Physics 10154 - Fall 2018 Exam #3B

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 12-gram bullet is fired horizontally into a 340-gram stationary wooden block. The bullet embeds itself into the block. After the collision, the bullet/block system slides 13 meters across a rough horizontal surface (coefficient of kinetic friction 0.29). What is the initial velocity of the bullet?

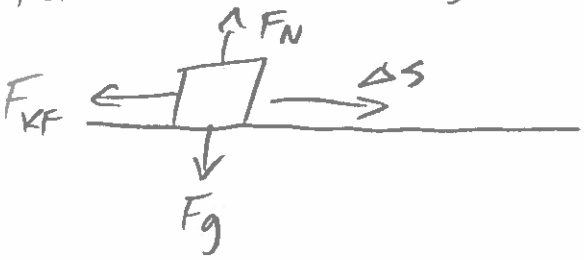
Part 1: Collision

$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$

$$.012\, v_{1i} + 0 = .352\, v_f$$

$$v_{1i} = 29.3\, v_f \leftarrow v_0 \text{ for pt 2}$$

Part 2: Sliding



$$\Sigma W_F = W_{KF} + \cancel{W_N}^{0} + \cancel{W_g}^{0} = 0 - \tfrac{1}{2} m v_0^2$$

$$-\mu_K m g \Delta s = -\tfrac{1}{2} m v_0^2$$

$$v_0 = \sqrt{2 \mu_K g \Delta s}$$

$$= 8.60 \text{ m/s}$$

Back to pt 1: $v_{1i} = (29.3)(8.60)$

$$= \boxed{250 \text{ m/s}}$$

2. (20 pts) A machine pulls thread from a spool of radius 1.3 cm. Starting from rest and pulling with a constant acceleration, the machine pulls 15 meters of thread from the spool in 8.5 seconds.

a) Through how many revolutions does spool turn during this time interval?
b) During the 8.5 second time interval, what is the angular acceleration of the spool?

$V_0 = 0$ $\quad \Delta s = V_0 t + \frac{1}{2} a t^2$

$\Delta s = 15\ m$ $\quad 15 = 0 + \frac{1}{2} a (8.5)^2$

$t = 8.5\ s$

$a = 0.415\ m/s^2$

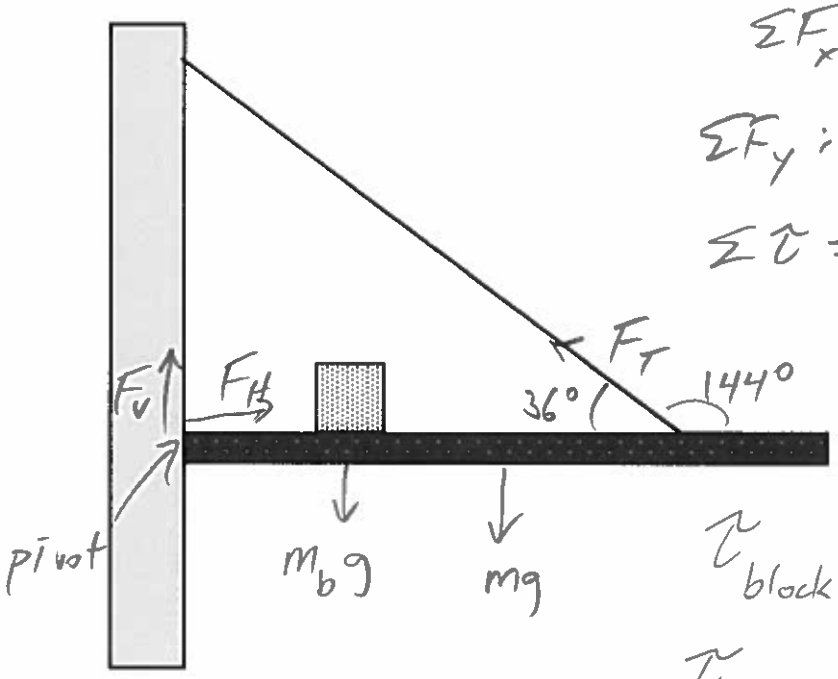
a) $\Delta\theta = \frac{\Delta s}{r} = \frac{15}{.013} = 1153.8\ rad$

$= \boxed{180\ rev}$

b) $\alpha = \frac{a}{r} = \frac{0.415}{.013} = \boxed{32\ rad/s^2}$

3. (30 pts) A horizontal, uniform beam of mass 22.0 kg is supported by a wire that is connected 80.0% of the way down the beam as measured from the wall. The wire makes a 36° angle with the horizontal. There is a 65.0 kg block resting on the beam 25.0% of the way along the beam from the wall.

Determine the magnitude and direction of the tension force in the support wire and the vertical and horizontal components of the reaction force where the beam is attached to the wall.



$$\Sigma F_x: F_H - F_T \cos 36°$$

$$\Sigma F_y: F_V + F_T \sin 36° - m_b g - mg = 0$$

$$\Sigma \tau = \tau_{block} + \tau_{beam} + \tau_T = 0$$

$$\tau_{block} = -(.25\ell)(65)(9.8)\sin 90°$$

$$\tau_{beam} = -(.5\ell)(22)(9.8)\sin 90°$$

$$\tau_T = +(.8\ell) F_T \sin 144°$$

$$\Sigma \tau = -159.25\ell - 107.8\ell + .47\ell F_T = 0$$

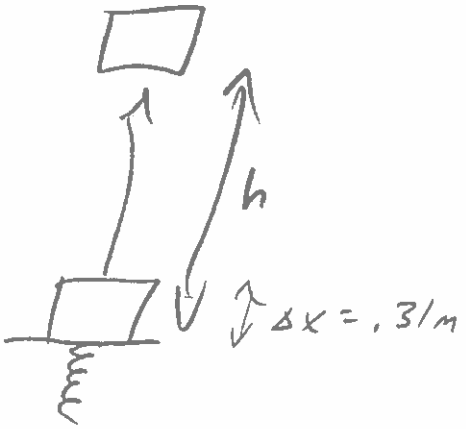
$$0.47 F_T = 267.05 \Rightarrow \boxed{F_T = 568\ N}$$

$$\Sigma F_x: F_H = F_T \cos 36° = \boxed{460\ N}$$

$$\Sigma F_y: F_V = (65)(9.8) + (22)(9.8) - F_T \sin 36°$$

$$= \boxed{519\ N}$$

4. (20 pts) A vertically oriented spring (k = 2750 N/m) is compressed by 31.0 cm, and a 4.40-kg mass is placed on the spring. The system is released from rest, and the mass is launched to a maximum height of 2.68 meters above the point at which it was initially released from rest. How much work do frictional forces do during this motion?



$$\Sigma W_F = W_{spr} + W_{grav} + W_{Fric} = \Delta K$$

$$W_{spr} = +\frac{1}{2}kx^2 = 132.14\ J$$

$$W_{grav} = -mgh = -115.56\ J$$

$$W_{Fric} = ?$$

$$\Delta K = 0 - 0 = 0$$

$$132.14 - 115.56 + W_{Fric} = 0$$

$$\boxed{W_{Fric} = -16.6\ J}$$