

(R): The retardation for upward motion is more than the acceleration for downward motion.

(1) Both (A) and (R) are true and (R) is the correct explanation of (A).

(2) Both (A) and (R) are true and (R) is not the correct explanation of (A).

(3) (A) is true but (R) is false.

(4) (A) is false but (R) is true.

6. A block is pushed up a rough inclined plane of 45°. If the time of descent is twice the time of ascent, the coefficient of friction is

1) 0.6 2) 0.4 3) 0.5 4) 0.2

7. 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 co-efficient of friction between the body and inclined plane is $\frac{1}{2\sqrt{3}}$, the angle of inclined plane is

1) 60° 2) 45° 3) 30° 4) 15°

8. A block slides down a rough inclined plane of slope angle with constant velocity. It is then projected up the same plane with an initial velocity v. The distance travelled by the block up the plane before coming to rest is,

1. $\frac{v^2}{4g\sin\theta}$ 2. $\frac{v^2}{2g\sin\theta}$ 3. $\frac{v^2}{g\sin\theta}$ 4. $\frac{4gv^2}{\sin\theta}$

9. Sand is piled up on a horizontal ground in the form of a regular cone of a fixed base radius R. The coefficient of static friction between sand layers is μ. The maximum volume of sand that can be piled up, without the sand slipping on the surface is

1) $\frac{\mu R^3}{3\pi}$ 2) $\frac{\mu R^3}{3}$ 3) $\frac{\pi R^3}{3\mu}$ 4) $\frac{\mu \pi R^3}{3}$

10. 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 body is m. The work done against friction before the body comes to rest is (2002 E)

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

11. A block of mass 2kg is lying on an inclined plane at an angle of 30^0 with the horizontal the coefficient of friction between the block and the plane is 0.7 the frictional force acting on the inclined plane will be

(1) Zero (2) 9.8N (3) 9.8 x $\sqrt{3}$ N (4) 9.8 x 0.7x $\sqrt{3}$ N

12. An object of mass 2kg slides down an inclined plane which makes an angle of 30^0 with the horizontal. The coefficient of friction between the object and the surface is $\sqrt{\frac{3}{2}}$ the force applied to the object so that the object moves down on the surface with a uniform speed is

(1) 11.2N (2) 15N (3) 5N (4) None

13. A particle is projected up a 45^0 rough incline with a velocity 'v'. The coefficient of friction is 0.5 the speed with which it returns back to the straight point is v^1 then $\frac{v^1}{v}$ is

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

14. A body slides down a rough inclined plane of angle of inclination 30⁰ and takes times twice as great as the time taken in slipping down a similar frictionless plane. The coefficient of friction between the body and the plane is

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

15. A body slides down a rough inclined plane of angle of inclination 30° and takes time twice as great as the time taken in slipping down a identical frictionless plane. The coefficient of friction between the body and the plane is

1. $\sqrt{3}/4$ 2. $\sqrt{3}$ 3. 4/3 4. ¾

16. A body slides down a smooth inclined plane of height h and angle of inclination 30° reacting the bottom with a velocity v. Without changing the height, if the angle of inclination is doubled, the velocity with which it reaches the bottom of the plane is

1. Vv 2. v/2 3. 2v 4. $\sqrt{2}$ v

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

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

18. The minimum force required to move a body up an inclined plane of inclination 30° 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

1. $1/\sqrt{3}$ 2. $1/2\sqrt{3}$ 3. $1/3\sqrt{3}$ 4. $1/4\sqrt{3}$

19. A block takes twice as much time to slide down a rough 45^0 inclined plane as it takes to slide down an identical smooth 45^0 inclined plane. The coefficient of kinetic friction between the block and the rough inclined plane is

1) 0.25 2) 0.5 3) 0.75 4) 1.0

20. A body of mass m_1 projected vertically upwards with an initial velocity 'u' reaches a maximum height h. Another body of mass m_2 is projected along an inclined plane making an angle 30º with the horizontal and with speed 'u'. The maximum distance travelled along the incline is

1. 2h 2. h 3. $\frac{h}{2}$ 4. $\frac{h}{4}$

21. 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

1. 15º 2. 30º 3. 45º 4. 60º

22. A body takes four–third times as much time to slide down rough inclined plane as it takes to side down an identical but smooth inclined plane if the angle of inclined plane is 45º. The coefficient of friction is

1. 7/16 2. 9/16 3. 7/9 4. ¾

23. A 30kg box has to move up an inclined slope of 30º to horizontal at a uniform velocity of 5 m/sec. If the frictional force retarding the motion is 250N the horizontal force to move up is (g=10 m/sec^2)

1. $300\sqrt{2}$ N 2. 300N

3. $300\sqrt{3}$ N/2 4. $300 \times 2/\sqrt{3}$ N

24. A body is released from the top of a smooth inclined plane at height h above the ground. Simultaneously another body is pushed up with a velocity V from the bottom. If they meet after time t, inclination of that inclined plane to the horizontal is

1. $\sin^{-1}\left(\frac{t}{hu}\right)$ 2. $\cos^{-1}\left(\frac{t}{hu}\right)$ 3. $\sin^{-1}\left(\frac{h}{ut}\right)$ 4. $\cos^{-1}\left(\frac{hu}{t}\right)$

25. An insect crawls up a hemispherical surface. The coefficient of friction between the insect and the surface is 1/3. If the line joining the centre of the hemispherical surface to the insect makes an angle with the vertical, the maximum possible value of α is given by

1. Cot α = 3 2. Tan α = 3 3. Sec α = 3 4. Cosec α = 3

KEY

1)1 2) 4 3) 2 4) 2 5)1 6) 1 7) 1 8) 3 9) 4 10) 4 11)4 2)1 13)3

14)1 15) 1 16) 1 17) 3 18) 2 19) 3 20) 1 21) 3 22)1 23) 4 24) 3 25)1

HINTS

6. $t_\alpha = 2t_a$

$$\mu = Tan\theta\left[\frac{n^2-1}{n^2+1}\right] \Rightarrow \mu = Tan45\left[\frac{2^2-1}{2^2+1}\right]$$

$$\mu = 0.6$$

7. $$\mu = Tan\theta\left(\frac{n-1}{n+1}\right) \Rightarrow \frac{1}{2\sqrt{3}} = Tan\theta\left(\frac{3-1}{3+1}\right)$$

$$\frac{1}{2\sqrt{3}} = Tan\theta + \frac{2}{4}$$

$$Tan\theta = \frac{1}{\sqrt{3}} \Rightarrow \theta = 30$$

8. $\mu = Tan\theta$

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

$$s = \frac{V^2}{2g\,(\sin\theta + \tan\theta\cos\theta}$$

$$s = \frac{V^2}{4g\sin\theta}$$

9. $\mu = Tan\theta$

$$\mu = \frac{h}{R} \Rightarrow h = \mu R$$

Volume of the cube

$$v = \frac{1}{3}\pi R^2 h = \frac{1}{3}\pi R^2.\mu R = \frac{\mu\pi R^3}{3}$$

10. Work = f x s

$$W = \mu\, mg\cos\theta \times \frac{u^2}{2a}$$

$$W = \mu\, mg\cos\theta \times \left(\frac{u^2}{2g\ (\sin\theta + \mu\cos\theta)}\right)$$

$$W = \frac{\mu E\cos\theta}{(\sin\theta + \mu\cos\theta)}$$

11. Frictional force = μmg cos θ

$$F = 0.7 \text{ x } 2 \text{ x } 9.8 \text{ x} \frac{\sqrt{3}}{2} = 0.7 \text{ x } 9.8 \text{ x} \sqrt{3} \text{ N}$$

12. F_r = mg sin θ + F

R = mg cos θ

F_1 = μmg cos θ – mg sin θ

$$= \sqrt{\frac{3}{2}} \times 2 \times 10 \times \frac{\sqrt{3}}{2} - 2\text{x}10\text{x } \frac{1}{2}$$

$$= \frac{30}{\sqrt{2}} - 10 = 11.21 \text{ N}$$

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

16. $V = \sqrt{2gh}$

And V does not depends on when h=constant

17. a = g (sinθ + μ_k cosθ)

18. $mg\left(\sin\theta+\mu\cos\theta\right)=3mg\left(\sin\theta-\mu\cos\theta\right)$

19. $a_1 = g\sin 45 = \frac{g}{\sqrt{2}}$

$a_2 = g(\sin 45 - \mu_k \cos 45^0) = \frac{g}{\sqrt{2}}(1-\mu_k)$

$\because t^2 \alpha \frac{1}{a}$

$\frac{t_2^2}{t_1^2} = \frac{a_1}{a_2}$; $t_2 = 2t_1$

Substituting $\mu_k = 0.75$

20. $u^2 = 2gh$

$u^2 = 2g\, l \sin\theta$

21. mg cosθ x 2 = mg sinθ

22. $t_s = \sqrt{\frac{2l}{g\sin\theta}}; t_r = \sqrt{\frac{2l}{g\left(\sin\theta-\mu\cos\theta\right)}}$

23. F = mg sinθ + mg cosθ

Horizontal component of force = F cosθ

24. $S_1 = \frac{1}{2}g\sin\theta t$

$S_2 = ut - \frac{1}{2}g\sin\theta t$

$S = S_1 + S_2 = ut$

$$\theta = \sin^{-1}\left(\frac{h}{ut}\right)$$

25. $\tan\alpha = 1/3$

$\cot\alpha = 3$