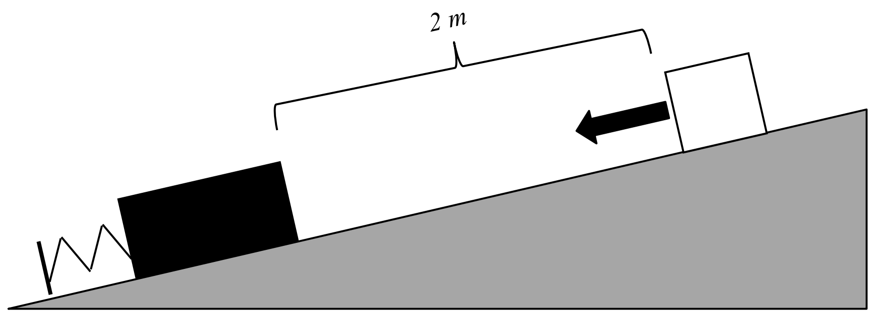
PHY 131 Fall 2018
Exam #6: *Momentum*
*(50 points each)* NAME________________________________

SHOW ALL WORK and BOX YOUR ANSWERS

1. A 1.0-kg block is released from rest 2.0 meters up the ramp from a 2.0-kg block resting against an uncompressed spring. The frictionless ramp is inclined at 25° above the horizontal. After the 1-kg block hits and sticks to the 2-kg block, they both come to a stop after compressing the spring a distance of 50 cm. What is the stiffness constant of the spring?




We first need to get the speed of the 1 kg block after it slides 2 m down the incline. We can do this with conservation of energy. The change in the height of the 1 kg mass when it slides 2 m down the incline is (2 m) sin 25°, which is 0.845 m. We now can write.

$$\frac{1}{2}(1\text{ kg})v^2 = (1\text{ kg})\left(10\frac{\text{m}}{\text{sec}^2}\right)(0.845\text{ m}) = 8.45\text{ J}$$

Which give us a collision speed of 4.11 m/sec. Now we use conservation of momentum.

$$(1\text{ kg})\left(4.11\frac{\text{m}}{\text{sec}}\right) = 3\text{ kg } v$$

The speed of the combined masses just after the collision is thus 1.37 m/sec.

The KE and GPE of the combined blocks all gets transformed into EPE.

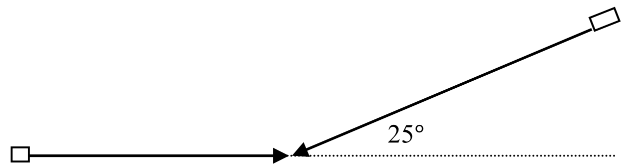
If we call the distance the spring stretches 50 cm, the height the combined masses falls is 50 cm sin 25°. Using conservation of energy again, we get

$$\frac{1}{2}k(0.5\ m)^2 = (1\text{ kg})\left(10\frac{\text{m}}{\text{sec}^2}\right)(0.5\text{ m }\sin 25°) + \frac{1}{2}(3\text{ kg})(1.37\text{ m/sec})$$

$$\frac{1}{2}k(0.5\ m)^2 = 2.11\text{ J} + 2.81\text{ J} = 4.92\text{ J}$$

$$\boxed{k = 39.4\text{ N/m}}$$

2. A 10-gram confederate lead bullet is traveling at 250 m/sec to the right and an 8-gram union bullet is traveling at 300 m/sec toward but at an angle of 25° with the confederate lead bullet (see figure). The bullets collide and stick together.




a) What is the direction of travel of the combined masses after the collision?
b) How much thermal energy is generated in the collision?

We start by getting the initial momentum of the two-bullet system - in both the horizontal and vertical directions.

The initial momentum in the horizontal direction is

$$p_{x,i} = (10 \text{ grams})(250 \text{ m/sec}) + (8 \text{ grams})(-300 \text{ m/ sec} \times \cos 25°) = +324.9 \text{ g} \cdot \text{m/sec}$$

$$p_{y,i} = (8 \text{ grams})(-300 \text{ m/ sec} \times \sin 25°) = -1014 \text{ g} \cdot \text{m/sec}$$

The final momentum of the combination of the two bullets must be the same.

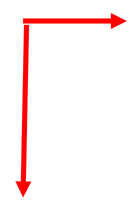
$$p_{x,f} = (18 \text{ grams})v_x = +324.9 \text{ g} \cdot \text{m/sec}$$

Therefore, the speed of the 18 g combination in the horizontal direction is +18.0 m/sec.

$$p_{y,f} = (18 \text{ grams})v_y = -1014 \text{ g} \cdot \text{m/sec}$$

Therefore, the speed of the 18 g combination in the vertical direction is +53.3 m/sec.

The speed of the 18-gram combination is



$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{18.0^2 + 53.3^2} = 59.2 \text{ m/sec}$$

The direction is:

$$\theta = \arctan\frac{53.3}{18.0} = 71.3°$$

| The combination of the two bullets is traveling at 59.2 m/sec @ 71.3° below the positive horizontal axis. |
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b) The initial kinetic energy of the two bullets is:

$$KE_i = \frac{1}{2}(0.010\ kg)(250\ m/\text{sec})^2 + \frac{1}{2}(0.008\ kg)(3000\ m/\text{sec})^2 = 312.5\ J + 360\ J = 672.5\ J$$

The final kinetic energy of the two-bullet combination is:

$$KE_i = \frac{1}{2}(0.018\ kg)(59.2\ m/\text{sec})^2 = 31.5\ J$$

So, 641 of the 672.5 Joules of kinetic energy were "transformed" into thermal energy. This is **95%**.