1.

A ladybug traveling with tangential velocity v sits halfway between the axis and the edge of a phonograph record.

What will happen to its tangential speed if the RPM rate is tripled? At this tripled rate, what will happen to its tangential speed if it crawls out to the edge?

1. $\frac{v}{3}$; $\frac{v}{6}$

2. $6\,v$; $6\,v$

3. $3\,v$; $6\,v$

4. $\frac{v}{3}$; $\frac{v}{3}$

5. $\frac{v}{6}$; $\frac{v}{3}$

6. v; $3\,v$

7. $\frac{v}{6}$; $\frac{v}{6}$

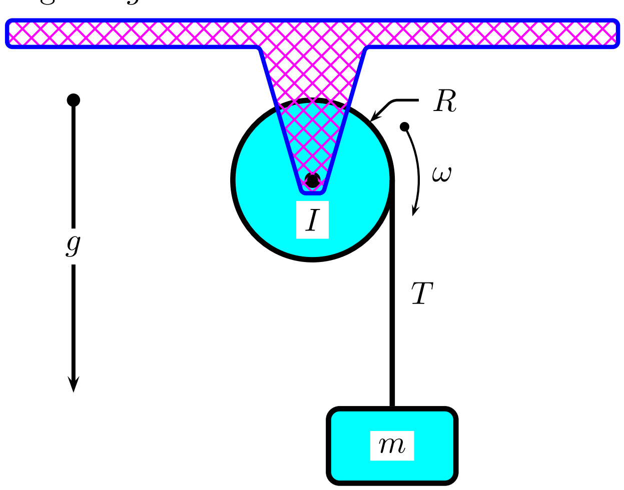
8. $3\,v$; $3\,v$

9. v; $\frac{v}{3}$

10. $6\,v$; $3\,v$

2.

A circular disk with moment of inertia $\frac{1}{2}\,m\,R^2$, mass m and radius R is mounted at its center, about which it can rotate freely. A light cord wrapped around it supports a weight $m\,g$.



Find the total kinetic energy of the system when the weight is moving at a speed v.

1. $K = \frac{3}{4}\, m\, v^2$

2. $K = m\, v^2$

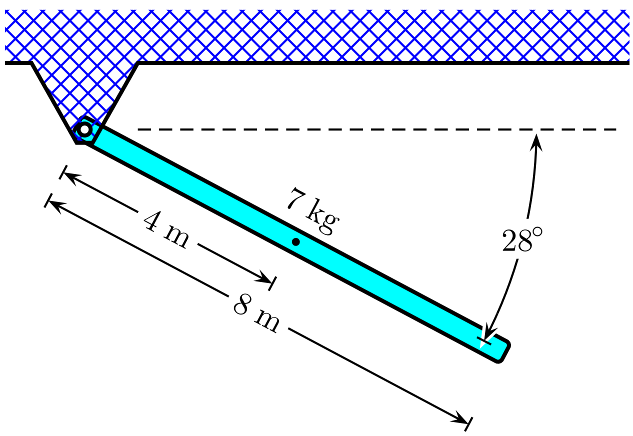
3. $K = \frac{5}{4}\, m\, v^2$

4. $K = \frac{2}{3}\, m\, v^2$

5. $K = \frac{1}{3}\, m\, v^2$

3.

A uniform 7 kg rod with length 8 m has a frictionless pivot at one end. The rod is released from rest at an angle of 28° beneath the horizontal.



What is the angular acceleration of the rod immediately after it is released? The moment of inertia of a rod about the center of mass is $\frac{1}{12}\, m\, L^2$, where m is the mass of the rod and L is the length of the rod. The moment of inertia of a rod about either end is $\frac{1}{3}\, m\, L^2$, and the acceleration of gravity is $9.8\ \mathrm{m/s^2}$.

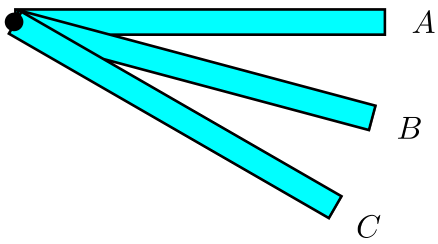
4.

A simple pendulum consists of a small object of mass 4.1 kg hanging at the end of a 2.4 m long light string that is connected to a pivot point.

Find the magnitude of the torque (due to the force of gravity) about this pivot point when the string makes a 4.71951° angle with the vertical. The acceleration of gravity is $9.8\ \mathrm{m/s^2}$.

5.

A long rod is pivoted (without friction) at one end. It is released from rest at A in a horizontal position and swings down, passing positions B and C.



Compare the angular accelerations at B and C.

1. $\alpha_B > \alpha_C$

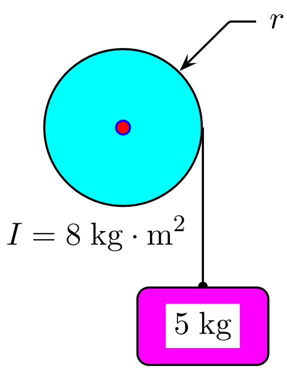
2. There is not enough information.

3. $\alpha_B < \alpha_C$

4. $\alpha_B = \alpha_C$

6.

A 5 kg mass is attached to a string, which is wrapped several times around a uniform solid cylinder of radius 6 m and moment of inertia of 8 kg $\cdot$ m^2.



Find the torque on the cylinder. Assume the cylinder can rotate freely and the acceleration of gravity is 9.8 m/s^2 .

ANSWERS

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1. Choice 3 is correct.

Explanation:

Since $v = r\,\omega$, if the RPM rate ω is tripled, the speed is tripled. Then if r is also doubled, the speed doubles on top of the ladybug's speed at the halfway point.

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2. Choice 1 is correct.

Explanation:

$v = r\,\omega$, so the total kinetic energy is

$$\begin{aligned} K_{tot} &= K_m + K_{rot} \\ &= \frac{1}{2}\,m\,v^2 + \frac{1}{2}\,I\,\omega^2 \\ &= \frac{1}{2}\,m\,v^2 + \frac{1}{2}\left(\frac{1}{2}\,m\,R^2\right)\left(\frac{v}{R}\right)^2 \\ &= \frac{3}{4}\,m\,v^2 \,. \end{aligned}$$

3.

Correct answer: 1.62242 rad/s^2.

Explanation:

$$\begin{aligned} \text{Let}: \quad m &= 7\text{ kg}\,, \\ L &= 8\text{ m}\,, \quad \text{and} \\ \theta &= 28^\circ\,. \end{aligned}$$

The rod's moment of inertia about its endpoint is $I = \frac{1}{3}\,m\,L^2$, so the angular acceleration of the rod is

$$\alpha = \frac{\tau}{I} = \frac{\frac{1}{2}\,m\,g\,L\cos\theta}{\frac{1}{3}\,m\,L^2} = \frac{3}{2}\,\frac{g}{L}\,\cos\theta$$

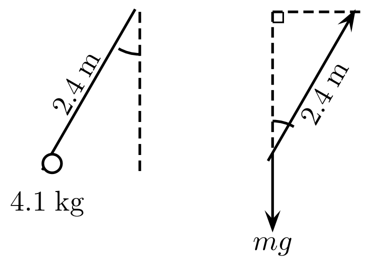
$$\begin{aligned} &= \frac{3}{2}\,\frac{9.8\text{ m/s}^2}{8\text{ m}}\,\cos 28^\circ \\ &= \boxed{1.62242\text{ rad/s}^2}\,. \end{aligned}$$

4.

Correct answer: $7.93422\ \mathrm{N \cdot m}$.

Explanation:

$$\text{Let}:\quad m = 4.1\ \mathrm{kg}\,,\quad L = 2.4\ \mathrm{m}\,,\quad \text{and}\quad \theta = 4.71951^\circ\,.$$



The torque is

$$\begin{aligned}\tau &= F\,d\\ &= m\,g\,L\,\sin\theta\\ &= (4.1\ \mathrm{kg})(9.8\ \mathrm{m/s^2})(2.4\ \mathrm{m})\ \sin 4.71951^\circ\\ &= \boxed{7.93422\ \mathrm{N\cdot m}}\,.\end{aligned}$$

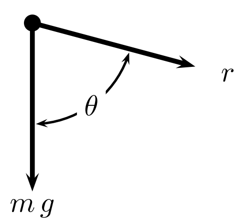
5. Choice 1 is correct.

Explanation:

Using the rotational analogue to Newton's second law

$$\tau = m\,\vec{g} \times \vec{r} = I\,\alpha$$

$$\alpha = \frac{m}{I}\,\vec{g} \times \vec{r} = \frac{m}{I}\,g\,r\,\sin\theta\,.$$



The angular acceleration decreases as the rod falls and the angle θ decreases, so $\alpha_B > \alpha_C$.

6.

Correct answer: 12.5106 N · m.

Explanation:

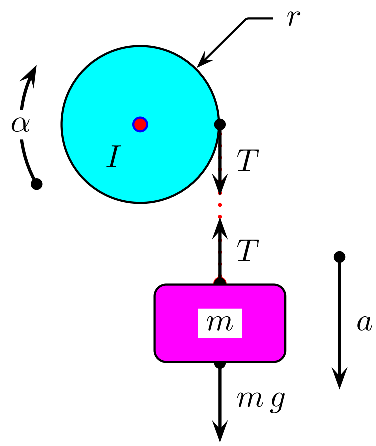
Let : $m = 5\text{ kg}$,

$r = 6\text{ m}$,

$I = 8\text{ kg}\cdot\text{m}^2$, and

$g = 9.8\text{ m/s}^2$.

Consider the free-body diagram.



Applying translational equilibrium,

$$m\,a = m\,g - T$$
$$a = \frac{m\,g - T}{m}$$

Applying rotational equilibrium,

$$\tau = I\,\alpha$$
$$T\,r = I\,\left(\frac{a}{r}\right) = I\,\left(\frac{m\,g - T}{m\,r}\right)$$
$$m\,r^2\,T = m\,I\,g - I\,T$$
$$T\,(I + m\,r^2) = m\,I\,g$$
$$T = \frac{m\,I\,g}{I + m\,r^2}$$

$$\begin{aligned}\tau &= T\,r \\ &= \frac{m\,I\,g\,r}{I + m\,r^2} \\ &= \frac{(5\text{ kg})\,(8\text{ kg}\cdot\text{m}^2)\,(9.8\text{ m/s}^2)\,(6\text{ m})}{8\text{ kg}\cdot\text{m}^2 + (5\text{ kg})\,(6\text{ m})^2} \\ &= \boxed{12.5106\text{ N}\cdot\text{m}}\,.\end{aligned}$$