# Physics 10154 - Exam #4a

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 solid cylinder (moment of inertia $0.5MR^2$) is given an initial linear speed of 7.5 m/s. It rolls without slipping up a ramp that is inclined 33° above the horizontal. How far along the ramp does the cylinder roll before coming to a stop?

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

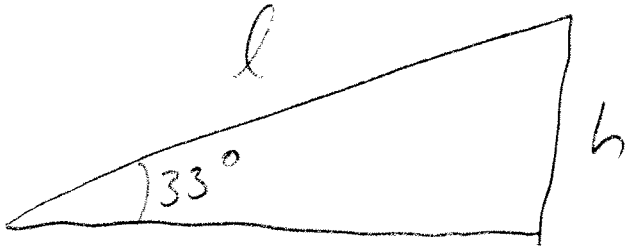
$$= \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}MR^2\right)\left(\frac{v^2}{R^2}\right)$$

$$= \frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$$

$$\Sigma W = W_{grav} = \Delta K$$

$$-mgh = 0 - \frac{3}{4}mv^2$$

$$h = \frac{3v^2}{4g} = \frac{3(7.5)^2}{4(9.8)} = 4.3\ m$$

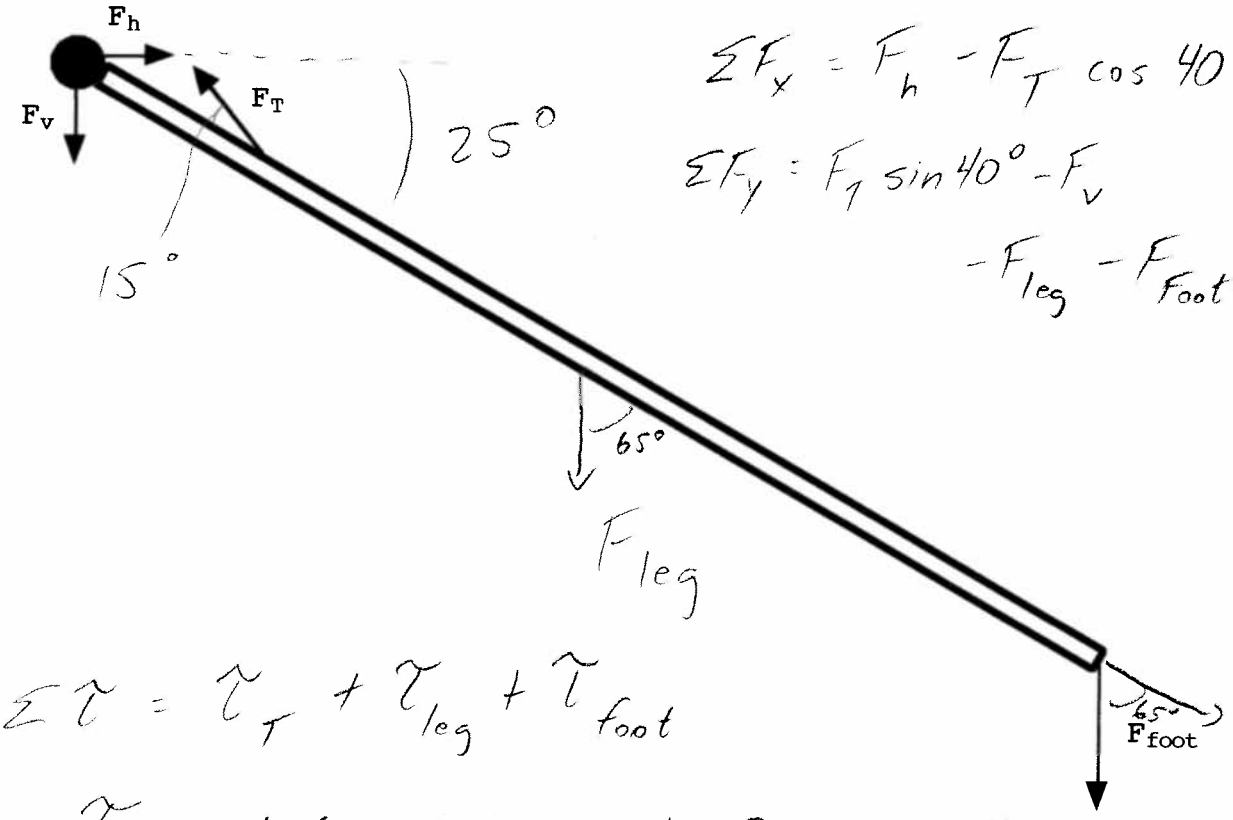



$$\sin 33^\circ = \frac{h}{\ell} \qquad \ell = \frac{h}{\sin 33^\circ}$$

$$= \boxed{7.9\ m}$$

2. (30 pts) The lower leg is represented by a uniform rod of length 38 cm and weight 32 N. Where the lower leg meets the knee, there are vertical and horizontal reaction forces exerted by the knee. On the lower end, the foot pulls vertically downward on the end of the leg with a weight of 14 N. Finally, a tendon connecting the knee to the lower leg holds the leg in place, 6.2 cm from the knee joint. Find $F_h$, $F_v$ and $F_T$.

The leg itself makes an angle of 25° below the horizontal. The tendon (denoted by $F_T$) makes an angle of 15° with the leg.




$$\Sigma F_x = F_h - F_T \cos 40^\circ = 0$$

$$\Sigma F_y = F_T \sin 40^\circ - F_v - F_{leg} - F_{foot} = 0$$

$$\Sigma \tau = \tau_T + \tau_{leg} + \tau_{foot}$$

$$\tau_T = +(.062) F_T \sin 165^\circ = .016 F_T$$

$$\tau_{leg} = -(.19)(32) \sin 65^\circ = -5.51$$

$$\tau_{foot} = -(.38)(14) \sin 65^\circ = -4.93$$

$$.016 F_T - 5.51 - 4.93 = 0 \Rightarrow F_T = \frac{10.44}{.016} = \boxed{650\ N}$$

$$F_h = F_T \cos 40 = \boxed{500\ N}$$

$$F_v = -32 - 14 + 650 \sin 40 = \boxed{370\ N}$$

3. (40 pts) While painting a water tower that is open to the air, a worker notices water leaking out of a 3.5 mm diameter hole. The water fills up a 1.0 gallon paint can in 33 seconds. How high above the hole is the surface of the water inside the tower?

$$A_V = \frac{1\ gal}{33\ s} \cdot \frac{3.786 \times 10^{-3}\ m^3}{1\ gal} = 1.15 \times 10^{-4}\ m^3/s$$

$$A = \frac{\pi (.0035)^2}{4} = 9.62 \times 10^{-6}\ m^2$$

$$V = \frac{1.15 \times 10^{-4}}{9.62 \times 10^{-6}} = 11.95\ m/s$$

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

$P_{top} = P_{bot}$ so those subtract out

Let $y_{top} = h$ and $y_{bot} = 0$

Assume $V_{top} = 0$

$$\rho g h = \frac{1}{2}\rho V_{bot}^2$$

$$h = \frac{V_{bot}^2}{2g} = \boxed{7.3\ m}$$