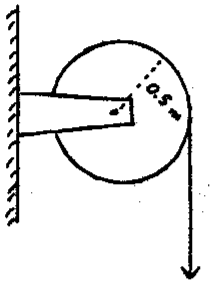
Exam Problems from Chapter 11

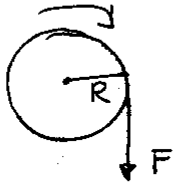
A cord is wrapped around the rim of a flywheel 0.50 m in radius. A constant force of 50.0 N is applied on the cord, as shown in the figure. The wheel is mounted on frictionless bearings on a horizontal shaft through its center. The moment of inertia of the wheel is 4.00 kg.(m**2). If the wheel starts from rest, find its angular velocity after 4.00 seconds.



A. 25.0 radians/second
B. 20.0 radians/second
C. 40.0 radians/second
D. 35.0 radians/second
E. 30.0 radians/second

$\omega_0 = 0 \quad \omega = ? \quad t = 4\ \text{sec}$

$\omega = \omega_0 + \alpha t \quad I = 4\ \text{kg m}^2$



$\tau = I\alpha$

$FR = I\alpha \Rightarrow \alpha = \frac{FR}{I} = \frac{(50)(0.5)}{4} = 6.25 \frac{\text{rad}}{s^2}$

$\omega = (6.25)(4) = 25.0 \frac{\text{rad}}{s}$

A torque of 0.80 N.m applied to a pulley increases its angular speed fr
45.0 revolutions/minute to 180 revolutions/min in 3.00 seconds. Find t
moment of inertia of the pulley.

A. 0.11 kg*(m**2)
B. 0.21 kg*(m**2)
C. 0.17 kg*(m**2)
D. 0.42 kg*(m**2)
E. 0.30 kg*(m**2)

$\tau = I\alpha \Rightarrow I = \frac{\tau}{\alpha}$

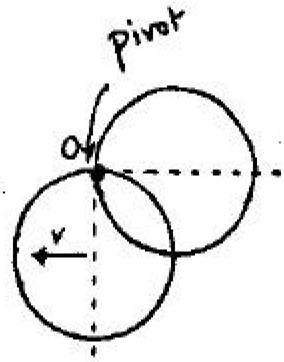
$\omega = \omega_0 + \alpha t \Rightarrow \alpha = \frac{\omega - \omega_0}{t} = 4.7\ \text{rad/s}^2$

$\omega_0 = \frac{45 \times 2\pi}{60} = 4.7\ \text{rad/s}$

$\omega = 18.8\ \text{rad/s}$

$I = \left(\frac{4.7}{0.8}\right)^{-1} = \frac{0.8}{4.7} = 0.17\ \text{kg m}^2$

A disk of radius 10 cm is free to rotate about a frictionless axle perpendicular to the disk and situated at a point on its rim. The disk is released from a position where its center is at the same height as the axle (see figure). Find the velocity of the center at its lowest position.



A. 3.21 m/s
B. 1.41 m/s
C. 21.30 m/s
D. 0.76 m/s
E. 1.14 m/s

$$\Delta K + \Delta U_g = 0$$

$$\left(\frac{1}{2} I \omega_f^2 - 0\right) + (-mgh) = 0$$

$$h = R \Rightarrow \frac{1}{2} I \omega_f^2 = mgR$$

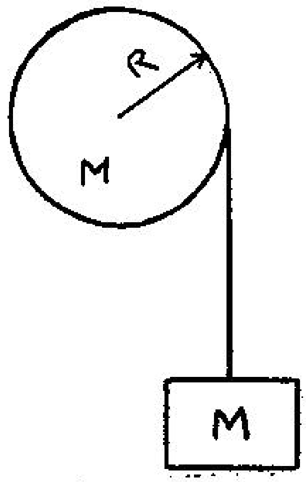
$$I = I_{cm} + md^2$$

$$I = \frac{1}{2} MR^2 + mR^2 = \frac{3}{2} mR^2$$

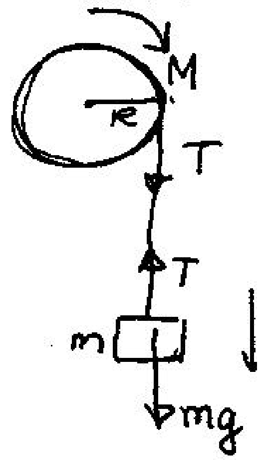
$$\frac{3}{4} mR^2 \omega_f^2 = mgR$$

$$\omega_f = \sqrt{\frac{4}{3}\frac{g}{R}} = 1.14 \text{ rad/s}$$

A mass of 5 kg is suspended from a light string which is wrapped around a flywheel of mass 5 kg and radius 0.5 m. The wheel is mounted on frictionless bearings on a horizontal shaft through its center (see figure). Find the acceleration of the mass and tension in the string. (take I wheel = 1/2 * M*R**2).



A. 10.80 m/s**2, 26.54 N
B. 3.75 m/s**2, 49.00 N
C. 5.35 m/s**2, 33.25 N
D. 6.53 m/s**2, 16.33 N
E. 2.25 m/s**2, 10.21 N



block: $mg - T = ma$ — (1)

pulley: $TR = I\alpha$ — (2)

$$T = \frac{I\alpha}{R} = \frac{Ia}{R^2}$$

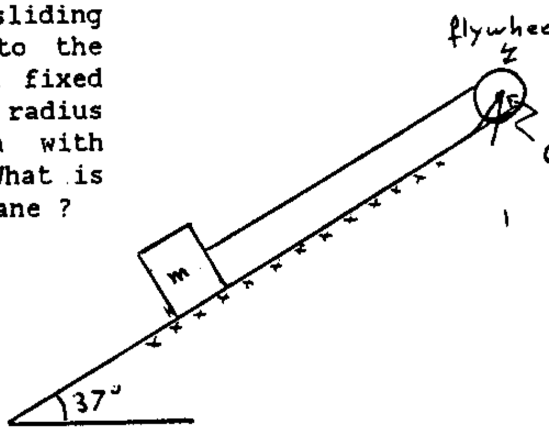
$$mg - \frac{Ia}{R^2} = ma$$

$$a\left(m + \frac{I}{R^2}\right) = mg \Rightarrow a = \frac{mg}{m + \frac{I}{R^2}}$$

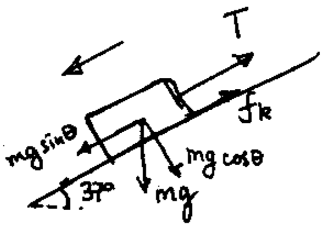
$$I = \frac{1}{2}MR^2 \Rightarrow a = \frac{mg}{m + \frac{M}{2}} = \frac{49}{7.5} = 6.53$$

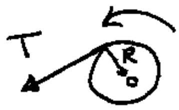
$$(1) \Rightarrow T = m(g-a) = 5(9.8 - 6.53) = \underline{16.3\text{ N}}$$

A block of mass m = 5.00 kg slides down a surface inclined at 37 deg to the horizontal, as shown in the figure. The coefficient of sliding friction is 0.250. A string attached to the block is wrapped around a flywheel on a fixed axis at O. The flywheel has an outer radius R = 0.200 m, and a moment of inertia with respect to its axis of 0.200 kg*m**2. What is the acceleration of the block down the plane ?



A. 1.96 m/s**2
B. 2.05 m/s**2
C. 0.00 m/s**2
D. 1.80 m/s**2
E. 0.98 m/s**2





$$mg\sin\theta - f_k - T = ma$$

$$f_k = \mu_k N = \mu_k mg\cos\theta$$

$$mg\sin\theta - \mu_k mg\cos\theta - T = ma \quad \text{— (1)}$$

$$mg(\sin\theta - \mu_k\cos\theta) - \frac{Ia}{R^2} = ma$$

$$\Rightarrow a\left(m + \frac{I}{R^2}\right) = mg(\sin\theta - \mu_k\cos\theta)$$

$$a = \frac{mg(\sin\theta - \mu_k\cos\theta)}{m + \frac{I}{R^2}} = \frac{19.6}{10} = 1.96\ \text{m/s}^2$$

$$TR = I\alpha \quad \text{— (2)}$$

$$= I\frac{a}{R}$$

$$T = \frac{Ia}{R^2}$$

A grinding wheel of moment of inertia 0.01 kg*(m**2) is brought to rest from an initial angular velocity of 3000 rev/min. What is the average power dissipated if the wheel is brought to rest in 10 revolutions ? (Assume constant angular acceleration).

A. 5.55*(10**3) watts
B. 725 watts
C. 923 watts
D. 1.23*(10**3) watts
E. 4.25*(10**3) watts

$\bar{P} = \tau \bar{\omega}$ $\qquad \bar{\omega} = \frac{\omega + \omega_0}{2}$

$\omega_0 = 3000 \frac{rev}{min} = 3000 \times \frac{2\pi}{60} \frac{rad}{s}$

$\omega_0 = 314.2 \frac{rad}{s}$

$\tau = I\alpha \qquad \cancel{\omega^2}^{\,0} = \omega_0^2 + 2\alpha\theta$

$\Rightarrow \alpha = -\frac{\omega_0^2}{2\theta} = -\frac{(314.2)^2}{2(10 \times 2\pi)}$

$\Rightarrow \alpha = -785 \text{ rad/s}^2$

$|\tau| = 0.01 \times 785 = 7.85 \text{ N}\cdot\text{m}$

$\bar{P} = \tau\bar{\omega} = 7.85 \times \frac{314.2}{2} = \underline{\underline{1.23 \times 10^3 \text{ W}}}$

A wheel with a moment of inertia of 86 kg.m**2 is rotating with an angular velocity of 17 rad/s. If an accelerating torque of 90 N.m is applied tc this wheel for 7.0 s, what is the final angular velocity of the wheel? Neglect any frictional effects.

A. 145 rad/s
B. 64.7 rad/s
C. 16.3 rad/s
D. 24.3 rad/s
E. 35.6 rad/s

$\tau = I\alpha \Rightarrow 90 = 86\alpha \Rightarrow \alpha = \frac{90}{86}$

$\alpha = 1.04 \text{ rad/s}^2$

$\omega = \omega_0 + \alpha t = 17 + 1.04 \times 7 = 24.3 \text{ rad/s}$

The second hand (arm) of a watch is 2 cm long. Find the linear speed of the tip of this hand.

A. 0.05 cm/sec
B. 0.84 cm/sec
C. 0.21 cm/sec
D. 0.42 cm/sec
E. 19.09 cm/sec

$\omega = \frac{1 \text{ rev}}{\text{min}} = \frac{2\pi}{60} \frac{rad}{s} = 0.1 \text{ rad/s}$

$v = \omega r = 0.1 * 2 \text{ cm} = 0.2 \text{ cm/s}$

A turntable is initially rotating at 33.33 rev/min. When the power to the turntable is switched off, the turntable slows down at a constant rate of 0.20 rad/s**2. How many revolutions will the turntable make before stopping?

A. 1.08 rev
B. 5.37 rev
C. 2.13 rev
D. 3.21 rev
E. 4.85 rev

$\omega_o = 33.3$ rev/min $\quad \omega_f = 0 \quad \alpha = 0.2$ rad/s^2

$$\cancel{\omega_f^2}^{\,0} = \omega_o^2 + 2\alpha\,\theta$$

$$\theta = \frac{\omega_o^2}{2\alpha} = \frac{\left(\frac{33.3 \times 2\pi}{60}\right)^2}{2 \times 0.2} = 30.4 \text{ rad}$$

$$\theta = \frac{30.4}{2\pi} = 4.8 \text{ rev.}$$

A disk 6 cm in radius rotates at a constant rate of 1200 rev/min about its axis. Find the radial acceleration of a point on the outer edge of the disk.

A. 0 m/s**2
B. 7200 m/s**2
C. 126 m/s**2
D. 200 m/s**2
E. 947 m/s**2

$R = 6$ cm $\quad \omega = 1200 \frac{\text{rev}}{\text{min}} = \frac{1200 \times 2\pi}{60} = 125.7$ rad/s

$$a_r = \frac{v^2}{R} = \frac{\omega^2 R^2}{R} = \omega^2 R = (125.7)^2 (0.06)$$

$$a_r = 947.5 \text{ m/s}^2 \sim \underline{948 \text{ m/s}^2}$$

note that since $\omega = $ Constant $\Rightarrow a_t = 0$