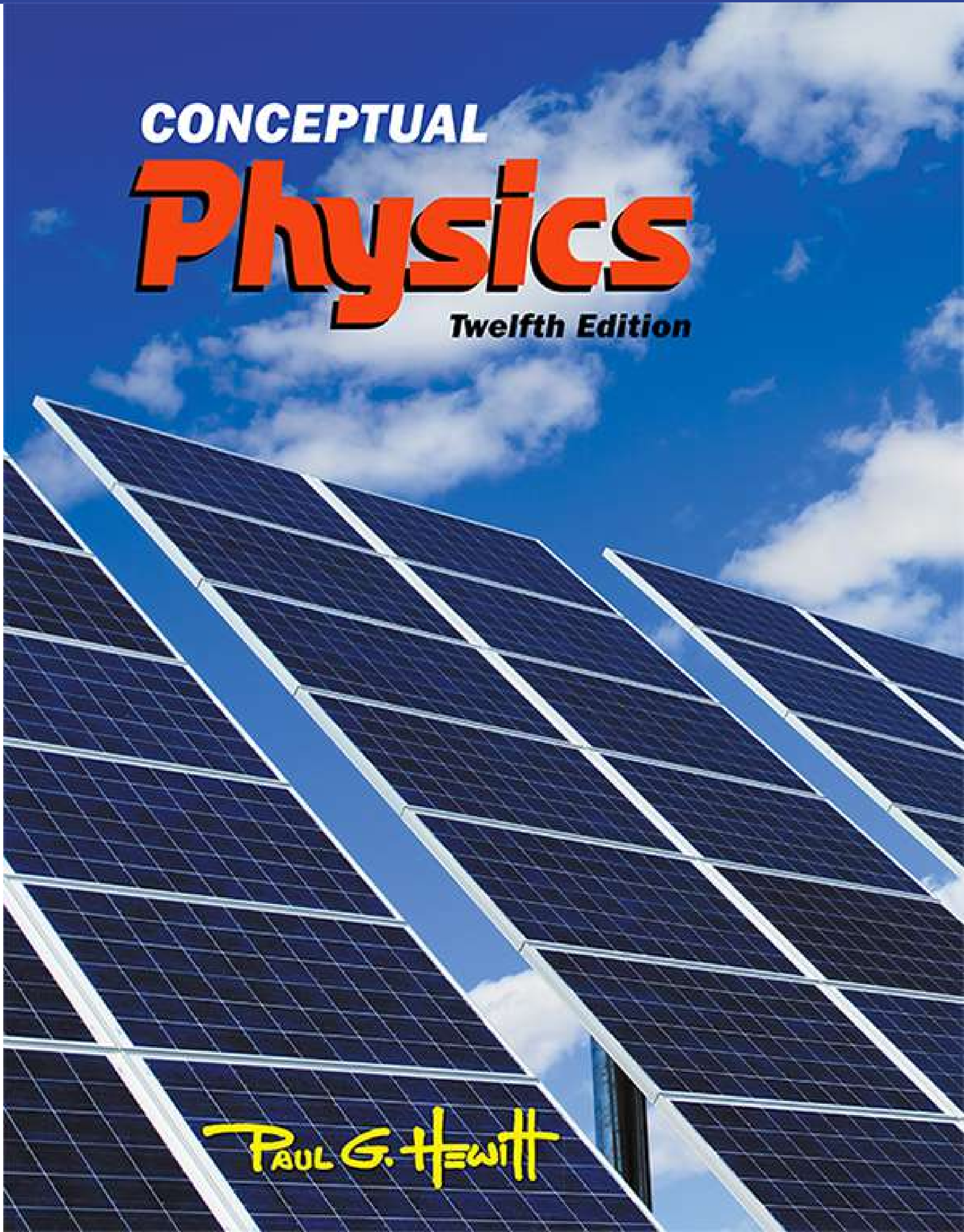
Lecture Outline

Chapter 6: Momentum

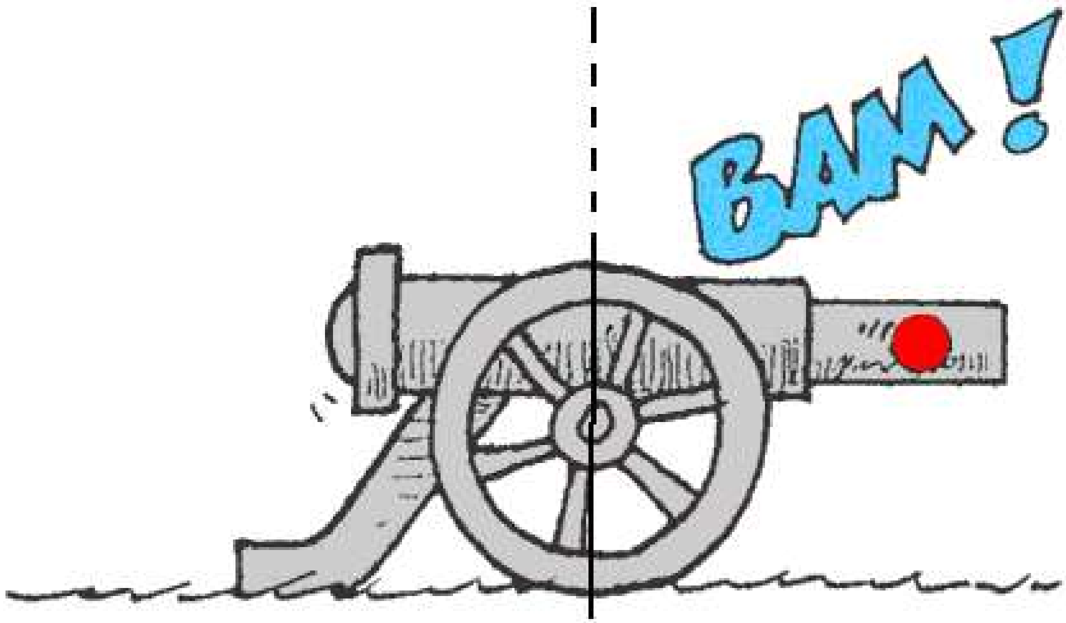


This lecture will help you understand:

- Conservation of Momentum
- Collisions
- More Complicated Collisions

Conservation of Momentum

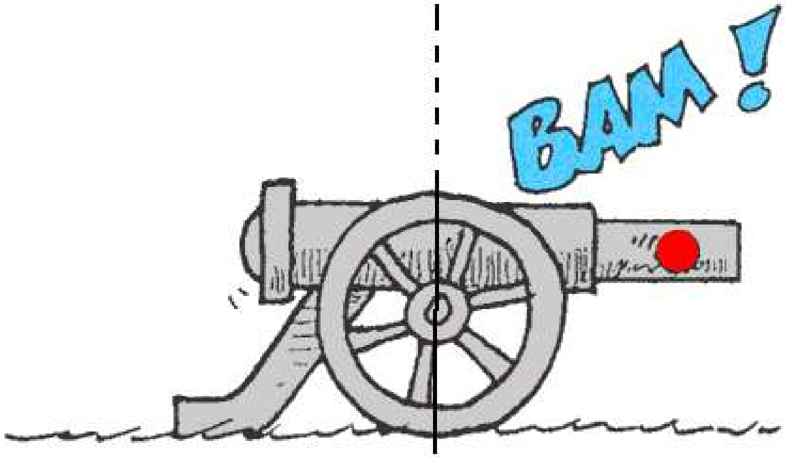
- Law of conservation of momentum:
  - In the absence of an external force, the momentum of a system remains unchanged.



Conservation of Momentum

Before firing, the cannon is at rest.

Its total momentum is zero.



After firing, the positive momentum gained by the cannon ball is equal in magnitude but opposite in direction to the momentum gained by the cannon.

momentum of cannon ← momentum of ball →

Conservation of Momentum, Continued

- Examples:
  - When a cannon is fired, the force on the cannonball inside the cannon barrel is equal and opposite to the force of the cannonball on the cannon.
  - The cannonball gains momentum, while the cannon gains an equal amount of momentum in the opposite direction—the cannon recoils.
- When no external force is present, no external impulse is present, and no change in momentum is possible.

Conservation of Momentum

- Examples (continued):

  \- Pushing against a car's dashboard has no effect on its momentum.

  – *Internal* molecular forces within a baseball come in pairs, cancel one another out, and have no effect on the momentum of the ball.

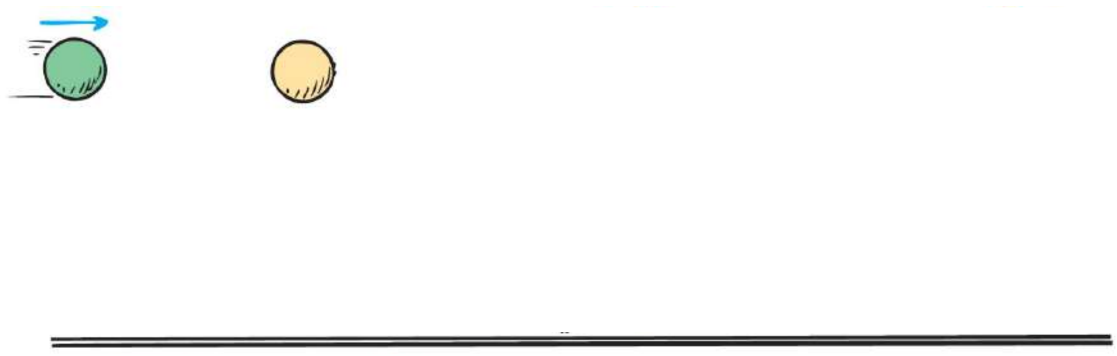
  Molecular forces within a baseball have no effect on its momentum.

Collisions

- For all collisions in the absence of external forces,
  - net momentum before collision equals net momentum after collision.
  - in equation form:

$$(\text{net } mv)_{\text{before}} = (\text{net } mv)_{\text{after}}$$

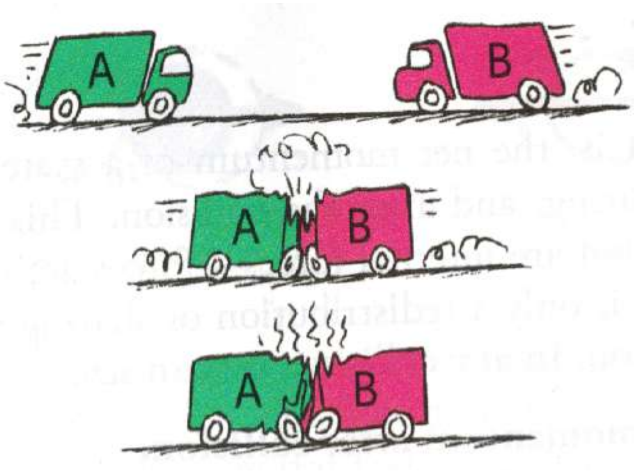
- Elastic collision
  - occurs when colliding objects rebound without lasting deformation or any generation of heat.

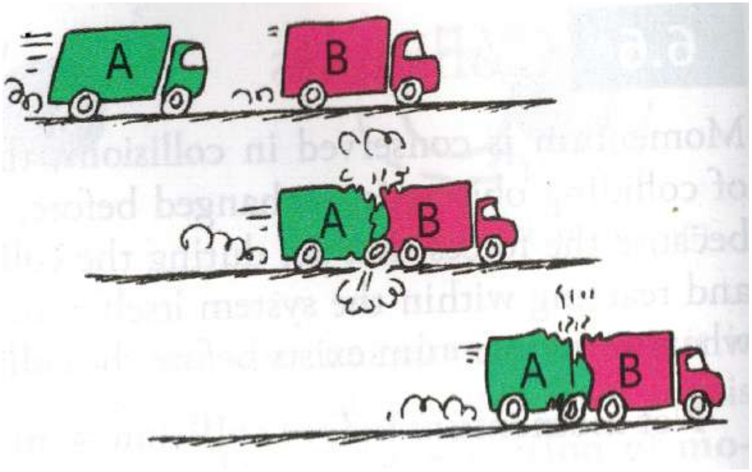


- Notice how momentum is *transferred* from one object to another….it is not lost or created.

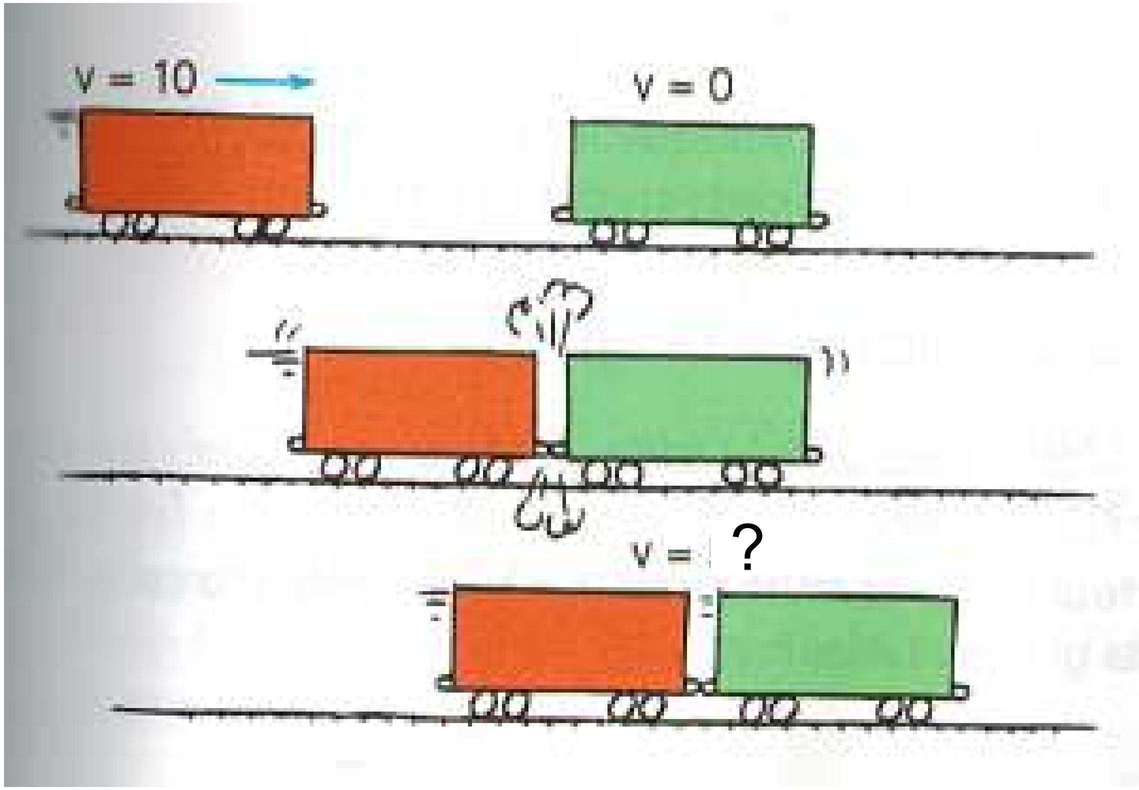
Collisions

- Inelastic collision
  - occurs when colliding objects result in deformation and/or the generation of heat.

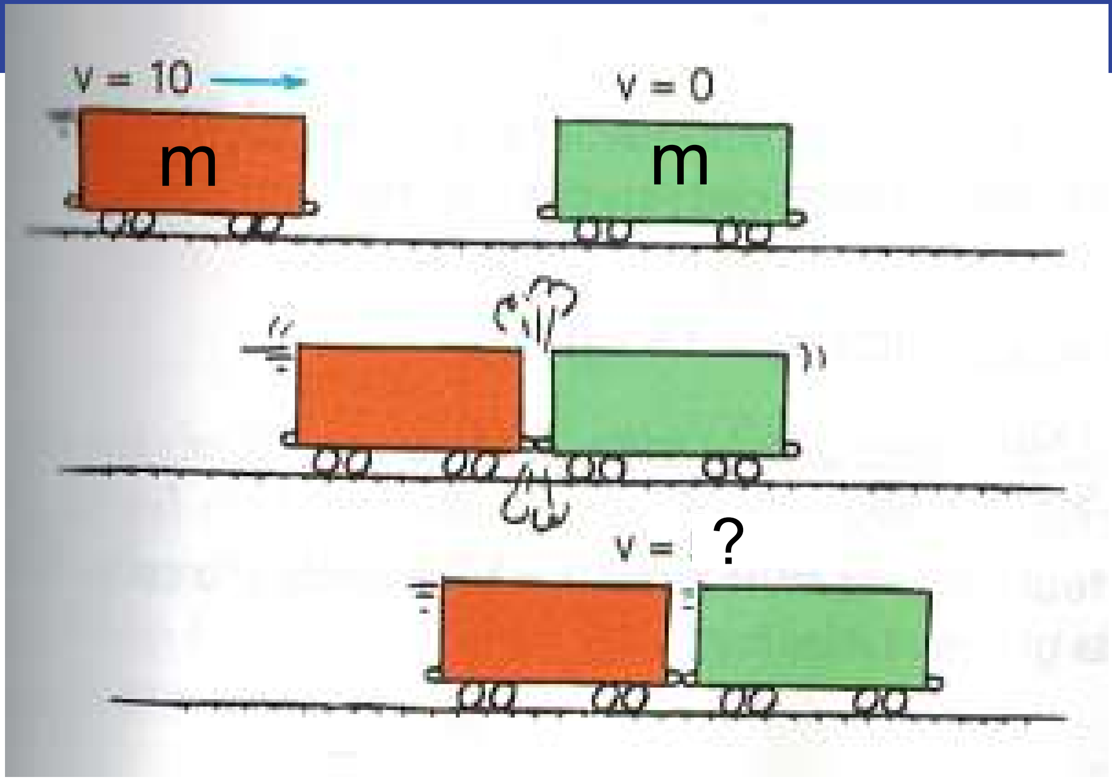




- Example of inelastic collision:
- single car moving at 10 m/s collides with another car of the same mass, *m*, at rest



From the conservation of momentum:



$$(\text{net } mv)_{\text{before}} = (\text{net } mv)_{\text{after}}$$

$$(m \times 10)_{\text{before}} = (2\text{m} \times V)_{\text{after}}$$

$$V = 5 \text{ m/s}$$

****Notice that the problem was solved without knowing anything about the complicated forces involved in a collision!

CHECK YOUR NEIGHBOR

Freight car A is moving toward identical freight car B that is at rest. When they collide, both freight cars couple together. Compared with the initial speed of freight car A, the speed of the coupled freight cars is

A. the same.
B. half.
C. twice.
D. None of the above.

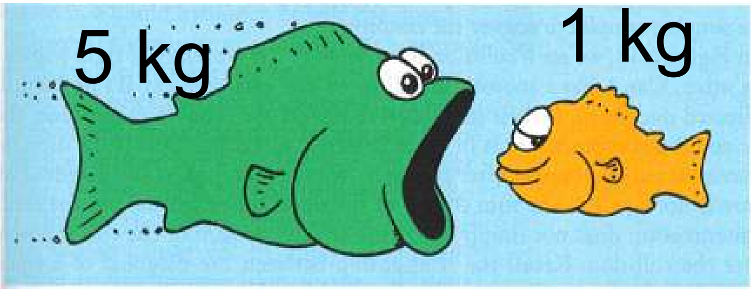
B. half.

Explanation:

After the collision, the mass of the moving freight cars has doubled. Can you see that their speed is half the initial velocity of freight car A?

Ex: Collision = Fish eats fish

A 5-kg fish swims at 1 m/s towards a 1-kg fish at rest. What is the velocity of the larger fish immediately after eating the smaller one?



net momentum before = net momentum after

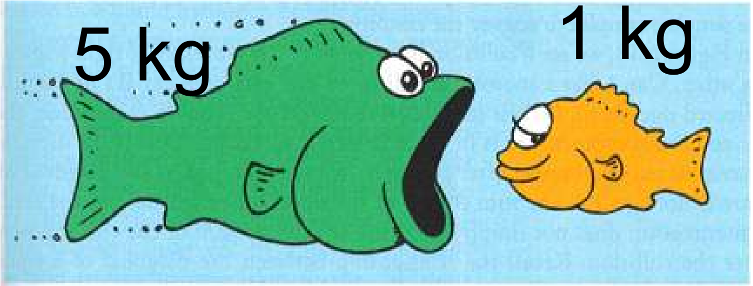
$$(5\text{ kg})(1\text{ m/s}) + (1\text{ kg})(0\text{ m/s}) = (5\text{ kg} + 1\text{ kg})\cdot v$$

$$5\text{ kg m/s} = (6\text{ kg}) \cdot v$$

$$v = 5/6\text{ m/s}$$

Ex: Collision = Fish eats fish, part 2

A 5-kg fish swims at 1 m/s towards a 1-kg fish that is swimming at 4 m/s to the left. What is the velocity of the larger fish immediately after eating the smaller one?



net momentum before = net momentum after

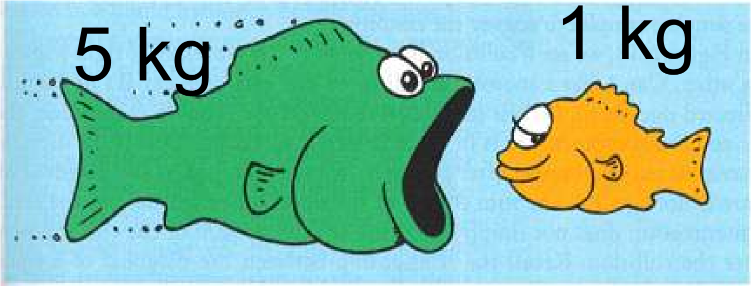
$$(5\text{ kg})(1\text{ m/s}) + (1\text{ kg})(-4\text{ m/s}) = (5\text{ kg} + 1\text{ kg})\cdot v$$

$$1\text{ kg m/s} = (6\text{ kg})\cdot v$$

$$v = 1/6\text{ m/s}$$

Ex: Collision = Fish eats fish, part 3

A 5-kg fish swims at 1 m/s towards a 1-kg fish that is swimming at 8 m/s to the left. What is the velocity of the larger fish immediately after eating the smaller one?



net momentum before = net momentum after

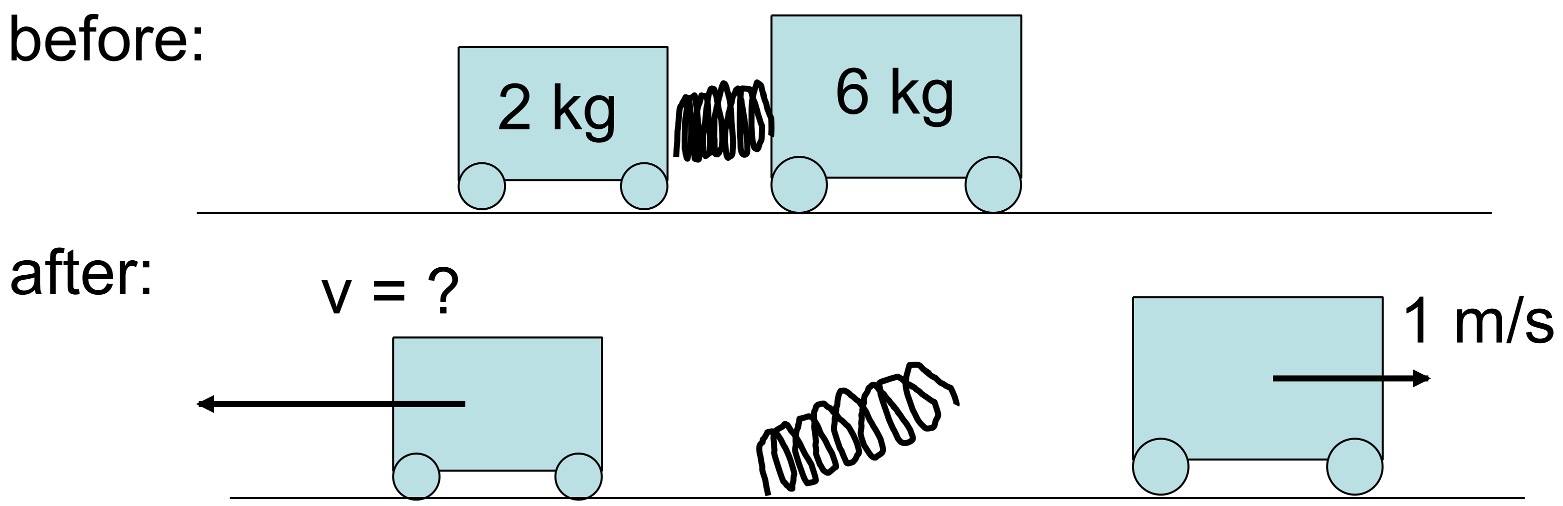
$$(5\ \text{kg})(1\ \text{m/s}) + (1\ \text{kg})(-8\ \text{m/s}) = (5\ \text{kg} + 1\ \text{kg})\cdot v$$

$$-3\ \text{kg m/s} = (6\ \text{kg}) \cdot v$$

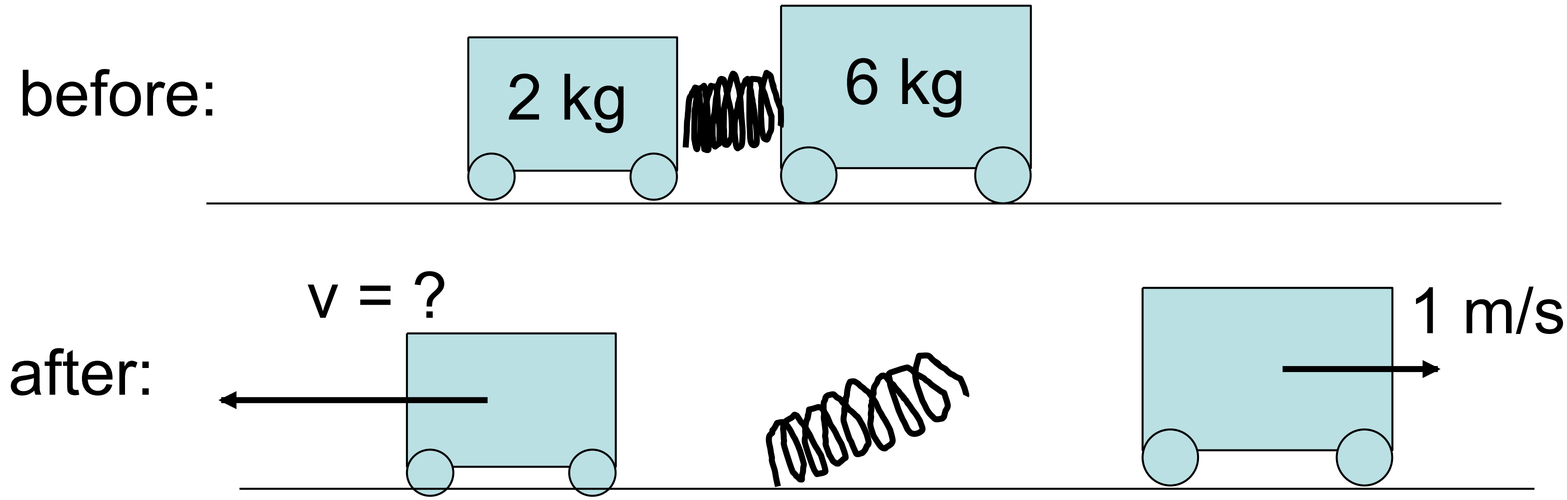
$$v = -1/2\ \text{m/s}$$

Conservation of Momentum-Separations

- A 2-kg cart and a 6-kg cart are pushed up against a a spring. They begin at rest. When the spring is released, the 6-kg cart moves to the right at 1 m/s. What is the speed of the 2-kg cart?



Conservation of Momentum-Separations



net momentum before = net momentum after

(2 kg)(0 m/s) + (6 kg)(0 m/s) = (2 kg)(v) + (6 kg)(1 m/s)

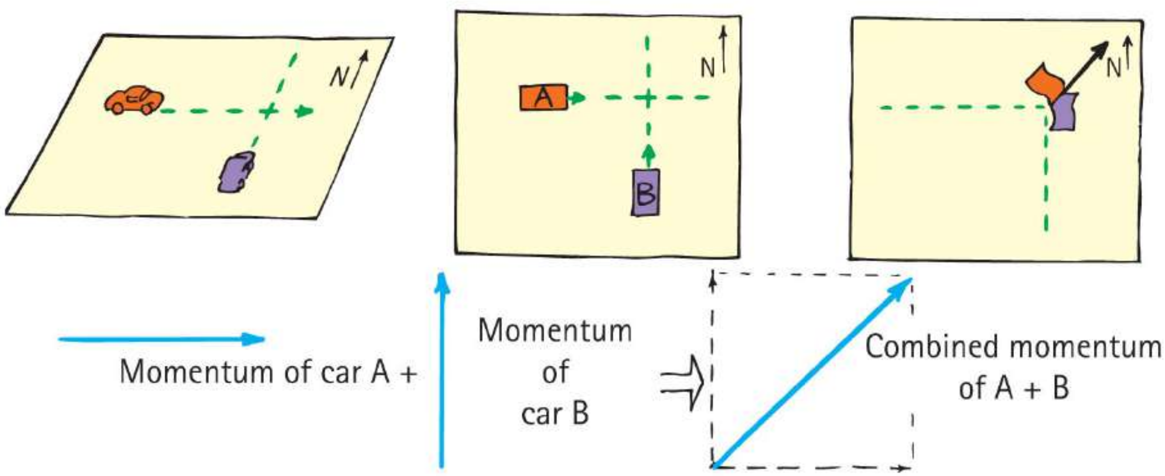
0 = 2 v + 6 kg m/s

v = -3 m/s

After they separate, which car had more momentum?

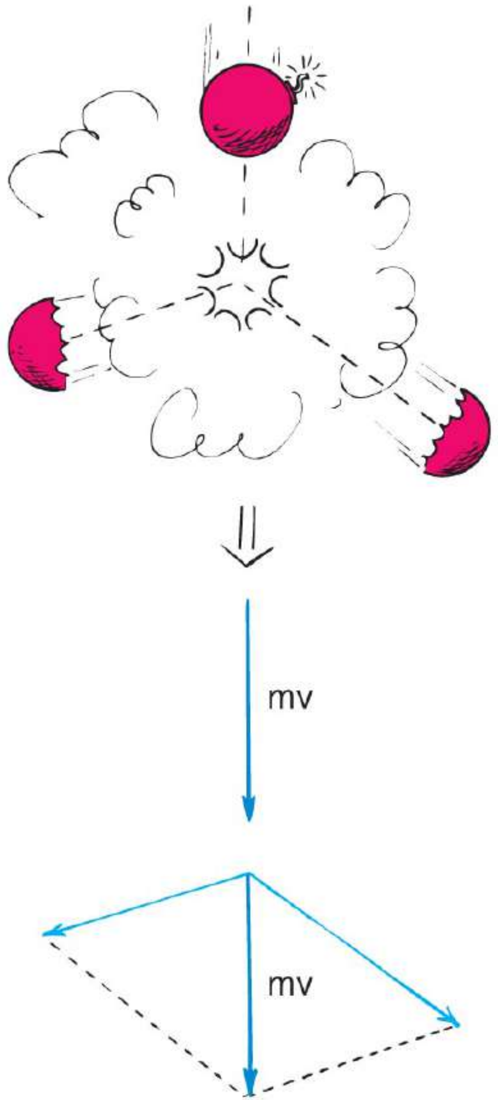
More Complicated Collisions

- Sometimes the colliding objects are not moving in the same straight line.
- In this case you create a parallelogram of the vectors describing each initial momentum to find the combined momentum.
  - Example: collision of two cars at a corner



More Complicated Collisions, Continued

- Another example:
  - A firecracker exploding; the total momentum of the pieces after the explosion can be added vectorially to get the initial momentum of the firecracker before it exploded.



Examples:

- Turn to page 104 in your text.
- Right now, we will do #17-19 together.

Homework:

- Study for test tomorrow.
- Test is on Chapters 5 and 6

- Homework: due *tonight* by 7 pm
- Page 104,
- do #12-14 and #16-20