Physics 10154 - Fall 2018 Exam #3A

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 pendulum string of length 2.9 meters holds a pendulum bob of unknown mass at its end. The string is pulled back so that it makes an angle of 31° with respect to the vertical and released from rest.

At the lowest point of its motion, the pendulum bob collides with a blob of putty initially at rest that is one-half as massive as the pendulum bob, and the two stick together after the collision. After the collision, the combined mass, still connected to the string, rises to what maximum height?

Part 1: Pendulum falls

$$h = \ell - \ell\cos\theta = 0.4142\,m$$

$$\Sigma W_F = W_g = \tfrac{1}{2}mv^2 - 0$$

$$+mgh = \tfrac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh} = 2.85\,m/s$$

↓ v_{1i} for part 2

Part 2: Collision

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

$$m(2.85) + 0 = (m + \tfrac{1}{2}m) v_f$$

$$2.85 = 1.5\, v_f \Rightarrow v_f = 1.9\,m/s$$

→ v_0 for part 3

Part 3: Pendulum rises

$$\Sigma W_F = W_g = 0 - \tfrac{1}{2}mv_0^2$$

$$-mgh = -\tfrac{1}{2}mv_0^2$$

$$h = \frac{v_0^2}{2g} = \boxed{0.18\,m}$$

2. (20 pts) A car drives along a horizontal road with an initial speed of 35 miles/hour. The car accelerates for 12 seconds and reaches a final speed of 49 miles/hour. The radius of one tire is 32 cm. If the tires roll without slipping…

a) Through how many revolutions does a tire go during this time interval?

b) During the 12 second time interval, what is the angular acceleration of a tire?

$V_0 = 35\ mi/hr = 15,643\ m/s$

$V = 49\ mi/hr = 21.900\ m/s$

$t = 12\ s$

$$a = \frac{v - v_0}{t} = 0,5214\ m/s^2$$

$$\Delta s = \frac{1}{2}(v + v_0)t = 225.258\ m$$

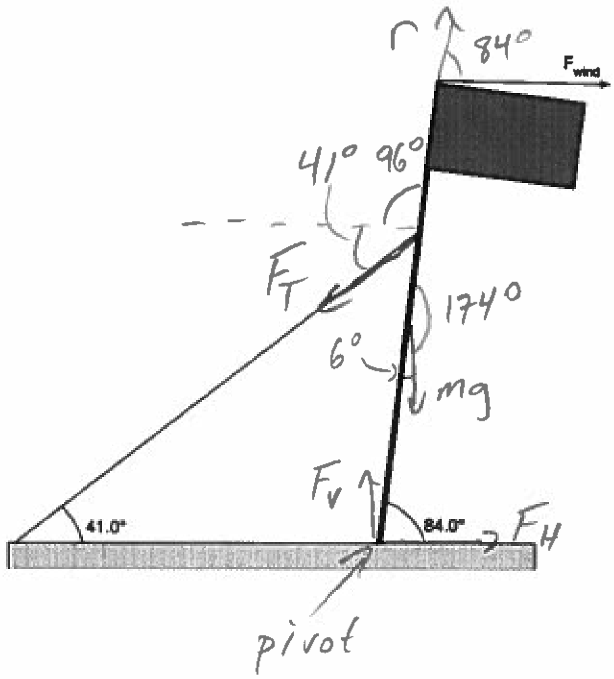
a) $$\Delta\theta = \frac{\Delta s}{r} = \frac{225.258}{.32} = 704\ rad \cdot \frac{1\ rev}{2\pi\ rad}$$

$$= \boxed{110.\ rev}$$

b) $$\alpha = \frac{a_{tan}}{r} = \frac{0,5214}{.32} = \boxed{1.6\ rad/s^2}$$

3. (30 pts) A uniform 45.0-kg flagpole is tilted as shown below. A strong wind causes the flag to pull horizontally on the flagpole at the top end with a force of 180 N (ignore the weight of fabric that makes up the flag). A support cable is connected to the flagpole as shown at a distance 75% of the way along the length of the pole from the ground.

Determine the magnitude and direction of the tension force in the support cable and the vertical and horizontal components of the reaction force where the flag is attached to the ground.



$$\Sigma F_x = F_{wind} - F_T \cos 41° + F_H = 0$$

$$\Sigma F_y = F_V - F_T \sin 41° - mg = 0$$

$$\Sigma \tau = \tau_{wind} + \tau_T + \tau_{grav} = 0$$

$$\tau_{wind} = -\ell F_{wind} \sin 84°$$

$$\tau_T = +.75\ell F_T \sin 137°$$

$$\tau_{grav} = -0.50\ell (mg) \sin 174°$$

$$\Sigma \tau = -\ell(179.014) + \ell F_T(.5115) - \ell(23.049) = 0$$

$$-179.014 - 23.049 + .5115 F_T = 0$$

$$\Rightarrow \boxed{F_T = 395\ N}$$

$$\Sigma F_x: F_H = F_T \cos 41° - F_{wind} = (395)\cos 41° - 180 = \boxed{118\ N}$$

$$\Sigma F_y: F_V = mg + F_T \sin 41° = (45)(9.8) + (395)\sin 41° = \boxed{700\ N}$$

4. (20 pts) A 245-gram mass is attached to a spring with k = 1430 N/m. The spring is stretched by 35.0 cm and released from rest to oscillate back and forth on a frictionless, horizontal surface.

a) What is the mechanical energy of the system?
b) What is the velocity of the mass when it passes through the equilibrium position of the spring?
c) For what value of x (displacement from equilibrium) is the potential energy of the spring equal to 33.3% of the total energy?

a) $E = \frac{1}{2}kA^2 = \frac{1}{2}(1430)(.35)^2 = \boxed{87.6\text{ J}}$

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

$v_{max} = \sqrt{\frac{k}{m}}A = \sqrt{\frac{1430}{.245}}(.35) = \boxed{26.7\text{ m/s}}$

c) When is $U = \frac{1}{3}E$?

$\frac{1}{2}kx^2 = \frac{1}{3}\left(\frac{1}{2}kA^2\right)$

$x = \sqrt{\frac{1}{3}}A = \boxed{20.2\text{ cm}}$