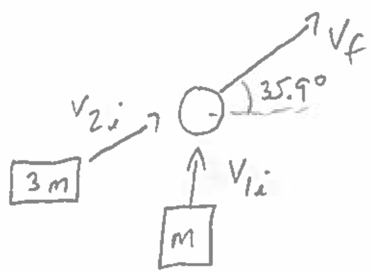
Physics 10154 - Exam #3A

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 car moving North with an unknown speed collides with a truck that is 3.00 times as massive as the car. The truck is moving in a direction 24.0° North of East initially with a speed of 46.0 m/s. After the collision, the two vehicles stick together and move off at an angle of 35.9° North of East.

a) What was the speed of the car prior to the collision?
b) What is the combined speed of the two vehicles after the collision?



x: $m(0) + 3m(46\cos 24°) = 4m\, v_{f,x}$

$126.07 = 4 v_{f,x}$

$v_{f,x} = 31.5\ m/s = v_f \cos 35.9°$

$v_f = 38.9$

y: $m(v_{1i}) + 3m(46 \sin 24°) = 4m v_f \sin 35.9°$

$v_{1i} + 56.13 = 4(38.9)\sin 35.9° = 91.24$

$\boxed{v_{1i} = 35.1\ m/s}$

b) $\boxed{v_f = 38.9\ m/s}$

2. (20 pts) The second hand of a wall clock has a length of 12.0 cm. Answer both parts with 3 SF.

a) How much distance does the tip of the second hand travel during a day (in meters)?

b) The minute hand of the clock has a length of 10.5 cm. How many revolutions is needed for the minute hand to travel one mile?

a) $r = 0.120\ m$

$t = 1\ day = 86400\ s$

$\omega = \frac{1\ rev}{min} = \frac{2\pi\ rad}{60\ s} = .1047\ rad/s$

$\Delta\theta = \omega t = 9048\ rad$

$\Delta s = r\,\Delta\theta = \boxed{1090\ m}$

b) $\Delta\theta = \frac{\Delta s}{r} = \frac{1609\ m}{.105\ m} = 15324\ rad$

$15324\ rad \cdot \frac{1\ rev}{2\pi\ rad} = \boxed{2440\ rev}$

3. (30 points) A sphere rolls up a 7.70-meter long ramp angled 22.0° above the horizontal with an initial speed of 8.50 m/s. What is the linear speed of the sphere when it reaches the top of the ramp, assuming no work is done by frictional forces?

$$K = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{v^2}{R^2}\right)$$

$$= \frac{1}{2}mv^2 + \frac{2}{10}mv^2 = \frac{7}{10}mv^2$$

$$\Sigma W_F = -mgh = \frac{7}{10}mv^2 - \frac{7}{10}mv_0^2$$

$$-\frac{10}{7}gh = v^2 - v_0^2$$

$$v^2 = v_0^2 - \frac{10}{7}gh$$

$$= (8.5)^2 - \frac{10(9.8)(7.70 \sin 22°)}{7}$$

$$= 72.25 - 40.38$$

$$= 31.87$$

$$\boxed{v = 5.65 \text{ m/s}}$$

4. (20 pts) A 265-gram mass is attached to a spring with spring constant k_s = 757 N/m on a frictionless, horizontal surface. When the spring is at its equilibrium length, the mass is given an initial speed of 4.65 m/s.

a) What is the amplitude of the spring's oscillation?
b) At what distance from the equilibrium length is the system's kinetic energy equal to 33.3% of its total mechanical energy?

a) $V_{max} = 4.65\ m/s$

$$E = \frac{1}{2} m V_{max}^2 = 2.865\ J$$

$$2.865 = \frac{1}{2} k A^2$$

$$\Rightarrow A^2 = .00757$$

$$\boxed{A = .0870\ m}$$

or 8.70 cm

b) If $K = 0.333E$, then $U = .667E$

$$\frac{1}{2} k x^2 = .667\left(\frac{1}{2} k A^2\right)$$

$$x = \sqrt{.667}\,A$$

$$= \boxed{.0711\ m} \text{ or } 7.11\ cm$$