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. (40 pts) A 12 gram bullet is fired into a 450 gram block that is initially at rest on a frictionless, horizontal surface against a spring with k = 120 N/m. The bullet remains in the block after the collision. After the collision, the bullet-block system compresses the spring by a maximum amount of 13 cm. Determine the initial speed of the bullet.

Collision:

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

$$0.012\, v_{1i} = 0.462\, v_f$$

Spring:

$W_{spr} = \Delta K$ since F_{spr} is only force that does work

$$-\tfrac{1}{2} k x^2 = 0 - \tfrac{1}{2} m v_0^2$$

$$(120)(0.13)^2 = (.462)\, v_0^2$$

$$v_0 = 2.095 \Rightarrow v_f \text{ from pt 1}$$

$$0.012\, v_{1i} = (0.462)(2.095)$$

$$\boxed{v_{1i} = 81 \text{ m/s}}$$

2. (30 pts) Two cars of equal mass collide at an intersection. Car A was originally moving East at 22.0 m/s, and car B was initially moving 65.0° North of East with an unknown speed. After the collision, the two cars stick together and move as a unit at a speed of 16.6 m/s in a direction 28.0° North of East. What was the initial speed of car B?

$$y: \quad m_1 v_{1i,y} + m_2 v_{2i,y} = (m_1 + m_2) v_{f,y}$$

$$m(0) + m v_{2i} \cdot \sin 65^\circ = 2m(16.6) \sin 28^\circ$$

$$v_{2i} = \frac{2(16.6)\sin 28^\circ}{\sin 65^\circ}$$

$$= \boxed{17.2 \text{ m/s}}$$

Check:

$$x: \quad m(22) + m v_{2i} \cos 65^\circ = 2m(16.6)\cos 28^\circ$$

$$22 + v_{2i} \cos 65^\circ = 33.2 \cos 28^\circ$$

$$v_{2i} \cos 65^\circ = 7.31$$

$$v_{2i} = 17.3 \text{ m/s}$$

3. (30 pts) A car on a circular track of radius 75 meters starts from rest and accelerates at a rate of 1.2 m/s^2. The coefficient of static friction between the tires and the pavement is 0.82. How far (in meters) does the car travel around the track with this constant acceleration before skidding off the track due to excessive speed?

Car skids when $\Sigma F_{rad} = -F_{sf,MAX} + \frac{mv^2}{r} = 0$

$$\frac{mv^2}{r} = \mu_s mg$$

$$v = \sqrt{\mu_s g r} = \sqrt{(.82)(9.8)(75)} = 24.5 \text{ m/s}$$

$v_0 = 0$

$a = 1.2 \text{ m/s}^2$

$$v^2 = v_0^2 + 2a\Delta s$$

$$24.5^2 = 0 + 2(1.2)\Delta s$$

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