Name MC

Date Hour

# Momentum Review Sheet

1. A rifle recoils while firing a bullet. Explain why the speed of the rifle's recoil is small compared to the speed of the bullet.

Overall the momentum before firing was zero therefore the momentum after will also have to be zero. Due to this the rifles momentum will have to be equal in magnitude to the momentum of the bullet. Since the rifle has such a larger mass the speed will be less than that of the bullet which has a small mass and a very large speed.

2. An egg dropped on concrete usually breaks while one dropped on grass usually doesn't break. Explant why this is true, your answer should include discussion about time and force.

In both cases the change in momentum will be the same. In the case of the grass the force will be less because it will be applied over a greater period of time. Due to this decrease in force the egg is less likely to break.

3. The following questions refer to the motion of a sports car.

a. Calculate the momentum of a 1000 kg sports car traveling at 30 m/s.

$$p = mv = 1000kg(30\tfrac{m}{s}) = 30{,}000\tfrac{kg\cdot m}{s} = 3.0\times10^4\ \tfrac{kg\cdot m}{s}$$

b. Determine the impulse needed to increase the car's speed from 30 m/s to 35 m/s.

$$F\Delta t = m\Delta v \Rightarrow m\Delta v = 1000kg(35\tfrac{m}{s} - 30\tfrac{m}{s}) = 5000\tfrac{kg\cdot m}{s} = 5.0\times10^3 N\cdot s$$

c. In a sad turn of events, the same sports car, formerly traveling at 35 m/s, plows into a rock wall and comes to rest in 0.25 seconds. Determine the size of the force the rock wall exerts on the car.

$$F\Delta t = m\Delta v \Rightarrow F = \frac{1000kg(0\tfrac{m}{s} - 35\tfrac{m}{s})}{0.25s} = \frac{1000kg(-35\tfrac{m}{s})}{0.25s} = -140{,}000N$$

d. How does the size of the force the rock wall exerts on the car compare to the force the car exerts on the rock wall? Briefly explain. Which of Newton's laws of motion applies to your answer?

Newton's 3rd Law tells us that the force the wall exerts on the car is equal to the force the car exerts on the wall. They are however in opposite directions.

4. The following questions refer to the motion of a baseball.

a. While being thrown, a net force of 132 N acts on a baseball (mass = 140 g) for a period of 4.5 x $10^{-2}$ sec. What is the magnitude of the change in momentum of the ball?

$$F\Delta t = m\Delta v \Rightarrow F\Delta t = 132N(0.045s) = 5.9N\bullet s = 5.9\tfrac{kg\bullet m}{s}$$

b. If the initial speed of the baseball is v = 0.0 m/s, what will its speed be when it leaves the pitcher's hand?

$$m\Delta v = 5.9\tfrac{kg\bullet m}{s} \Rightarrow \Delta v = \frac{5.9\tfrac{kg\bullet m}{s}}{140g\,\tfrac{1kg}{1000g}} = \frac{5.9\tfrac{kg\bullet m}{s}}{0.140kg} = 42\tfrac{m}{s}$$

c. When the batter hits the ball, a net force of 1150 N, opposite to the direction of the ball's initial motion, acts on the ball for 9.0 x $10^{-3}$ s during the hit. What is the final velocity of the ball?

$F\Delta t = m\Delta v \Rightarrow F\Delta t = -1150N(0.0090s) = (0.140kg)\Delta v \Rightarrow \Delta v = -74\frac{m}{s}$

$v_i$

$\Delta v = v_f - v_i \Rightarrow v_f = \Delta v + v_i \Rightarrow v_f = -74\frac{m}{s} + 42\frac{m}{s} = -32\frac{m}{s}$

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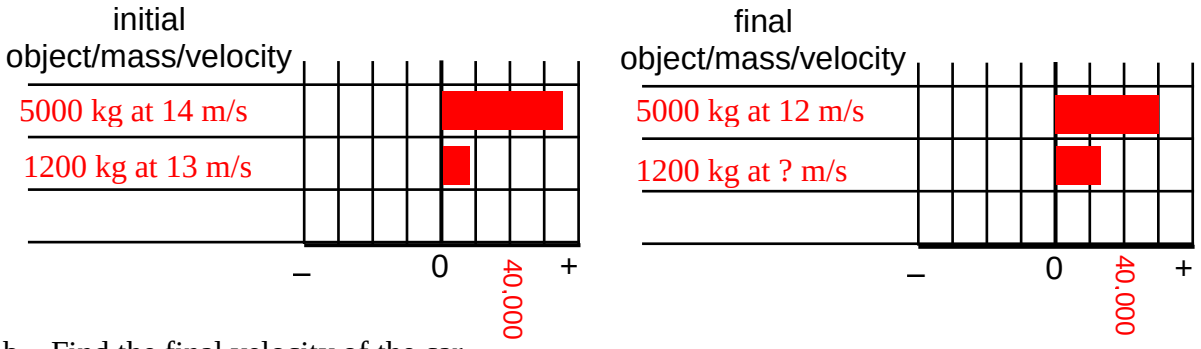
d. How large is the force the ball exerts on the bat? Explain.

The ball exerts a force on the bat of 1150N. Ball on bat and bat on ball are a 3rd Law pair.

5. On an icy road, a 5000 kg truck rear-ends a 1200 kg car that had been traveling at 13 m/s, causing the truck to slow from 14 m/s to 12 m/s and the car to speed up.

a. Complete the momentum conservation diagram for the accident.

event: Two moving objects collide but do not stick together.



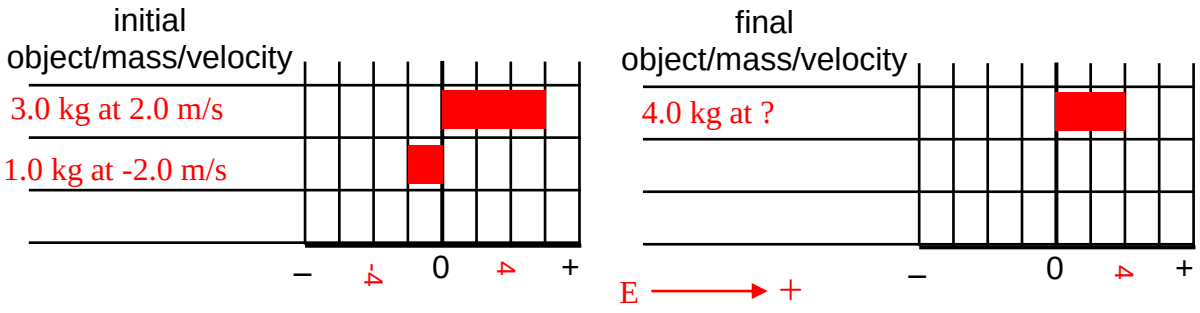

b. Find the final velocity of the car.

$5000kg(14\frac{m}{s}) + 1200kg(13\frac{m}{s}) = 1200kg(v_{1200f}) + 5000kg(12\frac{m}{s})$

$v_{1200f} = \frac{70{,}00\frac{kg\cdot m}{s} + 15{,}600\frac{kg\cdot m}{s} - 60{,}000\frac{kg\cdot m}{s}}{1200kg} = 21\frac{m}{s}$

6. A ball of mass 3.0 kg, moving at 2 m/s eastward, strikes head-on a ball of mass 1.0 kg that is moving at 2 m/s westward. The balls stick together after the impact. Complete the momentum conservation diagram. What is the magnitude and direction of the velocity of the combined mass after the collision?

event: Completely inelastic collision where two moving objects collide and stick together.



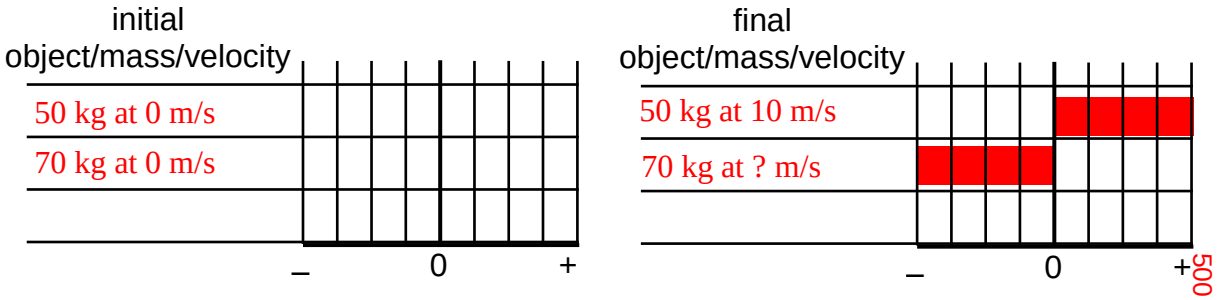

$m_{3i}v_{3i} + m_{1i}v_{1i} = (m_3 + m_1)v_f$

$3.0kg(2.0\frac{m}{s}) + 1.0kg(-2.0\frac{m}{s}) = (3.0\text{kg} + 1.0\text{kg})v_f \Rightarrow v_f = 1.0\frac{m}{s}$ eastward

7. Two girls with masses of 50 kg and 70 kg are at rest on frictionless in-line skates. The taller girl pushes the shorter girl so that the shorter girl rolls away at a speed of 10 m/s.

a. Show the effect of the push on both girls with a momentum conservation diagram.

event: Two objects in contact at rest, one object pushes the other.




b. Momentum conservation equation:

$$0 + 0 = m_{50f}v_{50f} + m_{70f} + v_{70f}$$

c. Calculate the impulse that each girl imparts to the other.

The tall girl gave an impulse on the short girl of 50 kg($10\ \frac{m}{s}$ -0) or 500 Ns. Therefore the short girl gave an equal and impulse of −500 Ns.