F2

PHY 111 Momentum: Block and bullet

1. A 3-kg block of wood is sitting at rest on frictionless ice. A 100-gram bullet traveling at 150 m/s hits the block of wood is and is embedded in the wood.
a) What is the momentum of the bullet before it hits the block?
b) How fast does the block (with the embedded bullet) move after being hit?
c) How much heat is generated as the bullet embeds in the wood?

2. This time suppose the bullet goes through the block instead of being embedded. The bullet comes out the other end of the block with a speed of 50 m/sec.
a) What is the momentum of the bullet before it hits the block? What is the momentum of the bullet after it leaves the block?
b) What is the final momentum of the block? What is the direction of the block's momentum?
c) What is the final velocity of the block?

PHY 111 **Momentum Homework**

2

14. A 5000 kg open train car is rolling on frictionless rails at 22 m/s when it starts pouring rain. A few minutes later, the car's speed is 20 m/s. What mass of water has collected in the car?

17. Dan is gliding on his skateboard at 4.0 m/s. He suddenly jumps backward off the skateboard, kicking the skateboard forward at 8.0 m/s. How fast is Dan going as his feet hit the ground? Dan's mass is 50 kg and the skateboard's mass is 5.0 kg.

b) How much energy does Dan use to kick the skateboard?

18. A 300 g bird flying along at 6.0 m/s sees a 10 g insect heading straight toward it with a speed of 30 m/s. The bird opens its mouth wide and enjoys a nice lunch. What is the bird's speed immediately after swallowing?

b) How much heat is generated?

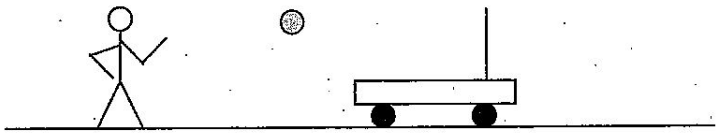
PHY 111 **Momentum problems**

1. An unoccupied 1200-kg automobile traveling at 25 m/sec to the right collides head on with an unoccupied 2000- kg truck traveling at 20 m/s to the left in a crash test. The two vehicles stick together after the collision.

a) What are the speed and the direction of the two vehicles immediately after the collision?

b) What percent of the total initial kinetic energy is converted to heat after the collision?

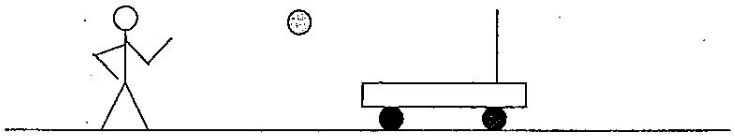
2a. A person standing on the ground throws a 4-kg ball at an 80-kg cart. The ball has an initial velocity of 20 m/s to the right and the cart is initially at rest. The ball lands and stops on the floor of the cart. How fast is the cart moving after the ball lands on the cart? Ignore friction.



b. How much heat is generated by the ball landing on the cart? (Hint: Find out how much kinetic energy is lost by the ball landing on the cart.)

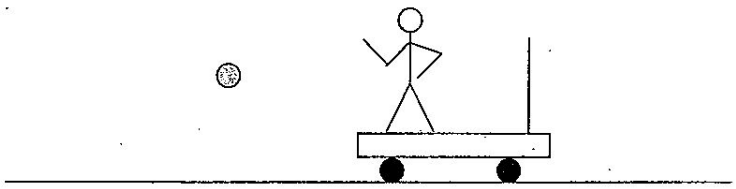
4

3. A person throws a 4-kg ball with a speed of 20 m/sec at an 80-kg cart. The ball rebounds off a wall attached to the cart with as velocity of 10 m/s to the left.

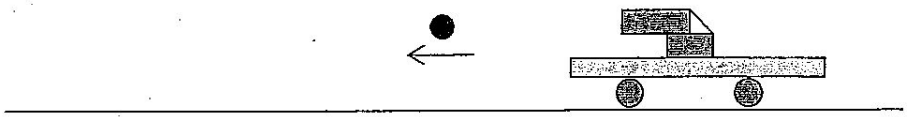


a) What is the final velocity of the cart?
b) How much heat is generated in the collision?

4. Now suppose the person is standing on the cart when he throws the ball. The combined mass of the person/cart is 130 kg. The mass of the ball is 4 kg. All objects are all initially at rest. The person throws the ball with a velocity of 20 m/s to the left.
a) What is the velocity of the person (and cart) after he throws the ball?
b) How much chemical potential energy must the person convert to kinetic energy to throw the ball (assuming 100% efficiency for the person)?



5. A cart with a mounted cannon is coasting to the right at a constant speed of 10 m/s. The mass of the cart/cannon is 150 kg. The mass of the cannon ball is 5 kg. (The initial mass is therefore 155 kg.)
The 5-kg cannon ball is shot to the left with a speed of 50 m/s (relative to the ground).



a) What is the initial momentum before the cannon ball is fired?

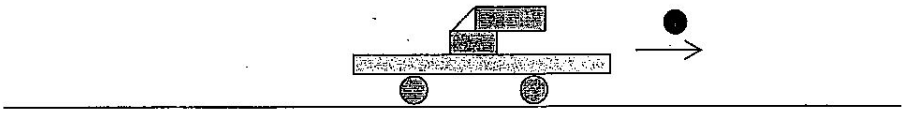
b) What is the momentum of the cannon ball after it is fired?

c) What is the velocity of the cart/cannon after firing (the mass now is only 150 kg)?

d) Assuming no heat loss, how much chemical energy is stored in the gun powder in the cannon?

6

6. A cart with a mounted cannon is coasting to the right at a constant speed of 5 m/s. The mass of the cart/cannon is 150 kg. The mass of the cannon ball is 5 kg. (The initial mass is therefore 155 kg.)
The 5-kg cannon ball is shot to the right with a speed of 200 m/s (relative to the ground).



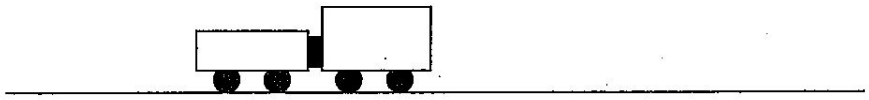
a) What is the initial momentum before the cannon ball is fired?

b) What is the momentum of the cannon ball after it is fired?

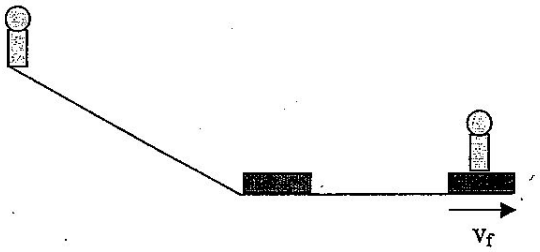
c) What is the velocity of the cart/cannon after firing (the mass now is only 150 kg)?

d) Assuming no heat loss, how much chemical energy is stored in the gun powder in the cannon?

7. Two carts (40 kg and 60 kg) on a track are initially at rest. There is a compressed string between them. The spring is released sending the 40 kg cart to the left with a speed of 12 m/sec.
a) What is the speed of the 60 kg cart?
b) What was the initial energy in the spring?



8. A 50-kg skier is initially at rest on the top of a hill. The hill has a vertical elevation of 10 m. At the bottom of the hill is a 25-kg sled, also initially at rest.
The skier slides down the hill, picking up speed. When the skier gets to the bottom of the hill, he jumps onto the sled. At that point the sled moves forward with a final velocity, v_f. Ignore friction.



8

PHY 111 Ballistics test: Determining the speed of a bullet (#2)

In this case we look at the more realistic example where the height of the pendulum is used to measure the velocity of the bullet.

The mass of the bullet and the block is the same as before. The block (with the bullet) swings to a height of 15 cm.

Follow the same steps as the first problem (only backwards) to find the initial velocity of the bullet.

(mass of bullet = 20 g)

(mass of block = 4 kg)

PHY 111 2-dimensional momentum problem

A 2500 kg car traveling north (in the +y direction) at a speed of 15 m/s collides with a 1800 kg car traveling east (in the +x direction) at a speed of 25 m/s. The two cars stick together after the collision.

a) What is the speed and **(b)** what is the direction of the two cars stuck together immediately after the collision? (Give the direction as an angle with respect to the x axis.)

c) How much kinetic energy was converted to heat during the collision itself?