IB Physics

Linear Momentum

Chapter 7 Syllabus

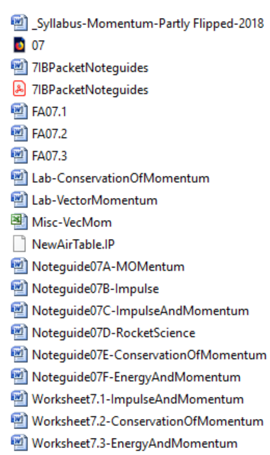
A/B	In Class:	Due on this class
5 Jan 7/8	**GW**-Energy lab **GW**-Problems	**VF Energy Lab**
6 Jan 9/10	**SA6.2&SA6.1 -Energy (first 60)** **IW**-Energy Lab **GW**-Energy Lab	Turn in: FA6.1, FA6.2
7 Jan 11/14	**GW**-Energy Lab **VF**-7A, 7B, 7C, 7D	**VF 7A, 7B** Turn in: Energy Lab
1 Jan 15/16	**GW**-Impulse and Rocket Science	**VF 7C, 7D**
2 Jan 17/18	**SA7.1 - Impulse and Momentum (first 30 min)** **VF**-7E - Conservation of momentum **DI**-Conservation of momentum/VF for COM lab	Turin in: FA7.1
3 Jan 22/23	**DI**-Demos - Car design **GW**-Vector Momentum Lab **GW**-Conservation of Momentum Lab GW-Conservation of Momentum problems (7.2)	**VF 7E** **VF First video for COM lab** **VF First two videos for Vector Momentum**
4 Jan 24/25	**DI**-Demos - Cannon **GW**-Vector Momentum Lab **GW**-Conservation of Momentum Lab **GW**-Conservation of Momentum problems (7.2) **GW**-Energy and Momentum problems (7.3)	**VF 7F**
Final	**Group Final for IB Questions**	
5 Feb 5/6	**DI**-Demos - Match rockets **GW**-Vector Momentum Lab **GW**-Conservation of Momentum Lab **GW**-Conservation of Momentum problems (7.2) **GW**-Energy and Momentum problems (7.3)	**VF 8A Angular Quantities** **VF 8B Angular Conversions** **VF 8C Tangential Relationships**
6 Feb 7/8	**SA7.2 Conservation of Momentum** **SA7.3 Energy and Momentum (First 60 minutes)** **VF**-8D - Rotational Mechanics	Turn in: FA7.2, FA7.3
1 Feb 11/12	**Rotational** Woo Hoo!! **Mechanics**!!! Woot!	**VF 8D Rotational Kinematics**

3 Labs:

- Cannon Lab (mini lab done in-class) /10 pts
- Conservation of momentum lab (with the air track – collision of gliders) /40 pts
- Vector Momentum Lab – 2-D vector momentum collision (simulation from the computer) /30 pts

3 Formative/Summative Assessments

- 7.1 – Impulse and momentum
- 7.2 – Conservation of momentum
- 7.3 – Energy and Momentum



Noteguide for MOMentum (Videos 7A) **Name** ________________________

Momentum:

p = mv where
p = momentum
m = mass in kg
v = velocity in m/s

Head on collision - small vs big

Example: What is the momentum of a 145 g baseball going 40. m/s?

Example: 60 kg Fran is running at 4 m/s when she collides with 80 kg Joe. They hit and stop dead, so how fast was Joe going?

Conservation of momentum:

Whiteboards:

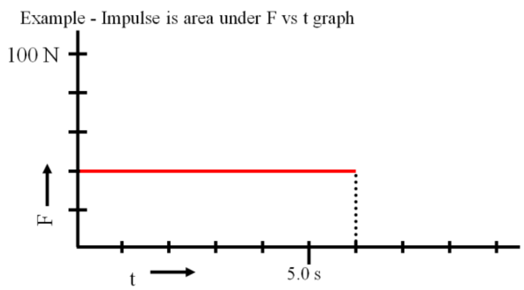
1. What is the momentum of a 22 g swallow going 5.2 m/s (0.11 kg m/s)	2. What velocity must a 6.5 gram bullet have for its momentum to be 5.8 kg m/s? (890 m/s)
3. A bowling ball has a momentum of 43.6 kg m/s when it is going 12 m/s. What is its mass? (3.6 kg)	

Noteguide for Impulse (Videos 7B) **Name** ________________________

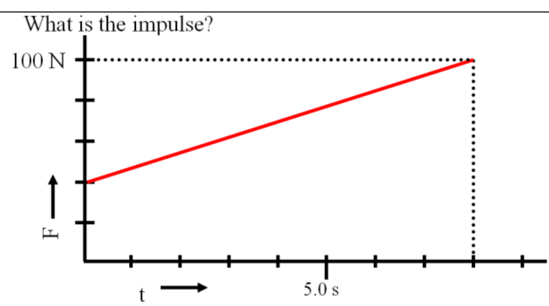
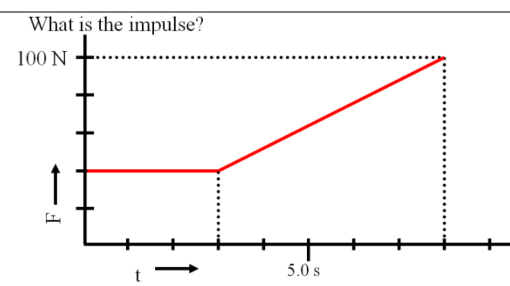
Impulse (change in momentum)

Impulse = F Δt where
F = Force
Δt = time that the force is exerted

Example: What impulse is imparted by exerting a 12 N force for 4.0 s?



Whiteboards:

1. What is the impulse of a 6.12 N force acting for 2.3 seconds (14 N s)	2. A rocket engine is rated at 14 N s of impulse, and burns for 1.7 seconds. What is the thrust of the engine? (8.2 N)
 3. (560 N s)	 4. (470 N s)

Noteguide for Impulse and Momentum (Videos 7C) **Name** ________________________

Impulse = Change in momentum

Impulse = $F\Delta t = m\Delta v$

F = Force (N)

Δt = Elapsed time (s)

m = Mass (kg)

Δv = Change in velocity (m/s)

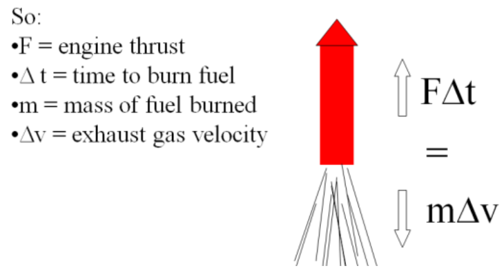
Example: A pitcher pitches a 0.145 kg baseball at 40. m/s, and the batter hits it directly back at 50. m/s to the outfield. What is the average force exerted by the bat if the collision lasted 0.013 s?

Deriving Newton's second law:

Whiteboards:

1. What force for 10. seconds makes a 2.0 kg rocket speed up to 75 m/s from rest? (15 N)	2. A baseball bat exerts a force of 200. N on a .50 kg ball for .10 seconds. What is the ball's change in velocity? (40 m/s)
3. Jolene exerts a 50. N force for 3.0 seconds on a stage set. It speeds up from rest to 0.25 m/s. What is the mass of the set? (600 kg)	4. A pitcher pitches a 0.145 kg baseball at 35.0 m/s, and the batter hits it directly back at 42.0 m/s to the outfield. The bat exerts an average force of 892 N on the ball. For what time does the collision last? (0.0125 s)

Noteguide for Rocket Science (Videos 7D) **Name _________________________**



Example 1: A rocket burns fuel at a rate of 1.2 kg/s, with an exhaust velocity of 1250 m/s. What thrust does it develop?

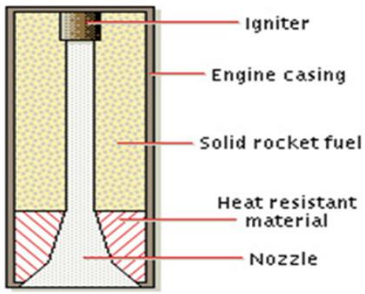
Example 2: A model rocket has a mass of 0.238 kg, 0.126 kg of which is fuel. It burns its fuel at a rate of 0.0184 kg/s and has an exhaust velocity of 718 m/s
What are the rocket's initial and final accelerations?

Whiteboards:

1. A certain rocket engine burns 0.0352 kg of fuel per second with an exhaust velocity of 725 m/s. What thrust does it generate? (25.5 N)	2. The Saturn V's first stage engines generated 33.82 MN of thrust (33.82 x 10^6 N) with an exhaust velocity of 2254.7 m/s. What was its fuel burn rate? (15,000 kg/s)
3. A 270. kg rocket, 185 kg of which is fuel, burns all of its fuel in 26.0 seconds with an exhaust velocity of 852 m/s. What are its initial and final acceleration as it takes off from earth? (12.6 m/s/s, 61.5 m/s/s)	4. A 43.0 kg rocket (total mass of fuel and rocket), burns fuel at a rate of 1.54 kg/s for 13.7 seconds with an exhaust velocity of 821 m/s. What are its initial and final acceleration as it takes off from earth? (19.6 m/s/s, 47.9 m/s/s)

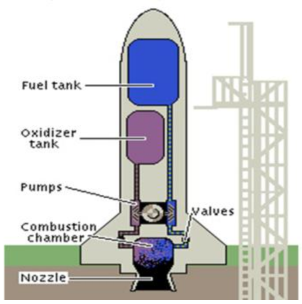
Solid Fuel:

Solid Fuel Engine:



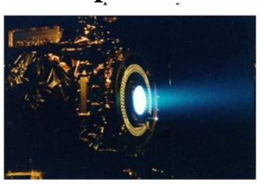
Liquid Fuel:

Liquid Fuel Engine:

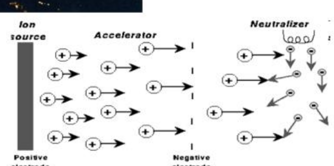


- How do you keep it from tipping?
- Why the "steam" coming off?

Ion Propulsion:



Low thrust/high Δv
20-50 km/s exhaust velocity
Dawn

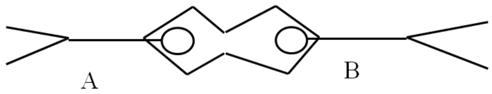


Practice Problems for 7.1

1. a. A rocket exerts 4.21 N of force for 1.47 seconds. What **impulse** does it impart? (6.19 N s) b. A 35.0 N unbalanced force is exerted on a 3.10 Kg mass for 39.2 seconds. What is the change of **velocity** of the mass? (442 m/s) c. A 0.147 Kg baseball going 37.0 m/s, strikes a bat, and heads straight **back** to the outfield at 48.0 m/s. If the bat exerted a force of 2341 N, for what **time** was it in contact with the bat? (0.00534 s) d. A rocket engine burns fuel at a rate of 14.5 grams per second, and develops a force of 9.20 N. What must be the exhaust **velocity**? (1000 grams = 1 kg) (634 m/s) e. A 122 kg rocket (total mass of fuel and rocket), burns its fuel at a rate of 3.45 kg/s for 23.0 seconds with an exhaust velocity of 772 m/s. What are its initial and final acceleration as it takes off from earth? (12.0 m/s/s, 52.6 m/s/s)
2. a. What is the **momentum** of a 1.22 kg hammer going 3.46 m/s? (4.22 kg m/s) b. A 59.0 N unbalanced force is exerted on an object for 5.20 seconds. The mass changes velocity from rest to 44.0 m/s. What is the **mass** of the object? (6.97 kg) c. A 0.142 Kg baseball going 37.0 m/s, strikes a bat, and heads straight **back** to the outfield at 59.0 m/s. If the collision lasted for 0.0135 seconds, what **force** did the bat exert on the baseball? (1010 N) d. A rocket engine burns fuel at a rate of 9.84 grams per second, and has an exhaust velocity of 985 m/s. What **thrust** does it develop? (1000 grams = 1 kg) (9.69 N) e. A 362 kg rocket, 282 kg of which is fuel, burns all of its fuel in 35.0 seconds with an exhaust velocity of 869 m/s. What are its initial and final acceleration as it takes off from earth? (9.53 m/s/s, 77.7 m/s/s)
3. a. A hammer has 22.3 kg m/s of momentum, and is going 3.57 m/s, what is its **mass**? (6.25 kg) b. A 24.0 N unbalanced force is exerted on a 12.0 Kg mass. The mass changes velocity from rest to 36 m/s. What **time** did the force act? (18.0 s) c. A 0.131 Kg baseball going 34.0 m/s, strikes a bat, and heads straight **back** to the outfield at 58.0 m/s. If the bat exerted a force of 952 N, for what **time** was it in contact with the bat? (0.0127 s) d. A rocket engine burns fuel at a rate of 13.0 grams per second, and develops a force of 11.7 N. What must be the exhaust **velocity**? (1000 grams = 1 kg) (900. m/s) e. A 19.0 kg rocket, 12.0 kg of which is fuel, burns its fuel at a rate of 0.465 kg/s with an exhaust velocity of 748 m/s. What are its initial and final acceleration as it takes off from earth? (8.50 m/s/s, 39.9 m/s/s)
4. a. A rocket imparts 24.0 Ns of impulse in 2.22 s. What **force** does it exert? (10.8 N) b. A force is exerted on a 14.0 Kg mass for 17.0 seconds. The mass changes velocity from rest to 38.0 m/s. What was the **force**? (31.3 N) c. A ball going 29.0 m/s, strikes a bat, and heads straight **back** to the outfield at 42.0 m/s. If the bat exerted a force of 1210 N for 0.00830 seconds, what is the **mass** of the ball? (0.141 kg) d. A rocket develops a thrust of 14.2 N, with an exhaust velocity of 816 m/s. What **mass** in fuel does the engine burn every second? (0.0174 kg/s) e. A 52.0 kg rocket (total mass of fuel and rocket), burns fuel at a rate of 2.17 kg/s for 19.3 seconds with an exhaust velocity of 748 m/s. What are its initial and final acceleration as it takes off from earth? (21.4 m/s/s, 160. m/s/s)
5. a. A rocket engine exerts 55.0 N of force, and imparts an impulse of 44.0 Ns. What **time** must it burn? (0.800 s) b. A 59.0 N unbalanced force is exerted on a 11.0 Kg mass for 5.20 seconds. What is the change of **velocity** of the mass? (27.9 m/s) c. A 0.148 Kg baseball going 35.0 m/s, strikes a bat, and heads straight **back** to the outfield at 67.0 m/s. If the collision lasted for 0.0125 seconds, what **force** did the bat exert on the baseball? (1210 N) d. A rocket engine burns fuel at a rate of 11.0 grams per second, and has an exhaust velocity of 845 m/s. What **thrust** does it develop? (1000 grams = 1 kg) (9.30 N) e. A 5.40 kg rocket, 4.30 kg of which is fuel, burns all of its fuel in 10.1 seconds with an exhaust velocity of 712 m/s. What are its initial and final acceleration as it takes off from earth? (46.3 m/s/s, 266 m/s/s)

Noteguide for Conservation of Momentum (Videos 7E) **Name** ______________________

Why is momentum conserved:



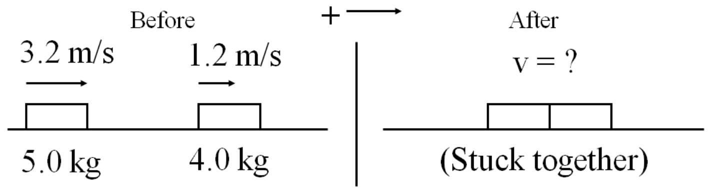
Example 1: A 4.30 g bullet travelling 925 m/s horizontally strikes and sticks in a 121 g block of wood. What is the velocity of the bullet and block after the collision?

Example 2: 60.0 kg Brennen is at rest on a 352 kg flatbed cart. He runs to the right and is going 5.30 m/s before he leaps from the car. What is the recoil velocity of the flatbed car? Ignore the friction of the wheels.

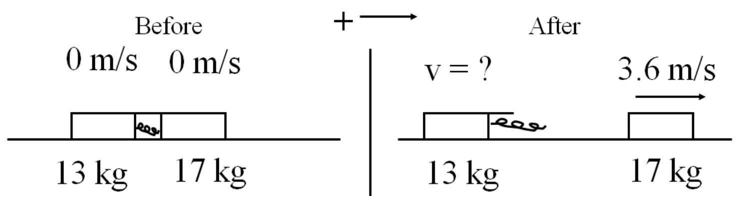
Example 3: A 2560 kg Mazda Protégé going 27.0 m/s strikes a Ford Escort traveling 13.0 m/s in the same direction from behind. The two cars stick together and are going 20.6 m/s after the collision. What is the mass of the Escort?

Example 4: Bumper car A (450 Kg) with velocity 2.90 m/s East collides with the front of car B (580. Kg) which has a velocity of 3.40 m/s West. After the collision, car B has a velocity of 1.20 m/s to the East. What is the velocity of car A after the collision? (Speed and direction)

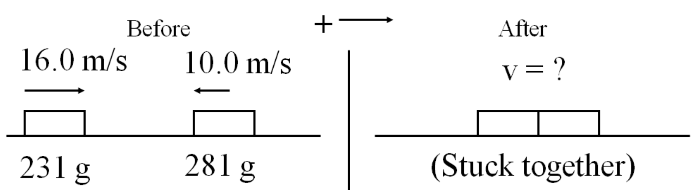
Whiteboards:

1. 

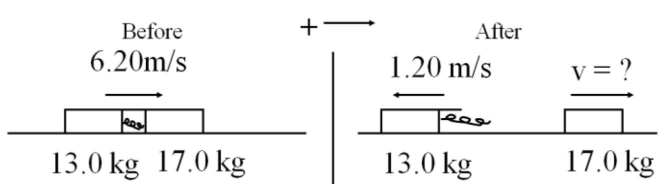
(2.3 m/s to the right)

2. 

(4.7 m/s to the left)

3. 

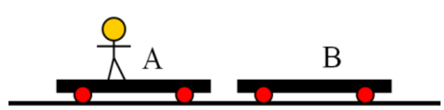
(1.73 m/s to the right)

4. 

(11.9 m/s to the right)

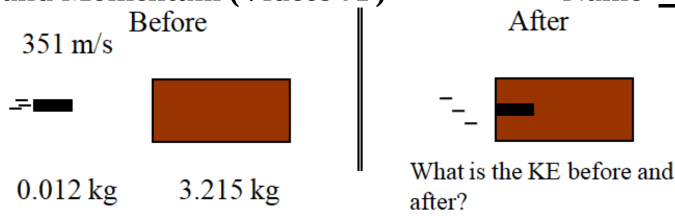
Momentum Practice Questions for 7.2

1. A 1200 Kg car going 13 m/s collides with a 4200 Kg truck at rest. Their bumpers lock. What is their speed afterwards? (2.89 m/s)
2. A 60.0 Kg person running 3.00 m/s East collides head on with a 100. Kg person running 2.00 m/s the other way. What is their final velocity if they stick together? (0.125 m/s West)
3. A 50. Kg ice skater at rest throws a 5.0 Kg shot put at a velocity of +3.5 m/s. What is the recoil velocity of the skater? (-0.35 m/s)
4. A 1200 Kg car going 15 m/s rear-ends with a 800. Kg car going 5.0 m/s in the same direction. Their bumpers lock. What is their speed afterwards? (11 m/s)
5. A bullet going 375 m/s imbeds in a stationary block of wood. The 1.42 kg bullet and block combo are going 16.5 m/s after the collision. What was the mass of the bullet? (0.0625 kg)
6. Two football players strike each other head on. Player 1 has a mass of 72.0 kg and is running 5.20 m/s to the East, and player 2 has a mass of 86.0 kg is running to the West. If they stick together, and are together moving 1.60 m/s to the West after the collision, was the velocity of player 2 before the collision? (Speed and direction) (7.29 m/s to the West)
7. Two football players strike each other head on. Player 1 has a mass of 119 kg and is running 6.20 m/s to the East, and player 2 has a mass of 102 kg is running 4.20 m/s to the West. What is their post-collision velocity if they stick together? (Speed and direction) (1.40 m/s East)
8. A 2000. Kg airplane going 45.0 m/s fires a 2.00 Kg shell forward at a speed of 1200. m/s. What is the final velocity of the plane? (Planes crashed because of this!) (43.8 m/s)
9. A 14.5 g bullet traveling 783 m/s horizontally strikes a 9.24 Kg block of wood at rest on a level frictionless table. The bullet goes through the block, but is traveling only 382 m/s in the same direction after the collision. What is the velocity of the block after the collision? (Assume the block loses no mass) (0.629 m/s)
10. Bumper car A (326 Kg) with velocity 3.7 m/s East collides with the rear of car B (536 Kg) which has a velocity of 2.4 m/s East. After the collision, car A has a velocity of 1.2 m/s to the West. What is the velocity of car B after the collision? (5.38 m/s East)
11. Bumper car A (428 Kg) with velocity 2.40 m/s East collides with the front of car B (509 Kg) which has a velocity of 3.10 m/s West. After the collision, car A has a velocity of 2.30 m/s to the West. What is the velocity of car B after the collision? (Speed and direction) (0.852 m/s to the East)
12. 95.0 kg Thor is standing on a 65.0 kg cart, and is holding a 8.90 kg hammer. Everything is moving to the right at 1.80 m/s. What is the velocity of Thor and cart if he throws the hammer 12.5 m/s to the right? (1.205 m/s)
13. 82.0 kg Big J Sandvik is standing on a 23.0 kg golf cart, and is holding a 3.60 kg golf club. Everything is moving to the right at 1.45 m/s. After he throws the golf club, he and his cart are moving 2.16 m/s to the right. What speed and in what direction did Big J Sandvik throw the golf club? (19.3 m/s to the left)
14. 96.0 kg Thor is standing on a 45 kg cart, and is holding a 9.40 kg hammer. Everything is moving to the right at 2.30 m/s. After he throws the hammer, he is moving 1.70 m/s to the right. What speed and in what direction did he throw the hammer? (11.3 m/s to the right)
15. 78.0 kg Big J Sandvik is standing on a 15.0 kg golf cart, and is holding a 3.40 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 23.0 m/s. What speed and in what direction was he, his cart and his club going to begin with? (3.71 m/s to the right)
16. A 132.45 g bullet traveling at 386 m/s rips a hole through a 1.34 Kg block of wood at rest on some frictionless ice. The bullet is traveling 153 m/s following the collision, what is the speed of the block? (23.0 m/s)
17. A 153 gram bullet going 452 m/s goes through the first of two stationary 3.50 kg blocks of wood, and sticks in the second. After this, the first block is traveling at 6.50 m/s in the same direction. What speed are the second block and bullet going? (12.7 m/s) What is the bullet's velocity between the blocks? (303 m/s)
18. 60.0 kg Brennen is playing on two flatbed rail cars initially at rest. Car A has a mass of 560. kg and B 780. kg. He reaches a velocity of +5.20 m/s on A, before jumping to B where he slows to +3.40 m/s before jumping off the other end. The cars are uncoupled, and rest on a frictionless track:



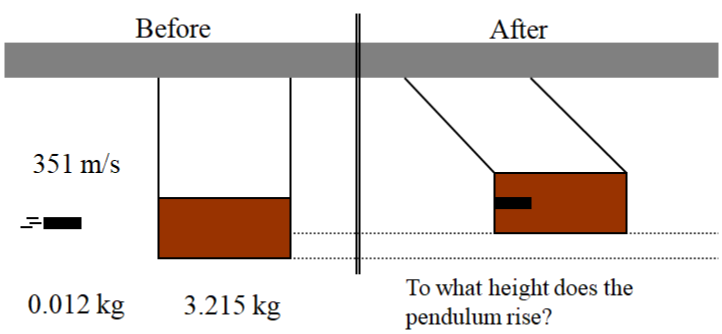
   i. What is the velocity of car A when he is in midair? (-0.557 m/s)
   ii. What is the velocity of car B when he leaves it? (+0.138 m/s)
   iii. What would have been the velocity of car B had he remained there, and not jumped off? (+0.371 m/s)
   iv. What would the velocity of car B have been had he jumped off the back of it to give himself a velocity of zero? (+0.40 m/s)

Noteguide for Energy and Momentum (Videos 7F) **Name** ____________________________



Example 1:

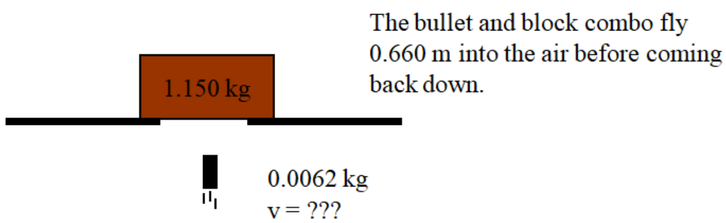
Example 2: A 220. gram air track glider going 0.120 m/s collides head on with a 410. gram glider going the other way at 0.380 m/s. The gliders then stick together. What is their post collision speed? How much kinetic energy is lost in the collision?



Example 3:

(See if you can work this one out...)
Whiteboard 4: A 4.50 g bullet going 916 m/s horizontally sticks into a 1.12 kg block of wood hanging from a very long string. What is the velocity of the block right after the collision? To what height does the block rise on the string? (3.67 m/s, 0.685 m)

Example 5:



(See if you can work this one out...)
Whiteboard 6: A 6.30 g bullet going straight up at some speed strikes the bottom of a 1.65 kg block of wood at rest, and sticks in it without going through. The bullet and block combo fly 1.14 m up into the air. What was the post collision speed of the combo, and what was the bullet's original speed?
(4.73 m/s, 1243 m/s)

Practice for 7.3 - Energy and Momentum

Loss of KE in collisions:

1. A 230. gram air track glider going 0.210 m/s collides head on with a 450. gram glider going the other way at 0.780 m/s. The gliders then stick together. What is their post collision speed? How much kinetic energy is lost in the collision? (0.445 m/s, 0.0746 J)
2. A 370. gram air track glider going 0.980 m/s collides with a 450. gram glider going the same way at 0.120 m/s. The gliders then stick together. What is their post collision speed? How much kinetic energy is lost in the collision? (0.508 m/s, 0.0751 J)
3. A 460. gram air track glider going 0.320 m/s collides with a stationary 450. gram glider. The gliders then stick together. What is their post collision speed? How much kinetic energy is lost in the collision? (0.162 m/s, 0.0116 J)
4. A 160. gram air track glider going 0.150 m/s collides head on with a 230. gram glider going the other way at 0.540 m/s. The gliders then stick together. What is their post collision speed? How much kinetic energy is lost in the collision? (0.257 m/s, 0.0225 J)
5. A 480. gram air track glider going 0.520 m/s collides with a 630. gram glider going the same way at 0.180 m/s. The gliders then stick together. What is their post collision speed? How much kinetic energy is lost in the collision? (0.327 m/s, 0.0157 J)
6. A 4.25 gram bullet going 613 m/s strikes a 216 g block of wood and sticks in it without emerging. What is the velocity of the bullet and block of wood after the collision? What is the kinetic energy of the bullet before the collision? What is the kinetic energy of the bullet and block combo after the collision? How much kinetic energy goes missing? What happens to the missing kinetic energy? (11.8 m/s, 799 J, 15.4 J, 783 J, turns to heat)

COM and COE:

7. A 12.5 g bullet going 516 m/s horizontally sticks into a 1.625 kg block of wood hanging from a very long string. What is the velocity of the block right after the collision? To what height does the block rise on the string? (3.94 m/s, 0.791 m)
8. A 12.5 g bullet going horizontally sticks into a 1.625 kg block of wood at rest hanging from a very long string. It makes the block rise to a height of 0.426 m. What was the velocity of the bullet and block combo right after the collision? What was this bullet's original velocity? (2.89 m/s, 379 m/s)
9. A 2.85 g bullet going 523 m/s vertically upward strikes the bottom of a 517 g block of wood at rest and sticks in the block without emerging. What is the velocity of the bullet and block combo right after the collision? To what height above its original position does the block rise after the collision? (2.87 m/s, 41.9 cm)
10. A 2.90 g bullet going straight up at some speed strikes the bottom of a 170. g block of wood at rest, and sticks in it without going through. The bullet and block combo fly 11.4 m up into the air. What was the post collision speed of the combo, and what was the bullet's original speed? (15.0 m/s, 892 m/s)
11. A 5.20 g bullet going horizontally strikes a 810. g ballistic pendulum at rest and sticks in it, making it swing up to a height of 31.0 cm. What speed were the block and bullet going just after the collision, and what was the bullet's speed before the collision? (2.47 m/s, 387 m/s)
12. A 3.10 g bullet going horizontally at 630. m/s strikes a 930. g ballistic pendulum at rest, and sticks in it making it swing up to some height before going back down. What was the velocity of the bullet and block just after the collision? To what height did the bullet and block combo swing? (2.09 m/s, 22.3 cm)
13. Yet another 12.5 g bullet going 516 m/s goes right through the 1.625 kg block of wood hanging from a very long string, and is going 314 m/s after it goes through the block. What is the block's velocity after it passes through, and to what height does the block rise? (1.55 m/s, 0.123 m)

IB Physics
Conservation of Momentum (groups of 2)

When a moving glider strikes a glider at rest on an air track the velocity will go down, but momentum will be conserved. Here you will test this. There are three different ways to determine the velocity of the cars before and after the collision, we can use the range finder, photo gates, and video analysis.

1. You will need <u>**one**</u> lab partner, (Work in groups of 2 – if you have a group of 3 then you must analyze two different collisions), an air track, two gliders, and a computer with Logger Pro on it.
2. **Mass** the two gliders and record this. Level the air track. Practice the collision (Not too fast, not too slow) – it sometimes helps to hold the stationary glider still with a finger until just before the collision. For the three ways you calculate velocity, you will need to gather the mass of both gliders, and the velocity of the gliders before and after, and the uncertainty of everything you measure.
3. Gather the velocity before and after the collision in one of three ways:

   Range Finder: Run the momentum lab on the desktop. You will need to adjust the rangefinder until you get a nice graph of the collision on your velocity graph. When you get the graph you want, you can use “Analyze” > “Statistics” and it will pop up a neat balloon on your graph that has the information you need. (Including uncertainty!)

   Photo gates: Run the momentum lab on the desktop. The photo gates simply time the duration that the infrared beam is blocked. The velocity of the glider is just the length of the “flag” on the top of the glider, divided by the duration of the blockage. So you will need to measure the length of the flag in m, and estimate the uncertainty of both the distance and the time. Set up the photo gates so that they time the flag just before, and just after the collision, but not during.

   Video Analysis: Put a meter stick in the field of view of the video camera, and go to “Insert” > “Video Capture” and set up your camera. Make a video of the collision being careful not to block the view of the carts. Then you can open the analysis tools on the movie, set the scale (and the origin if you like) and just click on the front of the first cart every frame, and the software will calculate position and even velocity. From the velocity before and after the collision in the table you should be able to estimate the uncertainty.

Here's what you turn in:

1. A brief description (4 words) of the general method you used (Rangefinder, photo gates, or video analysis)
2. **A nice data table that has the information you used in your calculations. (units and uncertainties)**
3. Your calculations of the momentum before the collision, and after the collision and the <u>uncertainty</u> of those momenta.
4. An appropriate conclusion and evaluation of the experiment as per IB criteria.
   a. Use the numbers to make an argument as to whether the data you have disproves conservation of momentum. You will need to intelligently use the uncertainties, as well as the calculated momenta before and after.
   b. Discuss the sources of error present, and what effect those source might have had on the investigation
   c. Suggest ways to improve the procedure to eliminate the sources you mentioned

IB Physics

Vector Momentum (Groups of 2 – if you have a group of 3 or 4, you must analyze 2 **different** collisions)

You will most likely encounter this lab in college done on a $2000 air table with pucks. The table resembles an air hockey table. In the lab, you collide two pucks of known mass, each of which leaves a trail of little marks at equal time intervals. You then analyze these tracks to see if momentum was really conserved. You will simulate this lab, and do essentially the same analysis using the tracking feature of Interactive Physics.

Part 1: Getting the image.

1. Run Interactive Physics from the launch bar, and open the File "NewAirTable.ip" on the desktop.
2. Click the "Run" button on the tool bar, and watch what happens. Notice that the objects leave little dots behind them. This is what a spark table would do, only it costs more. Notice also that the objects move and bounce off each other much as they would do in real life. When the objects leave the screen, hit the "Stop" button, and then hit the "Reset" button to start over.
3. Move the red object slightly off center to create your own unique collision by typing a new value into the text box. **Do not try to drag the red dot!** (With values at the extremes, or close to zero, you might get more tracking dots than you will care to count) Run the simulation until you get a nice looking picture. Make sure you can discern the individual tracking dots.
4. Once you are satisfied with your tracks, run the simulation, and let the objects go off the screen. Then hit the "Stop" button, and then **the "Reset" button so that the original position of the red dot is on the screen.**
5. For some reason, Interactive physics will not print tracking marks, but you can capture them with a screen shot. Make sure that all the tracks are visible, and then press the "Print Screen" button near the top middle right of the keyboard, and the computer will place the current screen image in a clipboard. Then you can paste your image into Word.
6. In Word 2007 do these things:
   Office Button>Print>Print Preview>Orientation>Landscape
   Paste (ctrl-V, or right click>Paste)
   Select the image, Click "Picture Tools" at the top, and crop the image.
   De-select the image, and select it again to get rid of the Crop tool
   Widen the margins a bit if you would like.
   Grab a corner handle and make the image as large as will fit on your page.
   Office Button>Print>Print Preview (Make Sure you are not on several pages) and Print

Part 2: Analyzing the image:

1. Go back to Interactive Physics, and hit the "Reset" button. Jot down on your printout which track goes with which object, and note their masses.
2. Circle the three dots in the middle, and ignore them, as we don't know if they are before or after the collision
3. Calculate the momentum of the Red object before the collision. You are going to simply do mass times velocity (displacement divided by time).

•Displacement:. Measure from the first to the last pre-collision dot for the red object. Measure this in cm using a cm ruler, to the nearest mm. (like 10.5 cm)

•Time: Count how many intervals this took place in. (There are one fewer intervals than there are dots…) Each interval between dots represents .04 seconds, so multiply number of intervals by .04 to get time.(like 8*.04s = .32 s)

•Then divide displacement by time to get velocity in cm/s. (like 10.5 cm/.32 s =32.8125 cm/s)

To get momentum, multiply by the mass of the red object to get momentum. Notice that it is entirely in the x-direction.

4. For each of the post collision tracks, pick the first and last dot, and measure the x and y components of their displacement, and calculate the x and y momenta directly from this using the same technique described in step 2. Note that one of the y-momenta needs to be negative.

Part 3: Interpreting results

1. •Make a table of the x and y components of momentum in kg cm/s for the entire system before and after. •Add up both x components, and both y components for the post collision. (Don't add x to y though, that would be bad) Put your calculations in the cells of the table.

Turn in for credit:

•your analyzed image

•a neat data table with the all the calculations you did in Part 2, steps 2, 3 and 4.