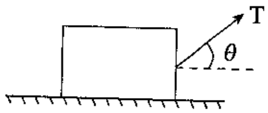
Take g = 10 m/s² as the acceleration due to gravity.

1. A block of mass m is pulled at constant velocity along a rough horizontal floor by an applied force $\vec{T}$, as shown. The magnitude of the frictional force is

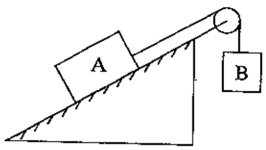


(1) $T\cos\theta$ (2) $T\sin\theta$ (3) zero (4) mg (5) $mg\cos\theta$

2. A box rests on a rough board 10 meters long. When one end of the board is slowly raised to a height of 6 meters above the other end, the box begins to slide. The coefficient of static friction is:

(1) 0.75 (2) 0.8 (3) 0.25 (4) 0.4 (5) 0.6

3. Block A, with a mass of 10 kg, rests on a 30° incline. The coefficient of kinetic friction is 0.20. The attached string is parallel to the incline and passes over a massless, frictionless pulley at the top. Block B, with a mass of 8.0 kg, is attached to the dangling end of the string. The acceleration of B is:



(1) 0.7 m/s^2, down (2) 0.7 m/s^2, up (3) 1.6 m/s^2, down (4) 0.4 m/s^2, up (5) 0.4 m/s^2, down

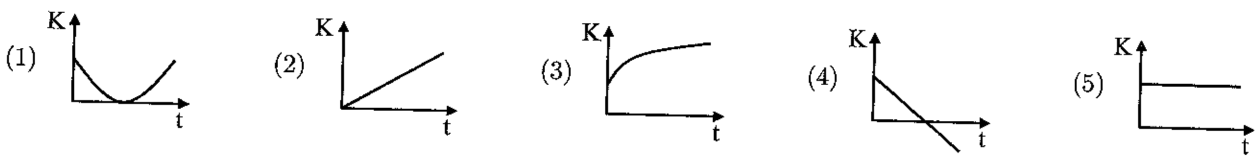
4. An object moves in a circle. If the radius is doubled keeping the speed the same, then the centripetal force must be:

(1) half as great. (2) twice as great. (3) four times as great. (4) one-fourth as great. (5) the same.

5. Find the work done by a force $\vec{\mathbf{F}} = (2 - 6x)\hat{\mathbf{i}} - 8y^2\hat{\mathbf{j}}$ acting on an object that moves along the x axis from $x_1 = 1$ m to $x_2 = 2$ m, where $\vec{\mathbf{F}}$ is measured in N and x and y are in m.

(1) −7 N·m (2) −8 N·m (3) 2 N·m (4) 8 N·m (5) 6 N·m

6. The diagram shows two horizontal forces $\vec{\mathbf{F}}_1$ and $\vec{\mathbf{F}}_2$ acting on a block that initially moves to the right on a frictionless surface. The plots below show the kinetic energy of the block as it changes with time. Which of the lines corresponds to the case when $F_2 > F_1$?



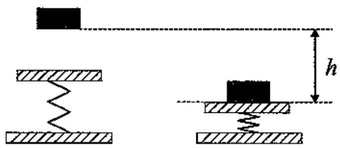
7. The potential energy of a particle moving on a straight line is described by the function:

$$U(x) = 7 - 20x + 2x^2$$

For what value of x is the acceleration of the particle zero?

(1) 5 (2) 7 (3) −20 (4) 2 (5) −7

8. A 1.5 kg crate falls from a height $h = 2$ m and sticks onto a spring scale with a spring constant of 1.5×10^5 N/m. At its greatest compression, what is the force exerted by the scale on the block? Assume any mechanical energy lost is negligible.

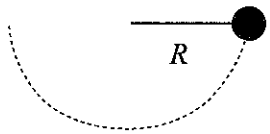


(1) 3×10^3 N (2) 9×10^6 N (3) 1.5×10^3 N (4) 9×10^3 N (5) 6×10^6 N

9. Two particles interact by conservative forces only and they complete round trips ending at the points where they started. Over this trip:

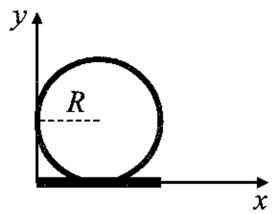
(1) Both the potential and kinetic energies are always the same at the beginning and at the end.
(2) The potential energy of the particles might have different value at the beginning and at the end.
(3) The kinetic energy of the particles might have different value at the beginning and at the end.
(4) The total mechanical energy of the particles might have different value at the beginning and at the end.
(5) Heat might be generated as a result of the motion.

10. A small ball of mass m is attached at the end of a massless cord and it is held horizontally at a distance R from a fixed support as shown. What is the maximum tension in the cord as the object swings freely?



(1) 3mg (2) 2mg (3) mgR (4) mg/R (5) mg

11. Find the center of mass (x_{com}, y_{com}) of an object that consists of a uniform hoop and a uniform rod as shown in the figure. The hoop has a radius R and a mass M and the rod has a mass $2M$ and a length $2R$. Use the coordinate system in the figure.



(1) $(R, R/3)$ (2) $(R, R/2)$ (3) $(R/3, R)$ (4) $(R/2, R)$ (5) $(R, R/4)$

12. A 0.20 kg rubber ball is dropped down from a window. It strikes the sidewalk below at 30 m/s and rebounds at 10 m/s. The change in momentum of the ball as a result of the collision with the ground is ______ kg·m/s. Take the positive direction as being vertically up.

(1) 8.0 (2) 6.0 (3) 4.0 (4) 2.0 (5) 1.0

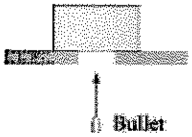
13. Two bodies A and B have equal kinetic energy. The mass of A is 9 times the mass of B. The ratio of the momentum of A to that of B is:

(1) 3:1 (2) 1:3 (3) 1:1 (4) 1:9 (5) 9:1

14. A man standing at rest on a horizontal completely frictionless floor might get himself moving horizontally by:

(1) Throwing a shoe (2) rolling (3) exhaling vertically (4) walking (5) crawling

15. In the figure a 0.05 kg bullet moving vertically upward at 1000 m/s strikes and passes through the center of a 5 kg block initially at rest. The bullet emerges from the block moving directly upward at 400 m/s. To what maximum height does the block then rise above its initial position?



(1) 1.8 m (2) 3.0 m (3) 0.5 m (4) 5.7 m (5) 6.5 m

16. Two objects X and Y are held at rest on a horizontal frictionless surface. A spring is compressed between X and Y. The mass of X is 2/5 times the mass of Y. After the objects are released, the ratio of the kinetic energy of X to that of Y is:

(1) 5/2 (2) 4/25 (3) 25/4 (4) 2/5 (5) 1

17. A wheel initially has an angular velocity of 20 rad/s, but it is slowing down at a rate of 2 rad/s^2. By the time it stops it will have turned through how many revolutions?

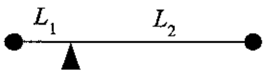
(1) $50/\pi$ (2) 100 (3) $150/\pi$ (4) $200/\pi$ (5) $100/\pi$

WRONG! IT'S A MISTAKE

18. The rotational inertia of a sphere about its diameter is $5MR^2/2$ where M is the mass and R is the radius of the sphere. If the sphere is rotated about an axis that is tangential to its surface, its rotational inertia around this axis is:

(1) $(7/2)MR^2$ (2) MR^2 (3) $(1/2)MR^2$ (4) $(3/2)MR^2$ (5) $(5/2)MR^2$

19. The figure shows particles 1 and 2 each of mass M attached to the end of a rigid massless rod of length $L = L_1 + L_2$ where $L_1 = 0.2$ m and $L_2 = 0.8$ m. The rod is held horizontally on a fulcrum and then released. What is the magnitude of the initial angular acceleration (in rad/s^2) of particle 1?

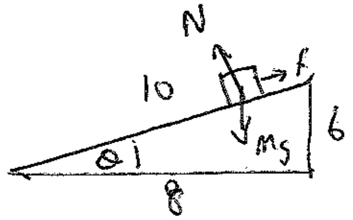


(1) 8.8 (2) 3.2 (3) 5.5 (4) 2.0 (5) 0.8

20. A worker is lowering a 3 kg block of ice down an inclined frictionless ramp at a constant speed. Find the work done by the worker if the block travels 2 m along the ramp. The angle between the ramp and the horizontal plane is 30°.

(1) −30 N·m (2) 60 N·m (3) −60 N·m (4) 26 N·m (5) −26 N·m

1. Constant $\vec{v} \Rightarrow \sum \vec{F} = 0$. In x-direction $|T\cos\theta| = |f|$

2. 

$\sin\theta = 0.6$

$\cos\theta = 0.8$

$N = mg\cos\theta$ $\quad N\mu_s$ (when first slipping) $= mg\sin\theta$

$mg\cos\theta\,\mu_s = mg\sin\theta \Rightarrow \mu_s = \frac{\sin\theta}{\cos\theta} = 0.75$

3. Does B go up or down? Ignore f and find out.

Take down as positive $\quad m_B g - T = m_B a$ ①

$T - m_A g \sin 30° = m_a a$ ②

$m_B g - m_A g \sin 30° = (m_a + m_b) a$

$8 \times 10 - 10 \times 10 \times 0.5 = 18a$

a positive $\Rightarrow$ B goes down

Now add $f = \mu_k m_A g \cos\theta = 0.2 \times 10 \times 10 \times \frac{\sqrt{3}}{2}$

$m_B g - m_A g \sin 30° - 10\sqrt{3} = 18a$

$80 - 50 - 10\sqrt{3} = 18a \Rightarrow a \approx \frac{13}{18} \sim 0.7\ m/s^2$

4. $a \sim \frac{v^2}{r} \Rightarrow a \propto \frac{1}{r}$ at constant v

5. Work $= \int_1^2 \vec{F}\cdot d\vec{x} = \int_1^2 (2 - 6x)\,dx = \left[2x - 3x^2\right]_1^2$

$= -8 + 1 = -7$ Nm

6. First it slows to $v=0$, then speeds up (K is always positive)

7. $F = \frac{-\partial U(x)}{\partial x} = -(-20 + 4x) = 20 - 4x$

$a \propto F$ so $a = 0$ at $x = 5$

8. Energy conservation

$-mgh + \frac{1}{2}kx^2 = 0 \Rightarrow x^2 = \frac{2mgh}{k}$

$= \frac{2 \times 1.5 \times 10 \times 2}{1.5 \times 10^5}$

$= 4 \times 10^{-4}$

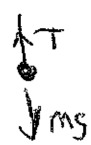
$\Rightarrow x = 2 \times 10^{-2}$

$F = -kx = -2 \times 10^{-2} \times 1.5 \times 10^5 = 3 \times 10^2 N$ (up)

9. ① Conservative forces ... conserve mechanical energy.
Back at starting point, potential is the same as at beginning
$\Rightarrow$ So is K.E.

10. At bottom Energy Conservation gives $mgR = \frac{1}{2}mv^2 \Rightarrow v^2 = 2gR$

$\Rightarrow a = \frac{v^2}{R} = 2g$.



$T - mg = ma \Rightarrow T = 3mg$

11. By symmetry $X_{cm} = R$

$Y_{cm} = \frac{RM + 2M \times 0}{3M} = \frac{R}{3}$

12. $\Delta m\vec{v} = m\vec{V}_{final} - m\vec{V}_{initial}$

$= 0.2(30) - 0.2(-10) = 8$ kg m/s

13. $\frac{1}{2} m_A V_A^2 = \frac{1}{2} m_B V_B^2 \Rightarrow \frac{V_B^2}{V_A^2} = \frac{m_A}{m_B}$

$\frac{m_A V_A}{m_B V_B} = \frac{m_A}{m_B}\sqrt{\frac{m_B}{m_A}} = \frac{9}{3} = 3$

14. D) is only answer that gives horizontal motion (using conservation of momentum) with no friction.

15. Momentum conservation $1000 \times 05 = 400 \times 05 + 5V$

$\Rightarrow$ 600 $v = 6$ m/s

Then energy conservation $\frac{1}{2} m 6^2 = mgh$

$18 = 10h \quad h = 1.8$ m

16. Momentum conservation gives $V_x = \frac{5}{2} V_y$

$\frac{1}{2} m_x V_x^2 = \frac{1}{2} \times \frac{2}{5} m_y \left(\frac{5}{2}\right)^2 V_y^2$

$= \frac{5}{2}\left(\frac{1}{2} m_y V_y^2\right)$

17. $\theta_2 - \theta_1 = \omega_0 t + \frac{1}{2}\alpha t^2$ and

$\omega = \omega_0 + \alpha t$
$0 = 20 - 2t$
$t = 10$ s to stop

$= 20 \times 10 - 1 \times t^2$

$= 100$ rads

$\Rightarrow$ revs $= \frac{100}{2\pi} = \frac{50}{\pi}$

18. Stupid mistake – you can't have $I = 5MR^2/2$
(uniform sphere is $\frac{2MR^2}{5}$)
If you could have $\frac{5}{2}MR^2$ then answer would be $\frac{5}{2}MR^2 + MR^2$

$$= \frac{7}{2}MR^2$$

19. $\tau = I\alpha$ and $I = m(L_1^2 + L_2^2)$
$\tau = Mg(0.8) - mg(0.2)$ in clockwise direction
$0.6\,mg = m(0.68)\alpha \Rightarrow \alpha \sim 8.8$ rad/s^2

20. Either use $W = \int \vec{F} \cdot d\vec{x}$ or energy conservation
$WD = \Delta(PE) = -\sin 30^\circ \times 3 \times g \times 2 = -30$ Nm