

Solutions

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 $\rightarrow K = \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2 = \frac{1}{2} (\frac{I}{R^2} + m) v^2$,
 Bigger $I/R^2 \rightarrow$ lower v since more energy goes into rotation. So the sphere ($I = \frac{2}{5} m R^2$) goes faster than the hoop ($I = m R^2$).

2. A spinning wheel slows down from $\omega_i = 25 \text{ 1/s}$ 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?

$$\omega_f^2 - \omega_i^2 = 2\alpha(\theta - \theta_0), \quad \omega_f = 0 \quad \text{so} \quad \theta - \theta_0 = \frac{-\omega_i^2}{2\alpha} \quad \text{radians!}$$

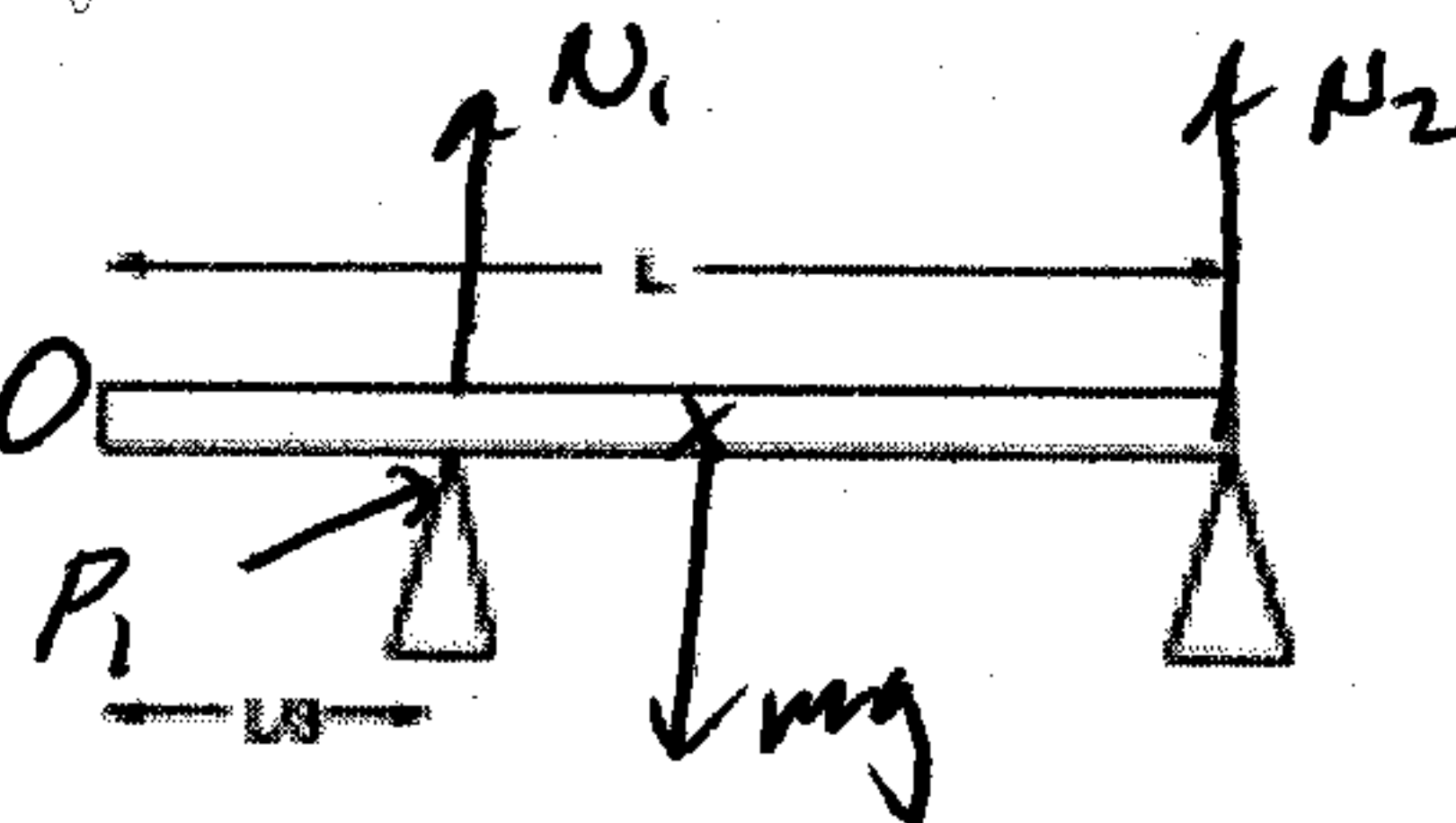
$$\# \text{ revolutions} = \frac{\theta - \theta_0}{2\pi} = \underline{904}$$

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

$$\text{Torques about } P_1, \quad \sum \tau_i = \frac{2}{3} L N_2 - (\frac{L}{2} - \frac{L}{3}) mg = 0$$

$$\frac{2}{3} L N_2 = (\frac{L}{2} - \frac{L}{3}) mg = \frac{L}{6} mg$$

$$N_2 = \frac{3}{2} \frac{1}{6} mg = \underline{mg/4}$$



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?

$R \downarrow$ so $I \downarrow$ and $I_i \omega_i = I_f \omega_f$
 (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?

\uparrow about center $(35\text{N})R + F_s R = I \alpha = \frac{1}{2} m a R$ ($I = \frac{1}{2} m R^2$)
 $\alpha = a/R$
 $35\text{N} - F_s = ma$
 So $35\text{N} + F_s = \frac{1}{2} m a$ and $F_s = 35\text{N} - ma$ $35\text{N} + 35\text{N} - ma = \frac{1}{2} m a$

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 ?

$$mgh = K_f = \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2 \quad I = \frac{1}{2} m R^2 = 6.14 \times 10^{-5} \text{ kg m}^2$$

$$mgh = \frac{1}{2} (\frac{1}{2} m R^2) (\frac{v}{R})^2 + \frac{1}{2} m v^2, \quad mgh = \frac{1}{2} (\frac{1}{2} m + m) v^2, \quad mgh = \frac{3}{4} m v^2$$

$$\text{So } v = \sqrt{\frac{4}{3} gh} = \underline{2.56 \text{ m/s}}$$

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

$$P = P_{atm} + P_h = P_{atm} + \rho_w g h$$

$$= 1.013 \times 10^5 \text{ Pa} + (1000 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(550 \text{ m})$$

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

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