True Story!

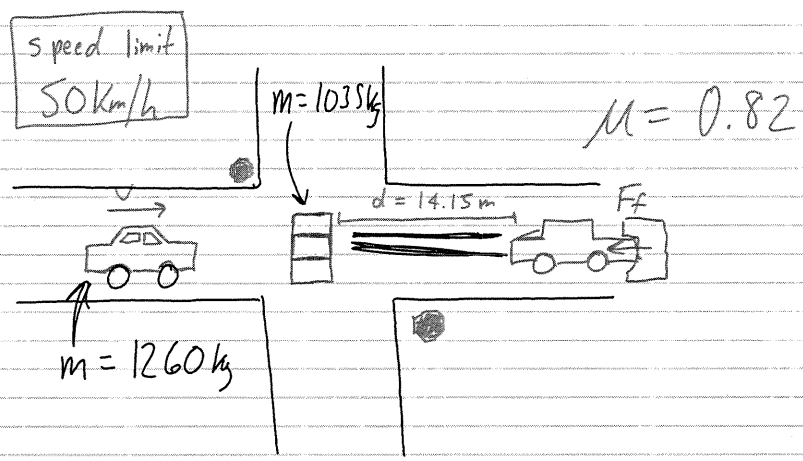
Police were called to the scene of an accident where a car headed east collided with the side of a second car in a "T-Bone" style crash as shown below. Both drivers reported very different stories.

The driver of the first car (shown in blue) claims that he was driving at the speed limit when the second car (shown in purple) flew through the intersection. He collided with the car before he was able to react and couldn't apply brakes due to the impact of the collision.

The driver of the second car claims that she had accidentally stalled in the middle of the intersection and was not moving when the first car came flying towards her. She claims that the first car was traveling well above the speed limit and that the driver made no attempt to avoid her or slow down.

The skid marks shown are from the second car traveling sideways. It was confirmed that both cars were brought to stop by the second car sliding along the road.

When the vehicle collision investigator arrived at the scene, he could tell immediately who was lying.



a) Explain how the investigator could tell immediately that the driver of the first car (blue) was lying. (No calculations required)

b) Use the data at the scene to determine the speed of the first car before the collision. (Many, many calculations required)

Terry Tate Office Linebacker
A Problem Set

1. (0:53) Terry Tate (135 kg) brings some pain at 12.0 m/s and collides with a stationary 80.0 kg office worker. If they stick together after collision what is their velocity?

2. (2:04) An unsuspecting office worker, with a mass of 45.0 kg is walking at 3.0 m/s to the right when Triple T (135 kg) tackles her. Their velocity together is 10.0 m/s to the left. How fast was 3T moving before the collision?

3. (2:20) A 75 kg mail cart traveling at 6.0 m/s to the left when it collides with Mr. Tate, who is at rest. If the mail cart comes to a complete stop, what is Terry's velocity immediately after impact?

4. (3:12) A 55kg fool is (wisely, but futilely) fleeing Terry Tate at 8 m/s. Terry is traveling at 14 m/s. What is their velocity after they collide and stick together?

Worksheet 6.1

Momentum

1. Calculate the momentum of a 4.0 kg object traveling at a velocity of 12.0 m/s east.

2. A 5.0 kg object has a momentum of 25.0 kgm/s west. What is its velocity?

3. An object has a velocity of 8.0 m/s south and a momentum of 36.0 kgm/s south. What is its mass?

4. An object has a velocity of 2.0 m/s east and a momentum of 29 kgm/s. What is the weight of the object?

5. A 6.6 N object is traveling at a velocity of 3.0 m/s north. What is the object's momentum?

6. A 7.0 kg object travels 2.6 m west in 1.1 s. Assuming uniform velocity, what is the momentum of the object?

7. A 5.0 kg object is dropped from a height of 2.5 m above the floor. What is the object's momentum after 0.25 s?

8. A 1.0 kg ball hits the floor with a velocity of 2.0 m/s. If the ball bounces up with a velocity of 1.6 m/s, what is the ball's change in momentum?

9. A 0.144 kg baseball is pitched horizontally at + 38 m/s. The batter hits a horizontal line drive at – 38 m/s (the opposite direction!). What is the ball's change in momentum?

10. The physics dragster is traveling at 35 km/h east when it hits the gas and accelerates at 12.5 m/s^2 for 3.25 s. What is its change in momentum during this time?

1) 48 kgm/s E 2) 5.0 m/s W 3) 4.5 kg 4) 140 N 5) 2.0 kgm/s 6) 17 kgm/s 7) -12 kgm/s 8) 3.6 kgm/s 9) -11 kg m/s 10) 49 000 kgm/s

1. A rocket at rest with a mass of 9.5×10^3 kg is acted on by an average net force of 1.5×10^5 N upwards for 15 s. What is the final velocity of the rocket?

2. A 26.3 kg object is traveling at 21.0 m/s north. What average net force is required to bring this object to a stop in 2.60 s?

3. An average force of 31.6 N south is used to accelerate a 15.0 kg object uniformly from rest to 10.0 m/s. What is the change in momentum?

4. An average net force of 25.0 N acts north on an object for 7.20×10^{-1} s. What is the change in momentum of the object?

5. A 5.00 kg object accelerates uniformly from rest to a velocity of 15.0 m/s east. What is the change in momentum on the object?

6. An average net force caused an 11.0 kg object to accelerate uniformly from rest. If this object travels 26.3 m west in 3.20 s, what is the change in momentum of the object?

7. A 1.30 kg object is dropped from a height of 6.5 m. How far did the object fall when its momentum is 6.0 kgm/s?

8. An average net force of 16.0 N acts on an object for 2.00×10^{-1} s causing it to accelerate from rest to 3.50 m/s. What is the mass of the object?

9. A 0.500 kg object is thrown vertically upward with an average applied force of 8.20 N by a student. The force is applied through a displacement of 1.50 m.

a. What is the average net force acting on the object?

b. What is the velocity of the object when it leaves the student's hand? (Assume initial velocity is zero)

1) 240 m/s 2) 212 N South 3) 150 kgm/s 4) 18 Ns 5) 75 kgm/s 6) 180. kgm/s 7) 1.1 m 8) 0.914 kg 9)a. 3.30 N b. 4.45 m/s

1. Calculate the momentum of a 4.0 kg object traveling at a velocity of 12.0 m/s east.

$p = mv = (4.0)(12.0)$

$= 48$ kgm/s East

2. A 5.0 kg object has a momentum of 25.0 kgm/s west. What is its velocity?

$p = mv \quad v = \frac{p}{m} = \frac{25.0 \text{ kgm/s}}{5.0 \text{ kg}}$

$= 5.0$ m/s West

3. An object has a velocity of 8.0 m/s south and a momentum of 36.0 kgm/s south. What is its mass?

$p = mv$

$m = \frac{p}{v} = \frac{36.0 \text{ kgm/s}}{8.0 \text{ m/s}} = 4.5$ kg

4. An object has a velocity of 2.0 m/s east and a momentum of 29 kgm/s. What is the weight of the object?

$= F_g$!

$p = mv$

$m = \frac{p}{v} = \frac{29 \text{ kgm/s}}{2.0 \text{ m/s}}$

$= 14.5$ kg

$F_g = mg$

$= (14.5)(9.8)$

$= 140$ N

5. A 6.6 N object is traveling at a velocity of 3.0 m/s north. What is the object's momentum?

$F_g = mg$

$m = \frac{F_g}{g} = \frac{6.6 \text{ N}}{9.8 \text{ m/s}^2} = 0.673$ kg

$p = mv = (0.673 \text{ kg})(3.0 \text{ m/s})$

$= 2.0$ kgm/s

6. A 7.0 kg object travels 2.6 m west in 1.1 s. Assuming uniform velocity, what is the momentum of the object?

$v = \frac{d}{t} = \frac{2.6 \text{ m}}{1.1 \text{ s}} = 2.364$ m/s

$p = mv = (7.0 \text{ kg})(2.364 \text{ m/s}) = 17$ kgm/s

7. A 5.0 kg object is dropped from a height of 2.5 m above the floor. What is the object's momentum after 0.25 s?

$v =$

$v_0 = 0$

$a = -9.80$

$d =$

$t = 0.25$

$v = v_0 + at$

$= 0 + (-9.80)(0.25)$

$= -2.45$ m/s

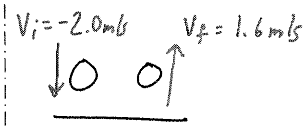
$p = mv$

$= (5.0 \text{ kg})(-2.45 \text{ m/s})$

$= -12$ kgm/s

or 12 kgm/s down

8. A 1.0 kg ball hits the floor with a velocity of 2.0 m/s. If the ball bounces up with a velocity of 1.6 m/s, what is the ball's change in momentum?



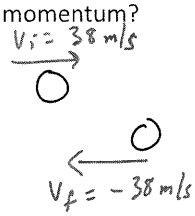
$\Delta p = m\Delta v$

$= m(v_f - v_i)$

$= (1.0 \text{ kg})(1.6 - (-2.0))$

$= 3.6$ kgm/s

9. A 0.144 kg baseball is pitched horizontally at + 38 m/s. The batter hits a horizontal line drive at – 38 m/s (the opposite direction!). What is the ball's change in momentum?



$\Delta p = m\Delta v$

$= m(v_f - v_i)$

$= (0.144 \text{ kg})(-38 \text{ m/s} - 38 \text{ m/s})$

$= -11$ kgm/s

10. The 1205 kg physics dragster is traveling at 35 km/h $\div 3.6$ east when it hits the gas and accelerates at 12.5 m/s^2 for 3.25 s. What is its change in momentum during this time?

$v = ?$

$v_0 = 9.72$ m/s

$a = 12.5$ m/s^2

$d =$

$t = 3.25$ s

$v = v_0 + at$

$= 9.72 + (12.5)(3.25)$

$= 50.35$ m/s

$\Delta p = m\Delta v$

$= (1205 \text{ kg})(50.35 - 9.72)$

$= 49\,000$ kgm/s

1) 48 kgm/s E 2) 5.0 m/s W 3) 4.5 kg 4) 140 N 5) 2.0 kgm/s 6) 17 kgm/s 7) -12 kgm/s 8) 3.6 kgm/s 9) -11 kg m/s 10) 49 000 kgm/s

1. A rocket at rest with a mass of 9.5×10^3 kg is acted on by an average net force of 1.5×10^5 N upwards for 15 s. What is the final velocity of the rocket?

$m\Delta v = F_{net}\, t$

$\Delta v = \frac{F_{net} \cdot t}{m} = \frac{(1.5\times10^5\ N)(15\ s)}{9.5\times10^3\ kg}$

$= 240\ m/s$

2. A 26.3 kg object is traveling at 21.0 m/s north. What average net force is required to bring this object to a stop in 2.60 s?

$F_{net}\, t = m\Delta v$

$F_{net} = \frac{m\Delta v}{t} = \frac{(26.3\ kg)(0 - 21.0\ m/s)}{2.60\ s}$

$= 212\ N$ (South)

3. An average force of 31.6 N south is used to accelerate a 15.0 kg object uniformly from rest to 10.0 m/s. What is the change in momentum?

$\Delta p = m\Delta v$

$= m(v_f - v_i)$

$= (15.0\ kg)(10.0\ m/s - 0)$

$= 150.\ kg\,m/s$

4. An average net force of 25.0 N acts north on an object for 7.20×10^{-1} s. What is the change in momentum of the object?

$\Delta p = F_{net} \cdot t = (25.0\ N)(7.20\times10^{-1}\ s)$

$= 18\ N \cdot s$

5. A 5.00 kg object accelerates uniformly from rest to a velocity of 15.0 m/s east. What is the change in momentum on the object?

$\Delta p = m\Delta v = (5.00\ kg)(15.0\ m/s - 0)$

$= 75\ kg\,m/s$

6. An average net force caused an 11.0 kg object to accelerate uniformly from rest. If this object travels 26.3 m west in 3.20 s, what is the change in momentum of the object?

$v = ?$
$v_0 = 0$
$a = ?$
$d = 26.3\ m$
$t = 3.20\ s$

$d = v_0 t + \frac{1}{2}at^2$

$a = \frac{2d}{t^2} = 5.14\ m/s^2$

$v = v_0 + at = 16.44\ m/s$

$\Delta p = m\Delta v = (11.0\ kg)(16.44\ m/s - 0) = 181\ kg\,m/s$

7. A 1.30 kg object is dropped from a height of 6.5 m. How far did the object fall when its momentum is 6.0 kgm/s?

$p = mv$

$v = \frac{p}{m} = \frac{6.0\ kg\,m/s}{1.30\ kg} = 4.615\ m/s$

$v = -4.615\ m/s$
$v_0 = 0$
$a = -9.80$
$d = ?$
t

$v^2 = v_0^2 + 2ad$

$d = \frac{v^2}{2a} = -1.1\ m$

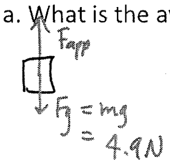
8. An average net force of 16.0 N acts on an object for 2.00×10^{-1} s causing it to accelerate from rest to 3.50 m/s. What is the mass of the object?

$m\Delta v = F_{net}\, t$

$m = \frac{F_{net}\, t}{\Delta v} = \frac{(16.0\ N)(2.00\times10^{-1}\ s)}{(3.50\ m/s - 0)} = 0.914\ kg$

9. A 0.500 kg object is thrown vertically upward with an average applied force of 8.20 N by a student. The force is applied through a displacement of 1.50 m.

a. What is the average net force acting on the object?



$F_{net} = F_{app} - F_g$

$= 8.20\ N - 4.9\ N$

$= 3.3\ N$

b. What is the velocity of the object when it leaves the student's hand? (Assume initial velocity is zero)

$a = \frac{F_{net}}{m} = 6.6\ m/s^2 \qquad t = \sqrt{\frac{2d}{a}} = 0.6742\ s$

$m\Delta v = F_{net} \cdot t$

$\Delta v = \frac{F_{net} \cdot t}{m} = \frac{(3.3\ N)(0.6742\ s)}{0.500\ kg}$

$= 4.45\ m/s$

1) 240 m/s 2) 212 N South 3) 150 kgm/s 4) 18 Ns 5) 75 kgm/s 6) 180. kgm/s 7) 1.1 m 8) 0.914 kg 9)a. 3.30 N b. 4.45 m/s