Chapter 9-10 Practice Test 2

Part I. Multiple Choice

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

1. With the same non-zero clockwise torque applied, if an object's angular acceleration is increasing, its moment of inertia must be
   A. increasing. B. decreasing. C. staying the same. mr^2

2. A rubber band car is powered by a rubber band pulling tangent to the axle. Increasing the wheel diameter
   A. increases the torque B. decreases the torque C. has no effect on the torque

$\tau = r_{axle} F$

3. The units of rotational inertia are
   A. kg m^2 B. rad C. rad/s D. rad/s^2 E. kg m^{2}s^{-1}

4. The units of angular ~~acceleration~~ momentum are
   A. kg m^2 B. rad C. rad/s D. rad/s^2 E. kg m^{2}s^{-1}

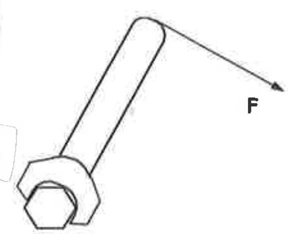
$L = I\omega$ rad/s kg m^2

5. A wheel with a radius of 0.500 m rolls for a distance of 6π meters. Through what angle has the a point on the wheel rotated?
   A. 3.14 radians B. 6 radians C. 18.8 radians D. 37.7 radians

$\left(\frac{6\pi\,m}{}\right)\left(\frac{1\,rad}{0.5\,m}\right)$

6. In an effort to tighten a bolt to a torque of 2.5 Nm, a force **F** is applied as shown in the figure below. If the distance from the end of the wrench to the center of the bolt is 25.0 cm, what force must be applied at the end of the wrench?
   A. 1N
   B. 2.5N
   ~~C. 5.00 N~~
   D. 10N
   E. 25N

$\frac{\tau}{r} = F$



7. If a wheel turning at a constant rate completes exactly 20 revolutions in 10.0 s, its angular speed is:
   A. 0.314 rad/s B. 0.628 rad/s C. 12.6 rad/s D. 6.28 rad/s E. 31.4 rad/s

$\left(\frac{20\,rev}{10\,s}\right)\left(\frac{2\pi\,rad}{rev}\right)$

8. A child initially standing at the center freely spinning merry-go-round moves to the edge. Which one of the following statements is necessarily true concerning this event and why?

$L_i = L_f$

$I\omega = I\omega$

   A. The angular speed of the system increases because the moment of inertia of the system has decreased.
   B. The angular speed of the system decreases because the moment of inertia of the system has decreased.
   C. The angular speed of the system increases because the moment of inertia of the system has increased.
   D. The angular speed of the system decreases because the moment of inertia of the system has increased.
   E. The angular speed of the system remains the same because the net torque on the merry-go-round is zero.

9. In order to increase the torque created by F_2 below, the fulcrum should be moved

   A. closer to F_1 B. closer to F_2

$\tau_{F_2} = r F_2$

10. A comet orbiting the Sun can be considered an isolated system with no outside forces or torques acting on it. As the comet moves closer to the sun in its highly elliptical orbit, what happens to its angular momentum?

    a. It increases b. It decreases c. It stays the same

$L_i = L_F$ when $\sum \tau = 0$

11. As a comet moves closer to the sun in its highly elliptical orbit, what happens to its rotational inertia?

    a. It increases b. It decreases c. It stays the same

$I = mr^2$

12. As a comet's position in its orbital path changes, its moment of inertia doubles. What happens to its kinetic energy as its moment of inertia doubles?

    a. multiplied by 0.5x b. No change c. multiplied by 2x d. multiplied by 4x

$L_i = L_F \Rightarrow I\omega = (2I)(\frac{\omega}{2})$ $KE_i = \frac{1}{2} I\omega^2$ $KE_F = \frac{1}{2}(2I)(\frac{\omega}{2})^2 = \frac{1}{4} I\omega^2$

13. Which of the following determine(s) how fast an object will roll down a smooth hill? Select all that apply. [Assume that all objects will actually roll without slipping.]

    a. Object radius b. Object mass c. Object Shape (distribution of mass)

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh = \frac{1}{2}mv^2 + \frac{1}{2}(mr^2)(\frac{v^2}{r^2})$

I is always some multiple of mr^2

14. A disk initially rolls along the flat ground at a constant speed without slipping. If the disk's radius is now doubled without changing its translational speed or its mass,

    A. the angular speed decreases by 2X and the kinetic energy ~~increases by 2X~~ decreases.
    B. the angular speed decreases by 4X and the kinetic energy ~~increases by 2X~~ decreases.
    C. the angular speed decreases by 2X and the kinetic energy remains the same.
    D. the angular speed decreases by 4X and the kinetic energy remains the same.

$\omega = \frac{v}{r}$ $\frac{\omega}{2} = \frac{v}{2r}$

$KE = \frac{1}{2} I\omega^2$

$\Downarrow$

$KE = \frac{1}{2} m(r)^2 \frac{v^2}{(2r)^2}$

15. What happens when a flipping gymnast opens up from a tucked position?

    A. His moment of inertia decreases causing him to speed up.
    B. His angular momentum decreases.
    C. The torque that he exerts increases his moment of inertia.
    D. His angular momentum increases.
    E. His moment of inertia ~~decreases~~ increases causing him to slow down.

$mgh = \frac{1}{2}mr^2(\frac{v^2}{r^2})$

$I_i\omega_i = I_F\omega_F$

16. A 3 kilogram rotating mass has a rotational radius of 1m and a moment of inertia of $3 kg \cdot m^2$. What shape could it be?

    A. Thin hoop
    B. Sphere
    C. Disk

$I = x\,mr^2$

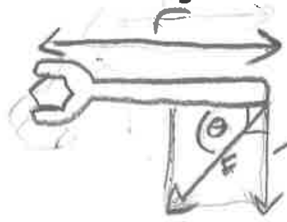
$3 kg m^2 = x(3 kg)(1 m)^2$

$x = 1 \rightarrow I = mr^2 \Rightarrow$ Thin hoop

17. If a mechanic applies a force (F) at an angle θ, relative to the length of a wrench, torque generated equals

    A. rFsinθ B. rFcosθ c. rFtan θ d. rF

$\tau = r F_{\text{Perp. to radius}}$

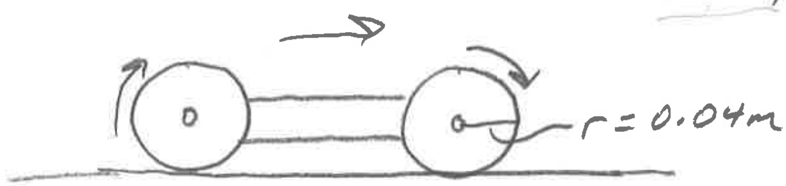


$F\sin\theta$

$\frac{F_\perp}{F} = \sin\theta$

$F_\perp = \sin\theta F$

1.



$V_0 = 0\,m/s$ $V = 3\,m/s$

$\Delta t = 1.5\,s$

a) $\alpha = \frac{\Delta\omega}{\Delta t}$ $\Delta\omega = \omega_F - \omega_i$ $\omega_F = \frac{V_F}{r}$

$\Delta\omega = \frac{3\,m/s}{0.04\,m/radian} - 0 = 75\,rad/s$

$\alpha = \frac{75\,rad/s}{1.5\,sec} = 50\,rad/s^2$

b) $\theta = \underset{0}{\omega_0} t + \frac{1}{2}\alpha t^2$

$\theta = \frac{1}{2}(50\,rad/s^2)(1.5\,sec)^2 = 56.25\,radians$

c) $\omega = \frac{75\,rad}{s}$ $\left(\frac{75\,rad}{s}\right)\left(\frac{1\,rev}{2\pi\,rad}\right)\left(\frac{60\,sec}{1\,min}\right) = 716\,rpm$

2. a) $\omega_0 = \frac{3\,rev}{sec}$ $\quad \alpha = -3\,\frac{rad}{s^2}$

$\omega = 0$

$$\left(\frac{3\,rev}{sec}\right)\left(\frac{2\pi\,rad}{rev}\right) = 18.9\,\frac{rad}{s} = \omega_0$$

$$\omega = \omega_0 + \alpha t$$

$$0 = 18.9\,rad/s + \left(-3\,\frac{rad}{s}\right)(t)$$

$$t = 6.3\,sec$$

b) $revs = \frac{\theta}{2\pi\,rad/rev}$ $\quad \theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$$\theta = 18.9\,\frac{rad}{s}(6.3\,s) + \frac{1}{2}\left(-3\,\frac{rad}{s}\right)(6.3\,s)^2$$

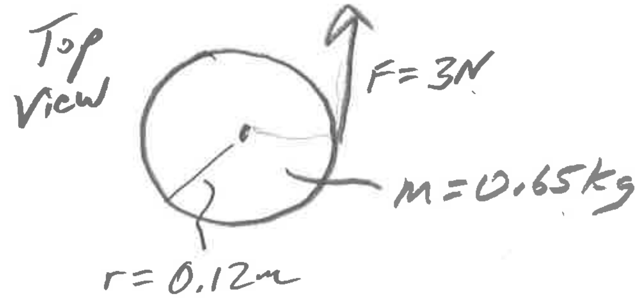
$$\theta = 59.5\,rad$$

$$revs = \frac{59.5\,rad}{2\pi\,rad/rev}$$

$$= 9.48\ revolutions$$

$$or\ 59.5\,rad\left(\frac{1\,rev}{2\pi\,rad}\right) =$$

3.



a) $\tau = rF = 0.12m(3N) = 0.36\,N\cdot m$

b) $\tau = I\alpha$

$0.36N\cdot m = \left(\frac{2}{3}mr^2\right)\alpha$

$0.36N\cdot m = \left(\frac{2}{3}\right)(0.65kg)(0.12m)^2(\alpha)$

$\alpha = 57.7\,rad/s^2$

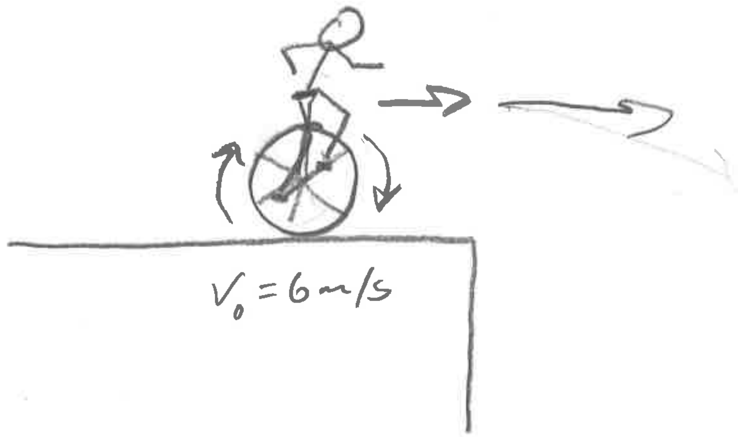
c) $\omega = \omega_0 + \alpha t$

$\omega = 0 + (57.7\,rad/s^2)(60s)$

$\omega = 3{,}460\,rad/s$

$\left(3{,}460\frac{rad}{s}\right)\left(\frac{1rev}{2\pi rad}\right) = 550\frac{rev}{s}$

4.



$V_0 = 6\,m/s$

a) $\omega = \frac{V_i}{r_i} = \frac{6\,m/s}{0.23\,m/rad} = \frac{26.1\,rad}{sec}$

b) $L = I\omega = (mr^2)\omega$

$L = (1.5\,kg)(0.23\,m)^2\left(26.1\,\frac{rad}{s}\right)$

$L = 207\,\frac{kg\,m^2}{s}$

c) The net momentum (L) is clockwise. before the wheel stops, so it is clockwise after the wheel stops.

d) $L_i = L_F \Rightarrow I_i\,\omega_i = I_F\,\omega_F \leftarrow 10\,rpm$

I_i, ω_i: wheel

I_F, ω_F: unicycle + unicyclist

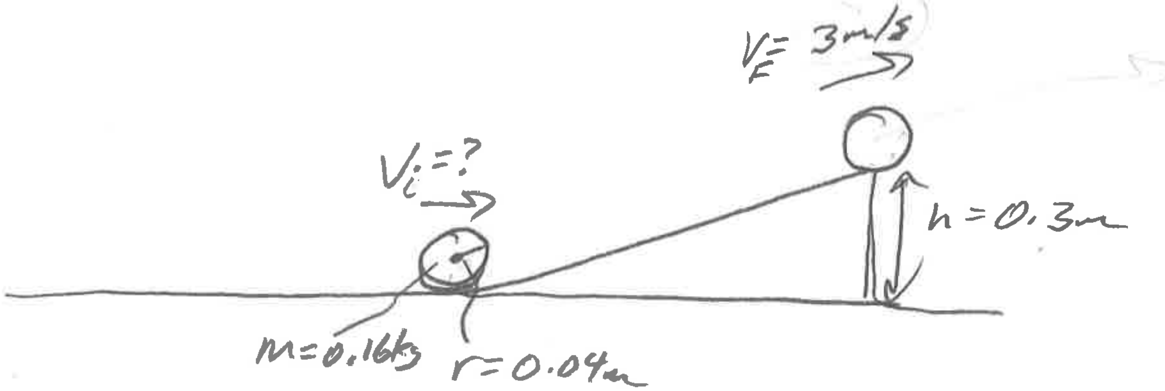
$10\,rpm$: $\left(\frac{10\,rev}{min}\right)\left(\frac{1\,min}{60\,s}\right)\left(\frac{2\pi\,rad}{rev}\right) = 1.05\,rad/s$

$207\,\frac{kg\,m^2}{s} = I_{total}\left(1.05\,\frac{rad}{s}\right)$

$I_{total} = 0.954\,kg\,m^2$

I_{total}: cyclist + unicycle

5.



$$PE_i + KE_i = PE_F + KE_F$$

$$0 + \tfrac{1}{2}mv_i^2 + \tfrac{1}{2}I\omega_i^2 = mgh + \tfrac{1}{2}mv_F^2 + \tfrac{1}{2}I\omega_F^2$$

$$\tfrac{1}{2}mv_i^2 + \tfrac{1}{2}\left(\tfrac{2}{5}m\cancel{r^2}\right)\left(\frac{v_i^2}{\cancel{r^2}}\right) = mgh + \tfrac{1}{2}mv_F^2 + \tfrac{1}{2}\left(\tfrac{2}{5}m\cancel{r^2}\right)\left(\frac{v_F^2}{\cancel{r^2}}\right)$$

$$\tfrac{1}{2}v_i^2 + \tfrac{1}{5}v_i^2 = gh + \tfrac{1}{2}v_F^2 + \tfrac{1}{5}v_F^2$$

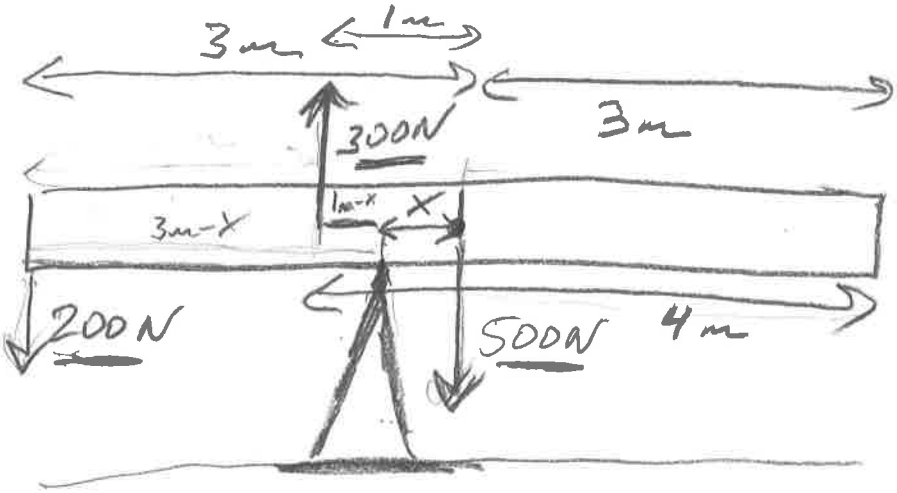
$$\tfrac{7}{10}v_i^2 = gh + \tfrac{7}{10}v_F^2$$

$$v_i^2 = \frac{10gh}{7} + v_F^2$$

$$v_i = \sqrt{\frac{10gh}{7} + v_F^2} = \sqrt{\frac{10(9.8\,m/s)(0.3\,m)}{7} + (3\,m/s)^2}$$

$$V_i = 3.63\,m/s$$

6.



$$\sum \tau = 0 \Rightarrow \tau_{ccw} = \tau_{cw}$$

$$(3m - x)(200N) = (1m - x)(300N) + (x)(500N)$$

$$600N\cdot m - 200Nx = 300N\cdot m - 300Nx + 500Nx$$

$$300N\cdot m = 400Nx$$

$$x = 0.75m$$

The fulcrum should be 0.75 to the left of the beam's center.