

Name: _____

You may answer the questions in the space provided here, or if you prefer, on your own notebook paper.

1. **Chapter 8: 37**

A shell of mass m and speed v explodes into two identical fragments. If the shell was moving horizontally with respect to Earth, and one of the fragments is subsequently moving vertically with speed v , find the velocity \mathbf{v} of the other fragment immediately following the explosion.

Solution: Since the fragments are identical, they split the mass and each has a mass of $m/2$.

The initial momentum is:

$$p_i = mv\hat{i}$$

The final momentum is

$$p_f = \frac{m}{2}v\hat{j} + \frac{m}{2}\mathbf{v}$$

In order to balance $p_i = p_f$, we need $\mathbf{v} = 2v\hat{i} - v\hat{j}$

2. Someone shoots a pellet gut a piece of cheese that sits on a massive block of ice. The 1.2 g pellet gets stuck in the cheese causing it to slide 25 cm before coming to a stop. If the muzzle velocity of the gun is known to be 65 m/s and the cheese has a mass of 120 g, what is the coefficient of friction between the cheese and the ice?

Solution: Start with momentum, find the velocity of the cheese after being struck, relate that to the force of friction needed to accelerate the cheese to rest.

Initial momentum of the bullet-cheese system:

$$p_i = m_b v_{b,i} + m_c v_{c,i} = 0.0012(65) + .120(0) = 0.078 \frac{\text{kg m}}{\text{s}}$$

Since the pellet gets stuck in the cheese, they will have the same final velocity:

$$p_f = (m_b + m_c) v_f = 0.1212v_f$$

Conservation:

$$p_i = p_f \rightarrow (0.1212 \text{ kg}) v_f = 0.078 \frac{\text{kg m}}{\text{s}}$$

We solve and find $v_f = 0.64 \frac{\text{m}}{\text{s}}$.

Now recall from the kinematic equations we have:

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

Since we know it goes 0.25 meters before coming to a stop,

$$0 = 0.64^2 + 2a(0.25) \rightarrow a = 0.83 \frac{\text{m}}{\text{s}^2}$$

Now recall that the friction force is related to the normal force as $f = \mu F_N$. The normal force in this case is going to be the opposite of the gravitational force since it is on a flat surface and nothing else but gravity and the surface are acting on the body, so $F_N = (m_b + m_c)g = 1.1878N$.

However, we just found the acceleration from the friction force, so we know that $f = (m_b + m_c)a = 0.1212(0.83) = 0.1N$.

$$0.1N = \mu(1.19N) \rightarrow \mu = 0.085$$

3. **Chapter 8: 47** A 60 g handball moving with a speed of 5.0 m/s strikes the wall at 40° angle with the normal and then bounces off with the same speed at the same angle. It is in contact with the wall for 2.0 ms. What is the average force exerted by the wall?

Solution:

$$F_{avg} = \frac{\Delta P}{\delta} = \frac{0.060 \text{ kg} (5 \cos(40) - -5 \cos(40))}{0.002s} = 230N$$

4. **Chapter 8: 87** A puck of mass 5.0kg moving at 2.0 m/s approaches an identical puck that is stationary on frictionless ice. After the collision, the first puck leaves with a speed of v_1 at 30° to the original line of motion; the second puck leaves with speed v_2 at -60° relative to the original line of motion.

Solution:

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$5(2.0)\hat{i} + 0 = \left(5v_1 \cos(30)\hat{i} + 5v_1 \sin(30)\hat{j}\right) + \left(5v_2 \cos(60)\hat{i} - 5v_2 \sin(60)\hat{j}\right)$$

Matching \hat{i} and \hat{j} , we require:

$$5v_1 \sin(30) = 5v_2 \sin(60) \quad \text{rightarrow} \quad v_1 = 1.7v_2$$

and

$$10 = 5v_1 \cos(30) + 5v_2 \cos(60) = 5(1.7)v_2 \cos(30) + 5v_2 \cos(60)$$

we solve to find,

$$10 = v_2(7.36 + 2.5) \quad \rightarrow \quad v_2 = 1.01 \frac{\text{m}}{\text{s}^2}$$

and

$$v_1 = 1.7v_2 = 1.72 \frac{\text{m}}{\text{s}^2}$$

Clean up with sig-figs...

5. A 1500 kg car traveling north at 70 km/h collides at an intersection with a 2000 kg car traveling west at 55 km/h. The two cars stick together. (a) What is the total momentum of the system before collision? (b) What are the magnitude and direction of the velocity of the wreckage just after the collision?

Solution:

$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$$

$$p_i = 1500(70)\hat{j} - 2000(55)\hat{i} = -110,000\frac{\text{kg km}}{\text{hour}}\hat{i} + 105,000\frac{\text{kg km}}{\text{hour}}\hat{j}$$

$$p_f = (m_1 + m_2)v = 3500v$$

Separate the x and y:

$$-110,000\hat{i} = -3500v \cos(\theta)\hat{i}$$

$$105,000\hat{j} = 3500v \sin(\theta)\hat{j}$$

$$\tan(\theta) = 105,000/110,000 \rightarrow \theta = 44$$

$$\frac{105,000}{3500 \sin(43.6)} = 43.5 \text{ km/hour}$$