Physics 1403-002 Practice exam #3

Instructions: Do real good. Show your work for all problems. Partial credit will be assigned for things that make sense. $g = 9.80\, \text{m/s}^2$

Short questions: 8 points each

1. A hoop and a sphere with the same radius roll down an incline. Which travels faster, and why?
   
   Gravitational PE $\rightarrow K = \frac{1}{2} I \omega^2 + \frac{1}{2} mv^2 = \frac{1}{2} \left( \frac{2}{5} I \omega^2 + mv \right) v^2$.
   
   Bigger $I \omega^2 \rightarrow$ lower $v$ since more energy goes into rotation. So the sphere ($I = \frac{2}{5} mv^2$) goes faster than the hoop ($I = 2mr^2$).

2. A spinning wheel slows down from $\omega_0 = 25\, \text{1/s}$ to a stop with an angular acceleration of $\alpha = 0.055\, \text{1/s}^2$.
   
   How many revolutions does the wheel go through in this process?
   
   $\omega_f^2 - \omega_0^2 = 2\alpha (\theta - \theta_0)$, $\omega_f = 0$ so $\theta - \theta_0 = \frac{\omega_0^2}{2\alpha}$ revolutions!

3. The plank on the right has a mass $M$. What is the normal force exerted on the plank by the right-hand fulcrum?

   Torques about $P_1$, $\sum \tau_i = \frac{1}{2} LN_2 - \left( \frac{2}{3} - \frac{1}{3} \right) mg = 0$.
   
   $\frac{1}{2} LN_2 = \left( \frac{2}{3} - \frac{1}{3} \right) mg = \frac{1}{3} mg$
   
   $N_2 = \frac{1}{2} mg = \text{kg} \cdot \text{m/s}^2$.

4. When stars use up their nuclear fuel, they collapse to a much smaller object.
   
   If the star is initially rotating, what happens to the speed of its rotation as it collapses, and why?
   
   $\mathbf{R} \downarrow$ so $\mathbf{I} \downarrow$, and $I \cdot \omega_i = F \cdot \omega_f$
   
   (angular momentum conserved), so $\omega_f \gg \omega_i$.

5. A cylinder with radius 0.25 m and mass 3.5 kg has a string wrapped around it, and rests on a horizontal surface with which it has a frictional force. The string is pulled horizontally from the top of the cylinder with a force of 35 N. What is the acceleration of the cylinder’s center of mass?

   $\sum \mathbf{F} = \mathbf{F}_s - \mathbf{N} + \mathbf{F}_F = \mathbf{F}_s - \mathbf{N} - \mathbf{F}_{\text{fric}}$
   
   $I = \frac{1}{2} m R^2$ and $\mathbf{F}_s = 35N - ma$
   
   $35N + F_s = \frac{1}{2} m a$ and $F_s = 35N - ma$
   
6. A Yo-yo with a radius of 3.2 cm and a mass of 0.120 kg is released from rest. What is its speed after it has dropped 0.50 m?

   $mg h = K_F = \frac{1}{2} I \omega^2 + \frac{1}{2} mv^2$
   
   $I = \frac{1}{2} m R^2 = 6.14 \times 10^{-7} \text{kg} \cdot \text{m}^2$
   
   $mg h = \frac{1}{2} m R^2 \left( \frac{1}{2} \right)^2 + \frac{1}{2} mv^2$, $mg h = \frac{1}{2} \left( \frac{1}{2} m + m \right) v^2$, $mg h = \frac{3}{4} mv^2$
   
   So $v = \sqrt{\frac{4}{3} gh} = 2.56 \, \text{m/s}$

7. A submarine is at a depth of 550 m underwater. What is the pressure on the hull of the submarine?

   $P = P_{\text{atm}} + P_h = P_{\text{atm}} + Pa \cdot gh$
   
   $= 1.013 \times 10^5 \, \text{Pa} + (1000 \, \text{kg/m}^3)(9.8 \, \text{m/s}^2)(550 \, \text{m})$

   $P = 1.013 \times 10^5 \, \text{Pa} + 5.39 \times 10^6 \, \text{Pa}$

   $P = 5.49 \times 10^6 \, \text{Pa}$