Physics 10154 - Exam #3A

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) Two pucks have a 1-dimensional, elastic collision on a frictionless, horizontal surface. Puck A has half the mass of puck B and is initially moving along the x-axis with a velocity of 7.44 m/s, and puck B is initially at rest.

a) After the collision, what is the magnitude and direction of the velocity of each puck?
b) Puck B is a pendulum bob attached to a vertical string of length 2.1 meters. After the collision, what is the maximum angle the string makes with the vertical?

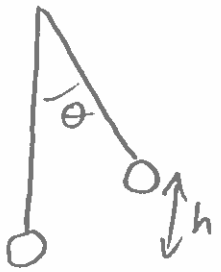
a) $v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} + 0 = \frac{m - 2m}{m + 2m}(7.44) = -\frac{1}{3}(7.44)$

$= \boxed{-2.48 \text{ m/s}}$

$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i} + 0 = \frac{2m}{m + 2m}(7.44) = \frac{2}{3}(7.44)$

$= \boxed{4.96 \text{ m/s}}$ use v_{2f} as v_0

b)



$\Sigma W = -mgh = 0 - \frac{1}{2}mv_0^2$

$h = \frac{v_0^2}{2g} = 1.255\text{m}$

$h = \ell(1 - \cos\theta)$

$1.255 = 2.1(1 - \cos\theta)$

$0.5977 = 1 - \cos\theta$

$\cos\theta = 0.4023$

$\boxed{\theta = 66.3^\circ}$

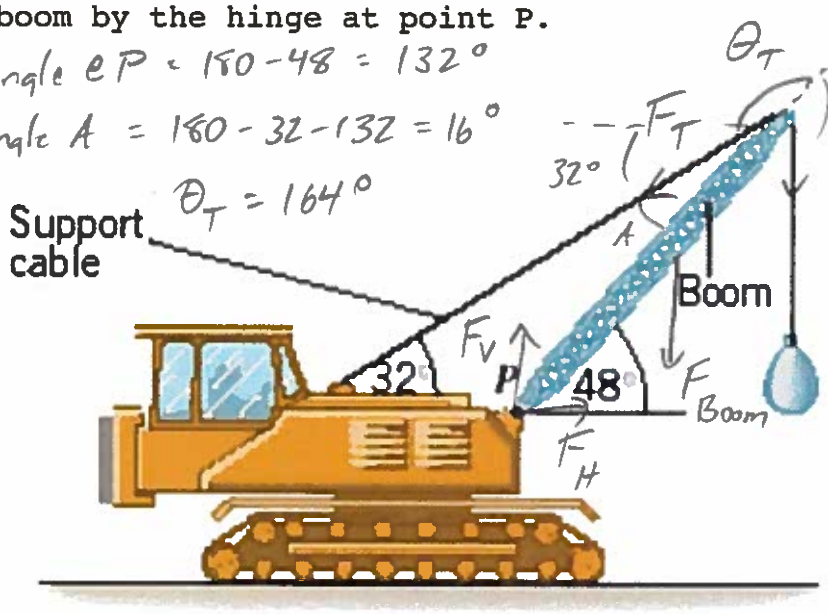
2. (35 pts) A wrecking ball (weight = 4550 N) is supported by a boom, which is uniform and weighs 3280 N. The boom makes an angle of 48.0° with the horizontal, and a supporting rope attached from the tractor to the end of the boom makes an angle of 32.0° with the horizontal. Find the magnitude of the tension in the supporting cable as well as the horizontal and vertical components of the reaction force exerted on the lower end of the boom by the hinge at point P.

Angle eP = 180 − 48 = 132°

Angle A = 180 − 32 − 132 = 16°

$\theta_T = 164°$

θ_T : 90 + 48 = 138°



$\tau_{Boom} = -\frac{\ell}{2}(3280)\sin 138°$

$\tau_{ball} = -\ell(4550)\sin 138°$

$\tau_T = +\ell(F_T)\sin 164°$

$\Sigma F_x = -F_T \cos 32° + F_H = 0$

$\Sigma F_y = F_V - 4550 - 3280 - F_T \sin 32° = 0$

$\Sigma \tau = \tau_{boom} + \tau_{ball} + \tau_T = 0$

$= -\ell(1097.4) - \ell(3044.5) + \ell(.2756)F_T = 0$

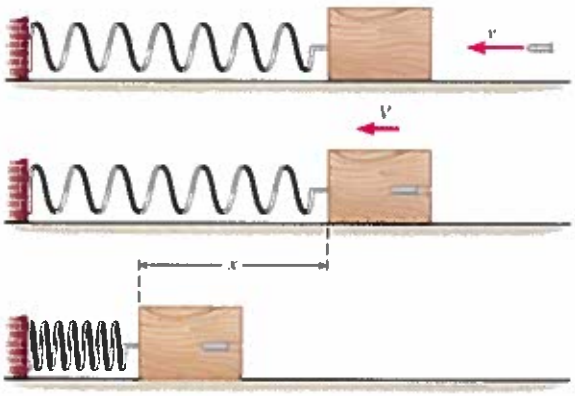
$\Rightarrow F_T = \frac{4141.9}{.2756} = \boxed{15000\ N}$

$F_H = -F_T \cos 32° = \boxed{12700\ N}$

$F_V = F_T \sin 32 + 4550 + 3280 = \boxed{15800\ N}$

3. (35 pts) A 24.5-gram bullet is fired into a 3.50-kg wooden block attached to one end of a massless, horizontal spring (k = 825 N/m). The other end of the spring is fixed, and the spring is initially in equilibrium. The bullet strikes the block and becomes embedded, and after the collision, the system oscillates back and forth with an amplitude of 18.0 cm.

a) What is the initial speed of the bullet?
b) How far is the block from equilibrium when the kinetic energy is equal to the the potential energy of the system?



a) $E = \frac{1}{2}kA^2 = \frac{1}{2}mv_{max}^2$

$v_{max} = \sqrt{\frac{k}{m}}\,A$

$= \sqrt{\frac{825}{3.5245}}\,(.18) =$

$= 2.75\ m/s$

v_f ↗ for collision

$m_1 v_{1i} + 0 = (m_1 + m_2) v_f$

$v_{1i} = \frac{3.5245}{.0245}(2.75) =$ **396 m/s**

b) $U = \frac{1}{2}kx^2$

Want $\frac{1}{2}kx^2 = \frac{1}{2}E$

$\frac{1}{2}kx^2 = \frac{1}{2}\left(\frac{1}{2}kA^2\right)$

$x = \sqrt{\frac{1}{2}}\,A = .707A =$ **12.7 cm**