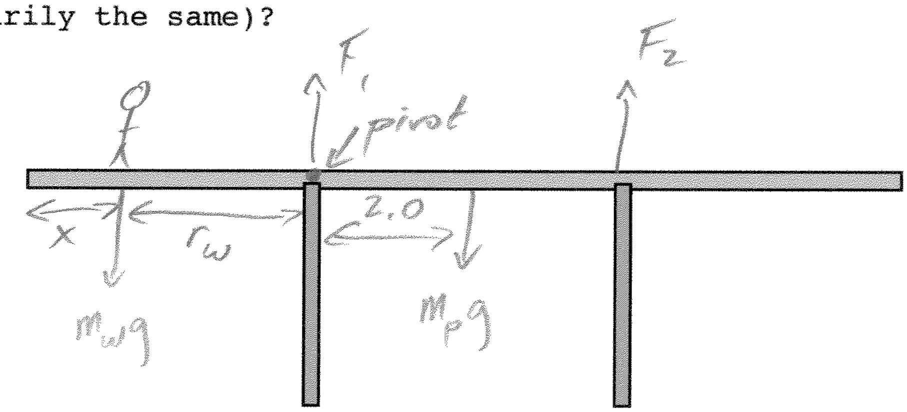
Physics 10154 - Exam #4c

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) A uniform 130-kg platform is 12 meters long. It is resting on two fixed posts, 4.0 meters from each end.

a) How close can a 95-kg worker stand to the left end before the platform will begin to tip over to the left?

b) When the worker is standing at that location, what is the normal force exerted by each beam (these forces are not necessarily the same)?



b) When platform is about to tip, $F_2 = 0$

$$\Sigma F_y = F_1 - (95)(9.8) - (130)(9.8) = 0$$

$$\boxed{\begin{aligned} F_1 &= 2200\,N \\ F_2 &= 0 \end{aligned}}$$

a) $\Sigma \tau = \tau_w + \tau_p$

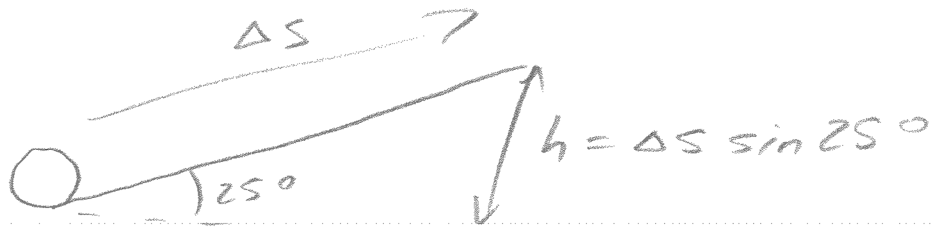
$$-r_w (95)(9.8)\sin 90 + (2.0)(130)(9.8)\sin 90 = 0$$

$$-r_w (931) + 2548 = 0$$

$$r_w = 2.74\,m$$

$$x = 4.0 - r_w = 1.3\,m$$

2. (30 pts) A uniform solid cylinder and a uniform ring are both rolling without slipping with a translational speed of 8.0 meters/sec at the bottom of a 25° upward incline. Which object travels further up the incline? Answer by determining how far each object travels before stopping.



Cylinder: $\Sigma W_F = W_{grav} = \Delta K$

$$-mgh = 0 - \left(\tfrac{1}{2} m v_0^2 + \tfrac{1}{2} I \omega_0^2\right)$$

$$-mgh = -\tfrac{1}{2} m v_0^2 - \tfrac{1}{2}\left(\tfrac{1}{2} MR^2\right)\left(\frac{v_0^2}{R^2}\right)$$

$$\cancel{m} gh = \tfrac{3}{4} \cancel{m} v_0^2$$

$$h = \frac{3 v_0^2}{4g} = 4.90$$

$$\Delta s = \frac{h}{\sin 25°} = \underline{11.6\ m}$$

Ring: $-mgh = 0 - \tfrac{1}{2} m v_0^2 - \tfrac{1}{2}(MR^2)\left(\frac{v_0^2}{R^2}\right)$

$$\cancel{m} gh = \cancel{m} v_0^2$$

$$h = \frac{v_0^2}{g} = 6.53$$

$$\Delta s = \frac{h}{\sin 25°} = \underline{15.5\ m}$$

$\boxed{\text{Ring goes further}}$

3. (40 pts) A large pipe is open to the air at both ends and rises through a vertical distance of 5.2 meters. At the bottom end of the pipe, there is a 85,000 Pa pump that adds pressure and forces the water to flow uphill. At the bottom end of the pipe, the diameter is 34 cm. At the top end of the pipe, the diameter is 22 cm.

Determine how much time it will take to fill a 42⁰⁰ gallon ~~drum~~ pool with water flowing from the top end of the pipe.

HINT: You may not neglect the velocity of the water at the bottom of the pipe. You will need to use both Bernoulli and the continuity equation to solve this one.

$$P_{bot} + \rho g Y_{bot} + \frac{1}{2}\rho V_{bot}^2 = P_{top} + \rho g Y_{top} + \frac{1}{2}\rho V_{top}^2$$

$$P_{bot} = 101300 + 85000$$

$$P_{top} = 101300$$

$$\rho g Y_{bot} = 0 \quad \text{since } Y_{bot} = 0$$

Continuity: $A_{bot} V_{bot} = A_{top} V_{top}$

$$V_{bot} = \frac{A_{top} V_{top}}{A_{bot}} = \frac{\pi d_{top}^2/4}{\pi d_{bot}^2/4} V_{top}$$

$$V_{bot} = \frac{d_{top}^2}{d_{bot}^2} V_{top} = 0.419\, V_{top}$$

$$85000 + \frac{1}{2}(1000)(.419 V_{top})^2 = (1000)(9.8)(5.2) + \frac{1}{2}(1000)V_{top}^2$$

$$85000 + 87.8 V_{top}^2 = 50960 + 500 V_{top}^2$$

$$34040 = 412.2 V_{top}^2$$

$$V_{top} = 9.09 \text{ m/s}$$

$$A_{top} V_{top} = \frac{\text{Volume}}{\text{time}}$$

$$A_{top} = \frac{\pi d_{top}^2}{4} = .038 \text{ m}^2$$

$$\text{time} = \frac{\text{Volume}}{A_{top} V_{top}}$$

$$\text{Volume} = 4200 \cdot \frac{3.786 \text{ L}}{\text{gal}} \cdot \frac{10^{-3} \text{ m}^3}{\text{L}} = 15.9 \text{ m}^3$$

$$= \boxed{46 \text{ sec}}$$