Physics
FA6.0 - Impulse and Momentum

Name____________________________

Movie Pet Peeve____

Show your work, and circle your answers and use sig figs to receive full credit.

1. What is the momentum of a 0.145 kg baseball going 32.0 m/s?

2. What is the impulse of a 13.0 N force acting for 3.20 s?

3. What speed does a 0.00820 kg bullet need to go to have 4.64 kgm/s of momentum?

4. A person running at 4.80 m/s has 317 kgm/s of momentum. What is their mass?

5. For what time must you exert a 11.2 N force to create 20.0 Ns of impulse?

Practice 6.0 - Impulse and Momentum

	Momentum **p = mv**
12190 kg m/s	1. What is the momentum of a 23 kg cannon shell going 530 m/s?
4.8 m/s	2. What speed must a 5 kg object go to have 24 kg m/s of momentum?
0.066 kg	3. A bullet going 640 m/s has 42 kg m/s of momentum. What is its mass?
2.825 kg m/s	4. What is the momentum of a 2.50 g bullet going 1130 m/s?
3.29 kg	5. What is the mass of a bowling ball that has a momentum of 46.0 kg m/s when it is going 14.0 m/s?
906 m/s	6. What speed must a 6.40 g bullet go to have the same momentum as a 145 g baseball going 40.0 m/s? (Roughly 90 mph)
	Impulse **Impulse = $F\Delta t$**
7.8 Ns	7. What is the impulse imparted by a rocket that exerts 4.8 N for 1.63 seconds?
0.36 s	8. For what time must you exert a force of 45 N to get an impulse of 16 Ns?
10.7 N	9. What force exerted over 6 seconds gives you an impulse of 64 Ns?
9.02 Ns	10. What is the impulse that a baseball bat gives a ball with a force of 2820 N exerted for 0.00320 s?
1.67 s	11. For what time must you exert a 12 N force to impart 20. Ns of impulse?
21.3 N	12. What force exerted for 15.0 s imparts an impulse of 320. Ns?
	(These that follow are assessed on 6.1 - these are just extra practice problems)
	Impulse and Momentum **$F\Delta t = m\Delta v$**
10.3 m/s	13. What is the change in velocity of a 0.35 Kg air track cart if you exert a force of 1.2 N on it for 3.0 seconds?
119 kg	14. A rocket engine exerts a force of 500 N on a space probe (in outer space!) for 5.0 seconds. The probe speeds up from rest to a speed of 21 m/s. What is its mass?
1184 N	15. What force exerted for 0.012 seconds will make a 0.145 Kg baseball change its velocity 98 m/s?
0.71 s	16. What time must the space probe in question 14. fire its engines to change its velocity by 3 m/s?
	Rocket Propulsion
3040 N 3.95 s 19.7 kg	17. A rocket engine burns 5 kg of fuel per second. The exhaust gas velocity is 608 m/s. What is the thrust of the engine? What time must it burn to impart an impulse of 12,000 Ns? How much fuel will it burn to do this?
880 m/s	18. An 11 Ns rocket engine has 12.5 grams of fuel. What is the exhaust velocity?
0.02 kg/s 6.0 kg	19. A rocket generates 25 N of thrust, and the exhaust gas velocity is 1250 m/s. At what rate does it consume fuel in kg/s? How much fuel has it burned in 5 minutes?
180.8 s 2.63 m/s/s 7.73 m/s/s	20. A small rocket probe in deep space has a mass of 68.5 kg, 45.2 kg of which is fuel. Its engine consumes .250 kg of fuel per second, and it has an exhaust velocity of 720 m/s. For how much time will the engine burn? What is the initial acceleration of the rocket engine? What is the acceleration just before it runs out of fuel?
140 s 75 kN 5.2 m/s/s 40.2 m/s/s	21. A rocket takes off from the surface of Earth straight up. The total mass of the rocket is 5000 kg, 3500 kg of which is fuel. The exhaust gas velocity is 3000 m/s, and the rocket consumes 25 kg of fuel per second. For how long do the engines burn? What is the thrust of the engine? What are the initial and final accelerations of the rocket? (Don't forget gravity!)

Quizlette 6.1 - Rocket Science **Name______________________________**

$F\Delta t = m\Delta v$

1) If you exert a force of 45 N on a 52 kg frictionless cart at rest for 3.5 seconds, what is its change in velocity?

2) A 295 kg spacecraft has rockets that exert a force of 0.050 N (ion propulsion).
For what time must you "burn" these engines to change the velocity of the spacecraft by 350. m/s?

3) A 540 kg stage set floating on air bearings undergoes a change in velocity of 1.2 m/s in 31 seconds.
What force was exerted?

Velocity reversal: the change of 34 m/s <u>to the left</u> to 40 m/s <u>to the right</u> is a **<u>change</u>** of 74 m/s, so
Δv = 74 m/s. (Use **$F\Delta t = m\Delta v$**)

4) A 0.145 Kg baseball going 40.0 m/s, strikes a bat, and heads straight back to the outfield at 61.0 m/s. If the collision lasted for 0.0120 seconds, what force did the bat exert on the baseball?

5) A 0.141 Kg baseball going 32.0 m/s, strikes a bat, and heads straight back to the outfield at 50.0 m/s. If the bat exerted a force of 1960 N, for what time was it in contact with the bat?

6) A ball going 35.0 m/s, strikes a bat, and heads straight back to the outfield at 42.0 m/s. If the bat exerted a force of 1780 N for 0.00630 seconds, what is the mass of the ball?

1) 3.03 m/s, 2) 2,065,000 s, 3) 20.9 N, 4) 1220 N, 5) 0.00590 s, 6) 0.146 kg

Rocket Thrust: **$F\Delta t = m\Delta v$ -** remember, if it says 45 grams per second that is 0.045 kg in 1 second

7) A rocket engine produces 410. N of thrust for 17.0 s with an exhaust velocity of 710. m/s. What mass of fuel does it burn in this time?

8) A rocket engine burns 1.20 kg of fuel generating 72.0 N of thrust with an exhaust velocity of 540. m/s. What time does the engine burn?

9) A rocket engine burns fuel at a rate of 13.0 **grams** per second, and has an exhaust velocity of 690. m/s. What thrust does it develop? (1000 grams = 1 kg)

10) A rocket engine burns fuel at a rate of 12.0 **grams** per second, and develops a thrust of 8.50 N. What must be the exhaust velocity? (1000 grams = 1 kg)

Initial and final acceleration:

11) A 8.30 kg rocket, 5.20 kg of which is fuel, burns all of its fuel in 12.0 seconds with an exhaust velocity of 610. m/s. What are its initial and final acceleration as it takes off from earth? (Thrust = 264.3 N)

12) A 320. kg rocket, 280. kg of which is fuel, burns all of its fuel in 32.0 seconds with an exhaust velocity of 780. m/s. What are its initial and final acceleration as it takes off from earth? (Thrust = 6825 N)

13)A 71.0 kg rocket (total mass of fuel and rocket), burns 51.0 kg of fuel at a rate of 2.10 kg/s with an exhaust velocity of 650. m/s. What are its initial and final acceleration as it takes off from earth? (Thrust = 1365 N)

14) A 140. kg rocket (total mass of fuel and rocket), burns 110.0 kg of fuel at a rate of 3.20 kg/s with an exhaust velocity of 810. m/s. What are its initial and final acceleration as it takes off from earth? (Thrust = 2592 N)

7) 9.82 kg, 8) 9.00 s, 9) 8.97 N, 9), 10) 708 m/s, 11) 22.0 and 75.5 m/s/s, 12) 11.5 m/s/s and 161 m/s/s, 13) 9.43 m/s/s and 58.5 m/s/s, 14) 8.71 m/s/s and 76.6 m/s/s

Physics
FA6.1 - Rocket Science

Name____________________________

School Pet Peeve____

Show your work, and circle your answers and use sig figs to receive full credit.

1. A 600. kg stage set on frictionless air bearings goes from rest to 0.850 m/s in 12.5 seconds. What force acted on the set?

2. A 0.142 Kg baseball going 41.0 m/s, strikes a bat, and heads straight **back** to the outfield at 53.0 m/s. If the bat exerted a force of 2350 N, for what **time** was it in contact with the bat?

3. A rocket engine burns 12.0 grams of fuel (0.0120 kg) in 1.10 seconds with an exhaust velocity of 782 m/s. What it the thrust of this engine?

4. A rocket engine burns fuel at a rate of 53.5 grams per second, and develops a force of 65.2 N. What must be the exhaust **velocity**? (1000 grams = 1 kg)

5. A 60.0 kg rocket, 48.0 kg of which is fuel, burns 2.15 kg of fuel per second with an exhaust velocity of 982 m/s. What are its initial and final acceleration as it takes off from earth? For what time do the engines burn?

optional: (What is its acceleration at t = 10.0 s? Make a graph of the acceleration.)

Practice 6.1 - Rocket Science!!!!! (optional)

1. a. A 35.0 N unbalanced force is exerted on a 7.10 Kg mass for 36.0 seconds. What is the change of **velocity** of the mass? (177 m/s) b. A 0.145 Kg baseball going 41.0 m/s, strikes a bat, and heads straight **<u>back</u>** to the outfield at 31.0 m/s. If the bat exerted a force of 2530 N, for what **time** was it in contact with the bat? (0.00413 s) c. A rocket burns 42.4 kg in 6.50 s with an exhaust velocity of 720. m/s. What is the thrust of the engine? (4697 N) d. A rocket engine burns fuel at a rate of 4.10 <u>grams</u> per second, and develops a force of 12.2 N. What must be the exhaust **velocity**? (1000 grams = 1 kg) (2976 m/s) e. A 114 kg rocket (total mass of fuel and rocket), burns 95.0 kg of fuel at a rate of 3.50 kg/s with an exhaust velocity of 790. m/s. What are its <u>initial</u> and <u>final</u> acceleration as it takes off from earth? (14.5 m/s/s, 136 m/s/s)
2. a. A 62.0 N unbalanced force is exerted on an object for 4.5 seconds. The mass changes velocity from rest to 47 m/s. What is the **mass** of the object? (5.94 kg) b. A 0.138 Kg baseball going 37.0 m/s, strikes a bat, and heads straight **<u>back</u>** to the outfield at 45.0 m/s. If the collision lasted for .0121 seconds, what **force** did the bat exert on the baseball? (935 N) c. A rocket engine develops 1240 N of thrust burning 56.2 kg of fuel in 21.5 s. What is the exhaust velocity? (474 m/s) d. A rocket engine burns fuel at a rate of 1.40 <u>grams</u> per second, and has an exhaust velocity of 890. m/s. What **thrust** does it develop? (1000 grams = 1 kg) (1.25 N) e. A 324 kg rocket, 292 kg of which is fuel, burns all of its fuel in 38.0 seconds with an exhaust velocity of 880. m/s. What are its <u>initial</u> and <u>final</u> acceleration as it takes off from earth? (11.1 m/s/s, 202 m/s/s)
3. a. A force is exerted on a 23 Kg mass for 15 seconds. The mass changes velocity from rest to 45 m/s. What was the **force**? (69.0 N) b. A ball going 27.0 m/s, strikes a bat, and heads straight **<u>back</u>** to the outfield at 41.0 m/s. If the bat exerted a force of 312 N for 0.0230 seconds, what is the **mass** of the ball? (0.106 kg) c. A rocket burns 35.1 kg of fuel generating 450. N of thrust with an exhaust velocity of 790. m/s. What time do the engines burn? (61.6 s) d. A rocket develops a thrust of 14.2 N, with an exhaust velocity of 910. m/s. What **mass** in fuel does the engine burn every second? (0.0156 kg/s or 15.6 g/s) e. A 67.0 kg rocket (total mass of fuel and rocket), burns 52.0 kg of fuel at a rate of 2.70 kg/s with an exhaust velocity of 642 m/s. What are its <u>initial</u> and <u>final</u> acceleration as it takes off from earth? (16.1 m/s/s, 106 m/s/s)
4. a. A 68 N unbalanced force is exerted on a 12 Kg mass. The mass changes velocity from rest to 35 m/s. What **time** did the force act? (6.18 s) b. A 0.141 Kg baseball going 34.0 m/s, strikes a bat, and heads straight **<u>back</u>** to the outfield at 58.0 m/s. If the bat exerted a force of 1830 N, for what **time** was it in contact with the bat? (0.00709 s) c. A rocket engine produces 360. N of thrust for 45.0 s with an exhaust velocity of 770. m/s. What mass of fuel does it burn in this time? (21.0 kg) d. A rocket engine burns fuel at a rate of 14.0 <u>grams</u> per second, and develops a force of 31.7 N. What must be the exhaust **velocity**? (1000 grams = 1 kg) (2264 m/s) e. A 19.0 kg rocket, 14.0 kg of which is fuel, burns its fuel at a rate of 0.420 kg/s with an exhaust velocity of 650. m/s. What are its <u>initial</u> and <u>final</u> acceleration as it takes off from earth? (4.57 m/s/s, 44.8 m/s/s)
5. a. A 23 N unbalanced force is exerted on a 46 Kg mass for 18 seconds. What is the change of **velocity** of the mass? (9.00 m/s) b. A 0.143 Kg baseball going 36.0 m/s, strikes a bat, and heads straight **<u>back</u>** to the outfield at 86.0 m/s. If the collision lasted for 0.0120 seconds, what **force** did the bat exert on the baseball? (1454 N) c. A rocket engine burns 2.20 kg of fuel generating 89.0 N of thrust with an exhaust velocity of 710. m/s. What time does the engine burn? (17.6 s) d. A rocket engine burns fuel at a rate of 11.0 <u>grams</u> per second, and has an exhaust velocity of 752 m/s. What **thrust** does it develop? (1000 grams = 1 kg) (8.27 N) e. A 5.70 kg rocket, 4.60 kg of which is fuel, burns all of its fuel in 10.3 seconds with an exhaust velocity of 610. m/s. What are its <u>initial</u> and <u>final</u> acceleration as it takes off from earth? (38.0 m/s/s, 238 m/s/s)

Quizlette 6.2 - Conservation of Momentum   **Name______________________________**

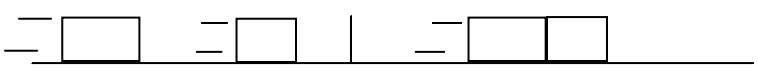
1) A 6.10 g bullet going 830. m/s imbeds in a stationary 310. g block of wood. What is the velocity of the block of wood just after the collision? (16.0 m/s)

2) A 6.50 g bullet imbeds in a stationary 170. g block of wood. The bullet and block combo are going 21.0 m/s after the collision. What was the velocity of the bullet before the collision? (570. m/s)

3) A person at rest fires a 1.70 g rifle bullet to the right at 1320. m/s. The person recoils at 0.0290 m/s to the left after this. What must be the mass of the person? (77.4 kg)

4) A 52.0 kg person at rest fires a 1.80 g rifle bullet to the right. The person recoils at 0.0720 m/s to the left after this. What must be the velocity of the bullet? (2080 m/s)

5) A 61.0 kg person fires a 5.40 g rifle shell at 870. m/s. If the person is initially at rest on a frictionless surface, what is their recoil velocity after firing? (0.0770 m/s)



6) A 3500 kg car going 23.0 m/s strikes a 1400 kg car traveling in the same direction at 13.0 m/s from behind. The two cars stick together. What velocity are they going after the collision? (20.1 m/s)

7) A 3800 kg car (going an unknown velocity) strikes a 1100 kg car traveling in the same direction at 17.0 m/s from behind. The two cars stick together and have a velocity of 23.0 m/s. What velocity was the first car going before the collision? (24.7 m/s)

8) A 1200 kg car going 24.0 m/s strikes a 2600 kg car traveling in the same direction from behind. The two cars stick together and are going 19.0 m/s just after the collision. What velocity did the other car have before the collision? (16.7 m/s)

Don't forget to do the EXCITING second side!!!

Draw your own picture!

9) Two football players strike each other head on. Player 1 has a mass of 120. kg and is running 3.30 m/s to the East, and player 2 has a mass of 95.0 kg is running 6.20 m/s to the West. What is their post-collision velocity if they stick together? (Speed and direction)
(0.898 m/s west)

10) Two football players strike each other head on. Player 1 has a mass of 110. kg and is running 3.50 m/s to the East, and player 2 has a mass of 85.0 kg is running to the West. If they stick together, and are together moving 1.90 m/s to the **West** after the collision, was the velocity of player 2 before the collision? (Speed and direction) (8.89 m/s west)

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11) Bumper car A (340. Kg) with velocity 4.50 m/s East collides with the rear of car B (610. Kg) which has a velocity of 2.40 m/s East. After the collision, car A has a velocity of 1.40 m/s to the West. What is the velocity of car B after the collision? (Speed and direction) (5.69 m/s east)

12) Bumper car A (480. Kg) with velocity 3.90 m/s East collides with the front of car B (410. Kg) which has a velocity of 5.10 m/s West. After the collision, car B has a velocity of 1.50 m/s to the East. What is the velocity of car A after the collision? (Speed and direction) (1.74 m/s west)

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13) 85.0 kg Thor is standing on a 35.0 kg cart, and is holding a 6.40 kg hammer. Everything is moving to the right at 3.40 m/s. What is the velocity of Thor and cart if he throws the hammer 25.0 m/s to the left? (Speed and direction) (4.91 m/s right)

14) 82.0 kg Thor is standing on a 25.0 kg cart, and is holding a 6.20 kg hammer. Everything is moving to the right at 2.40 m/s. What is the velocity of Thor and cart if he throws the hammer 18.0 m/s to the left? (3.58 m/s right)

15) 88.0 kg Thor is standing on a 42.0 kg cart, and is holding a 8.40 kg hammer. Everything is moving to the right at 4.30 m/s. After he throws the hammer, he and the cart are moving 6.60 m/s to the right. What speed and in what direction did he throw the hammer? (31.3 m/s left)

Physics

FA6.2 - Conservation of Momentum

Name____________________________

Driving Pet Peeve____

1. A bullet going 481 m/s imbeds in a stationary block of wood. The bullet and block combo are going 5.27 m/s after the collision, and the combo has a mass of 12.1 kg (Bullet and block). What was the **mass** of the bullet?

2. A 65 kg person dives 3.68 m/s to the right off of a 23 kg cart. What is the velocity of the cart if the cart and person were initially at rest?

3. 68 kg-Francois running 7.8 m/s jumps on a 45.3 kg cart already rolling at 2.3 m/s in the same direction. What speed are they going after he jumps on?

4. A 1240 kg Toyota Camry going 12.0 m/s to the east, strikes a 2530 kg SUV going west at 16.3 m/s. What is the velocity of the wreckage after the collision?

5. A 65 kg person is riding a 23 kg cart to the right at 3.15 m/s. What speed must he dive off the cart, and in what direction, to give the cart a velocity of 22.3 m/s to the right?

Practice 6.2 – Conservation of Momentum (optional)

1. a. A bullet going 560. m/s imbeds in a stationary block of wood. The 272 g bullet and block combo are going 26.0 m/s after the collision. What was the **mass** of the bullet? (12.6 g) b. Big J Sandvik (at rest) fires a 2.80 g rifle bullet to the left at 530. m/s. He recoils at 0.0220 m/s to the right after this. What must be the **mass** of Big J Sandvik? (67.5 kg) c. A 2960 kg Mazda Protégé going 34.0 m/s strikes a 1410 kg Ford Escort traveling in the same direction at 18.0 m/s from behind. The two cars stick together. What is the **velocity** of the cars as they are stuck together? (28.8 m/s) d. Two football players strike each other head on. Player 1 has a mass of 110. kg and is running 3.20 m/s to the East, and player 2 has a mass of 85.0 kg is running 8.30 m/s to the West. What is their post-collision **velocity** if they stick together? (Speed and direction) (1.81 m/s west) e. 85.0 kg Big J Sandvik is standing on a 35.0 kg golf cart, and is holding a 8.20 kg golf club. Everything is moving to the right at some speed. After he throws the club, he is moving on the cart 3.00 m/s to the right and the golf club is moving to the right at 41.0 m/s. What **speed and in what direction** was he, his cart and his club going to begin with? (5.44 m/s right)
2. a. A 3.5 g bullet going 960. m/s imbeds in a stationary block of wood. The bullet and block combo are going 17.0 m/s after the collision. What was the **mass** of the bullet and block combo? (0.198 kg) b. Big J Sandvik fires a rifle bullet to the right at 870. m/s. He has a mass of 72.0 kg. If he is initially at rest on a frictionless surface, and has a recoil velocity of 0.0450 m/s to the left, what is the **mass** of the bullet? (0.00372 kg) c. A 12.0 kg cat moving an unknown velocity to the right strikes a 13.0 kg cat traveling to the right at 15.0 m/s. The two cats stick together and have a velocity of 18.0 m/s to the right. What **velocity** was the first cat going before the collision? (21.3 m/s) d. Bumper car A (470. Kg) with velocity 3.80 m/s East collides with the front of car B (420. Kg) which has a velocity of 5.20 m/s West. After the collision, car A has a velocity of 1.30 m/s to the West. What is the velocity of car B after the collision? (Speed and direction) (0.507 m/s east) e. 71.0 kg Big J Sandvik is standing on a 28.0 kg golf cart, and is holding a 3.60 kg golf club. Everything is moving to the right at 1.10 m/s. After he throws the golf club, he and the cart are moving 2.50 m/s to the right. What **speed and in what direction** did Big J Sandvik throw the golf club? (37.4 m/s left)
3. a. A 6.20 g bullet going 860. m/s imbeds in a stationary 340. g block of wood. What is the **velocity** of the block of wood just after the collision? (15.4 m/s) b. A person at rest fires a 1.30 g rifle bullet to the right at 1120. m/s. The person recoils at 0.0240 m/s to the left after this. What must be the **mass** of the person? (60.7 kg) c. A 3520 kg car (going an unknown velocity) strikes a 1020 kg car traveling in the same direction at 15.0 m/s from behind. The two cars stick together and have a velocity of 21.0 m/s. What **velocity** was the first car going before the collision? (22.7 m/s) d. Bumper car A (310. Kg) with velocity 4.60 m/s East collides with the rear of car B (540. Kg) which has a velocity of 2.50 m/s East. After the collision, car A has a velocity of 1.20 m/s to the West. What is the velocity of car B after the collision? (Speed and direction) (5.83 m/s east) e. 95.0 kg Thor is standing on a 43.0 kg cart, and is holding a 5.20 kg hammer. Everything is moving to the right at 2.40 m/s. What is the **velocity** of Thor and cart if he throws the hammer 32.0 m/s to the left? (Speed and direction) (3.70 m/s right)
4. a. A 6.80 g bullet imbeds in a stationary 150. g block of wood. The bullet and block combo are going 24.0 m/s after the collision. What was the **velocity** of the bullet before the collision? (553 m/s) b. A 55.0 kg person at rest fires a 0.0130 kg rifle bullet to the right. The person recoils at 0.0890 m/s to the left after this. What must be the **velocity** of the bullet? (377 m/s left) c. A 3570 kg car going 21.2 m/s strikes a 1470 kg car traveling in the same direction at 15.0 m/s from behind. The two cars stick together. What **velocity** are they going after the collision? (19.4 m/s) d. Two football players strike each other head on. Player 1 has a mass of 110. kg and is running 7.20 m/s to the East, and player 2 has a mass of 95.0 kg is running 4.30 m/s to the West. What is their post-collision **velocity** if they stick together? (Speed and direction) (1.87 m/s east) e. 115 kg Thor is standing on a 23.0 kg cart, and is holding a 4.20 kg hammer. Everything is moving to the right at 1.40 m/s. What is the **velocity** of Thor and cart if he throws the hammer 15.9 m/s to the right? (Speed and direction) (0.959 m/s right)
5. a. A 4.50 g bullet going 770. m/s imbeds in a stationary 210. g block of wood. What is the **velocity** of the block of wood just after the collision? (16.2 m/s) b. A 62.0 kg person fires a 5.90 g rifle shell at 820. m/s. If the person is initially at rest on a frictionless surface, what is their recoil **velocity** after firing? (0.0780 m/s) c. A 3230 kg car going 24.0 m/s strikes a 2610 kg car traveling in the same direction from behind. The two cars stick together and are going 18.0 m/s just after the collision. What **velocity** did the other car have before the collision? (10.6 m/s) d. Two football players strike each other head on. Player 1 has a mass of 120. kg and is running 5.10 m/s to the East, and player 2 has a mass of 99.0 kg is running to the West. If they stick together, and are together moving 1.50 m/s to the West after the collision, was the **velocity** of player 2 before the collision? (Speed and direction) (9.50 m/s west) e. 105 kg Thor is standing on a 45.0 kg cart, and is holding a 8.30 kg hammer. Everything is moving to the right at 2.30 m/s. After he throws the hammer, he and the cart are moving 1.60 m/s to the right. What **speed and in what direction** did he throw the hammer? (15.0 m/s right)

Physics

Conservation of Momentum

When two airtrack gliders collide on a near frictionless surface, the sum of the momentum should not change. Here you will test this.

1. You will need one lab partner, (Work in groups of 2), an airtrack, two gliders, a computer with Logger Pro on it, and an ultrasonic range finder.
2. **Mass** the two gliders and record this. Since the precision of our balances is 0.1 g, the uncertainty of the mass of the gliders is 0.05 g. Write down the mass in grams with a decimal. If it comes out even to say 301 grams, write it 301.0 g to show you measured the tenths place.
3. Level the airtrack. Run the momentum lab on the computer which will bring up **a velocity v time graph**.
4. Position the rangefinder so that it is pointing down the airtrack, but is some distance from the end of the track as it cannot "see" things closer than 50 cm. Place the glider with the flag sticking up on it on the airtrack, hit "Collect" on the graph window, and give the glider a gentle shove toward the far end of the track. You should see a nice flat velocity v time graph. (At least until it hits the far end) If the graph tilts then you don't have the airtrack level, if the graph turns into garbage at some point, then you need to aim the rangefinder better.
5. Place the glider with no flag on it in the middle of the airtrack at rest, sticky side toward the rangefinder. Place the glider with the flag on it between the rangefinder and the other glider, sticky side toward the other glider. Hit "Collect" on the graph window, and give the glider nearest the rangefinder a gentle shove toward the middle glider. Repeat this until the gliders stick together, and you get a nice graph that shows straight line velocities before and after the collision. (The graph will be flat, then step down and be flat again. Make sure that you aren't looking at a collision with the end of the track. i.e. the velocity goes from positive to negative)
6. Select a portion of the graph before the collision, and Choose "Statistics" from the "Analyze" menu. This will pop up a bubble with the Mean, Max and Min for those points. Do the same for some points after the collision.
7. When you have a nice graph, print it and it will print the statistics too.
8. Mass the gliders. (Be careful not to drop them.)

Here's what you turn in:

1. Your calculations on the total momentum of both gliders before and after the collision **<u>written directly on the graph that you made</u>**. For each calculation, calculate the **Maximum**, **Best Guess** and **Minimum** values the momentum could have been.
2. Your own personal answer to these questions:
   A. "Does the data you have support conservation of momentum?" (Do the values overlap or not? – Cite specific numbers to back up what you say)
   B. "What inherent properties of the apparatus and procedure could contribute to any discrepancies you may have found?" (Identify 2 or 3 sources of error)
   C. How can you mitigate those sources of error?

written directly on the graph you made.

That's it - Just that **<u>one sheet of paper</u>**.