Phy 131 - Assignment 7

A. 1. a. Yes. Since the wheel is a rigid, solid object, you can't have parts of it making more revolutions per minute than other parts.

b. No. The farther from the center you go, the greater v is. You can see this from v = rω.

2.

$$\theta = 5t^3 - 30t + 10$$

$$\left.\begin{aligned} \omega &= \frac{d\theta}{dt} = 15t^2 - 30 \\ \alpha &= \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2} = 30t \end{aligned}\right\} \text{taking derivatives.}$$

Evaluate at $t = .8$ sec:

$$\omega = 15(.8)^2 - 30 = 9.6 - 30 = \boxed{-20.4 \ \frac{\text{RAD}}{\text{s}}} \ \text{ANS.}$$

$$\alpha = 30(.8) = \boxed{24 \ \frac{\text{RAD}}{\text{s}^2}} \ \text{ANS}$$

At the moment when it stops turning clockwise and starts turning counterclockwise, it does just that – momentarily stops. So, set ω equal to 0 and solve for t.

$$\omega = 15t^2 - 30$$

$$0 = 15t^2 - 30$$

$$30 = 15t^2$$

$$2 = t^2$$

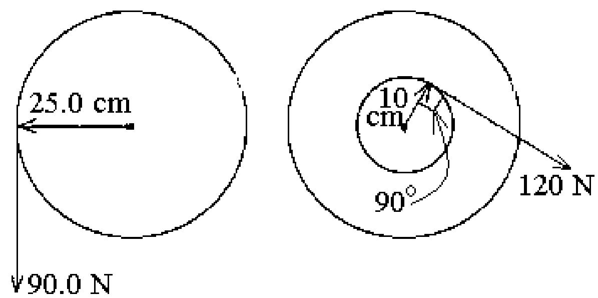
$$t = \sqrt{2} = \boxed{1.41 \ \text{s}} \ \text{ANS}$$

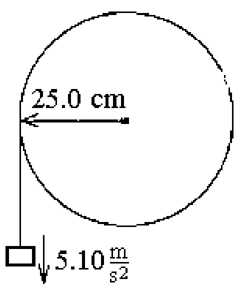
B. 1. a. angular speed: $\left(45\frac{rev}{\min}\right)\left(\frac{1\min}{60\sec}\right)\left(\frac{2\pi rad}{1rev}\right) = 4.71\frac{rad}{\sec}$

b. angular acceleration: Zero. Acceleration is the rate of change, and it says the 45 rpm is constant.

2. $\Sigma\tau = +(.25 \text{ m})(90 \text{ N}) - (.10 \text{ m})(120 \text{ N})$
$= 22.5 - 12 = 10.5 \text{ N}\cdot\text{m}$

The 30° is irrelevant. θ in $r \sin\theta F$ is the angle between r and F, which is 90°, not the angle from the horizontal.





$a_t = r\alpha$

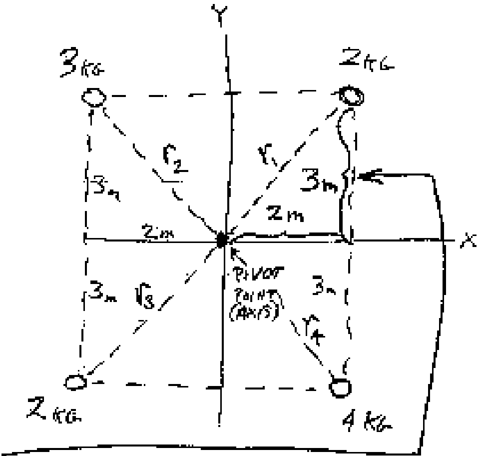
$\alpha = \frac{a_t}{r} = \frac{5.1}{.25} = 20.4 \text{ rad/s}^2$

$\tau = I\alpha \Rightarrow I = \frac{\tau}{\alpha} = \frac{10.5}{20.4} = \boxed{.515 \text{ kg}\cdot\text{m}^2}$

C. 1. No. With linear motion, no force is needed for an object to keep moving along a straight line. (Newton's first law.) In the same way, with circular motion, no torque is needed for something to keep spinning about the same axis. (Like the Earth does, for example.) Torque causes angular acceleration, not angular motion.

2. Zero. Throughout the whole table, ω stays constant. (at 5° / .01 s = 500 degrees/s) α is the rate ω changes, and it's not changing.

3.



a) $I = \sum_i m_i r_i^2$

$I = (2_{KG})(\sqrt{13})^2 + (3_{KG})(\sqrt{13}_m)^2 + (2_{KG})(\sqrt{13}_m)^2 + (4_{KG})(\sqrt{13}_m)^2$

$= 26 + 39 + 26 + 52$

$\boxed{I = 143\ \mathrm{KG \cdot m^2}}$ ANS

From triangle,

$r_1 = \sqrt{2^2 + 3^2} = \sqrt{13}\ m$

similarly, $r_2 = r_3 = r_4 = \sqrt{13}\ m$

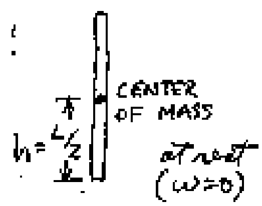
b) $KE_R = \frac{1}{2} I \omega^2$

$= \frac{1}{2}(143\ \mathrm{KG \cdot m^2})(6\ \frac{RAD}{S})^2$

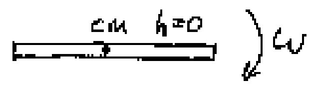
$= \boxed{2.57 \times 10^3\ J}$ ANS

D.

A) before:



after:



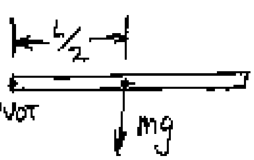
Conservation of Energy: $E_o = E_f$

$mgh_o = \frac{1}{2} I \omega_f^2$

$\cancel{m}g(\frac{\cancel{L}}{\cancel{2}}) = \cancel{\frac{1}{2}}(\frac{1}{3}\cancel{m}L^{\cancel{2}})\omega^2$ for a rod, pivoted at one end.

$g = \frac{1}{3} L \omega^2 \Rightarrow \boxed{\omega = \sqrt{\frac{3g}{L}}}$

B)



$\tau = I \alpha$

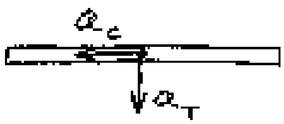
$(\frac{\cancel{L}}{2})(\cancel{m}g) = (\frac{1}{3}\cancel{m}L^{\cancel{2}})\alpha$

moment arm, force

$\frac{g}{2} = \frac{L}{3} \alpha \Rightarrow \boxed{\alpha = \frac{3g}{2L}}$

E. 1. The pole has a larger moment of inertia. (I is larger when mass is farther from the center. Its larger inertia makes the pole a more stable thing to hold on to.)

2.



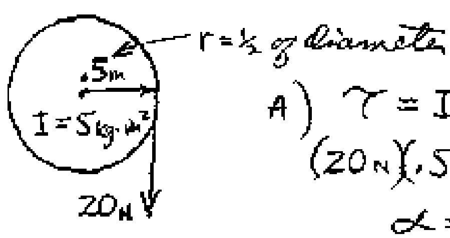
$$a_c = \frac{v^2}{r} = \frac{(r\omega)^2}{r} = r\omega^2 = \left(\frac{L}{2}\right)\left(\sqrt{\frac{3g}{L}}\right)^2$$

$$= \left(\frac{\cancel{L}}{2}\right)\left(\frac{3g}{\cancel{L}}\right) = \frac{3}{2}g$$

$$a_T = r\alpha = \left(\frac{\cancel{L}}{2}\right)\left(\frac{3g}{2\cancel{L}}\right) = \frac{3}{4}g$$

$$\boxed{\vec{a} = \underbrace{-\frac{3}{2}g\,\hat{i}}_{\text{left}} \underbrace{-\frac{3}{4}g\,\hat{j}}_{\text{down}}}$$

F.



A) $\tau = I\alpha$

$(20\text{N})(.5\text{m}) = (5\,\text{kg}\cdot\text{m}^2)\,\alpha$

$\alpha = \frac{(20)(.5)}{5} = \boxed{2.0\,\frac{\text{RAD}}{\text{s}^2}}$

B) $\omega_f = \omega_i + \alpha t = 0 + (2)(3\text{s}) = \boxed{6.0\,\frac{\text{RAD}}{\text{s}}}$

c) angle turned by wheel: $\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$

$= 0 + \frac{1}{2}(2)(3^2) = 9.0\,\text{RAD}$

length of rope unwound: $S = r\theta$

$= (.5\text{m})(9) = \boxed{4.5\text{m}}$