Two-Dimensional Collisions

LEARNING TARGET	DESCRIPTION
11.2	I can define, interpret, and solve problems involving the Law of Conservation of Momentum.
11.3	I can define, analyze, and solve problems involving two particle collision.

Impulse and Momentum

Key Concepts

- When doing a momentum problem, first examine the system before and after the event.
- The momentum of an object is the product of its mass and velocity and is a vector quantity.

$$\mathbf{p} = m\mathbf{v}$$

- The impulse on an object is the average net force exerted on the object multiplied by the time interval over which the force acts.

$$\text{Impulse} = \mathbf{F}\Delta t$$

- The impulse on an object is equal to the change in momentum of the object.

$$\mathbf{F}\Delta t = \mathbf{p}_f - \mathbf{p}_i$$

- According to Newton's third law of motion and the law of conservation of momentum, the forces exerted by colliding objects on each other are equal in magnitude and opposite in direction.
- Momentum is conserved in a closed, isolated system.

$$\mathbf{p}_f = \mathbf{p}_i$$

Accident Reconstruction

f=m x a

Lawyers looking to bring a claim, or police fatal crash investigators will often need to employ experts to reconstruct the scene of the accident. Experts will try to determine the most probable scenario that led to the accident. Operator or operational factors are the major cause of 90% of auto accidents. Information including statements, photos, skid marks, road way factors, laws of physics are used to analyze the dynamics of the collision. The most important evidence will be physical evidence in the form of photos and measurements of the scene often taken by police investigators at the scene in fatal and catastrophic injury cases. A diagram can be constructed showing the impact and rest positions.

- Roadway Factors
- Weather Conditions
- Lighting Conditions
- Driving Histories
- Traffic Signals and Signs
- Guard Rails, Crash Cushions and Utility Poles

Side Impact Collision

A 1325-kg car, C, moving north at 27.0 m/s, collides with a 2165-kg car, D, moving east at 11.0 m/s. The two cars get stuck together. In what direction and with what speed do they move after the collision?

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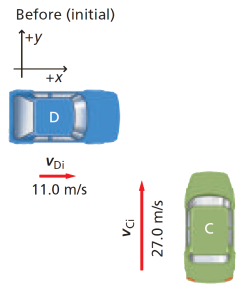

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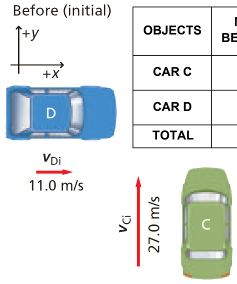

OBJECTS	MOMENTUM BEFORE (kg·m/s)	MOMENTUM AFTER (kg·m/s)
CAR C		
CAR D		
TOTAL		

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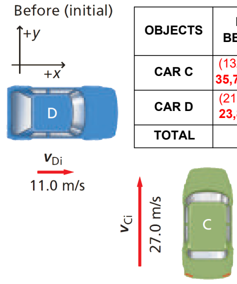
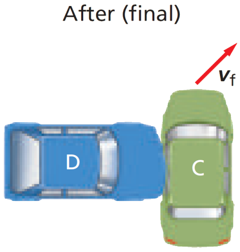


OBJECTS	MOMENTUM BEFORE (kg·m/s)	MOMENTUM AFTER (kg·m/s)
CAR C	(1325 kg)(27 m/s) = **35,775 kg·m/s North**	mv (3490 kg) v_f
CAR D	(2165 kg)(11 m/s) = **23,815 kg·m/s East**	
TOTAL		

Side Impact Collision

$$\vec{p}_{d,i} + \vec{p}_{c,i} = \vec{p}_f$$



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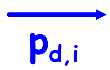

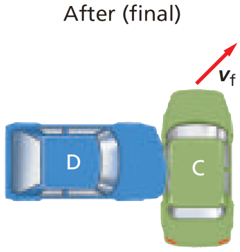

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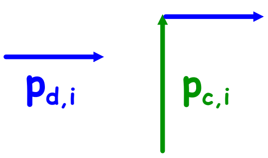
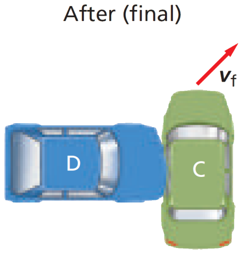
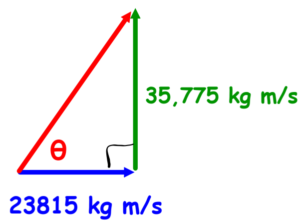
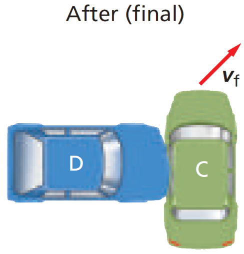




Side Impact Collision

$$\vec{p}_{d,i} + \vec{p}_{c,i} = \vec{p}_f$$





Side Impact Collision

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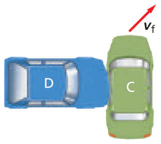
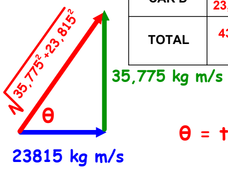
After (final)





OBJECTS	MOMENTUM BEFORE (kg·m/s)	MOMENTUM AFTER (kg·m/s)
CAR C	(1325 kg)(27 m/s) = 35,775 kg·m/s North	(3490 kg) v_f
CAR D	(2165 kg)(11 m/s) = 23,815 kg·m/s East	
TOTAL	43,000 kg·m/s @ 56.3° N of E	43,000

$\theta = \tan^{-1}(35,775/23,815)$

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$(3,490 \text{ kg})\, v_f = 43,000 \text{ kg·m/s}$

$v_f = 12.3 \text{ m/s}$

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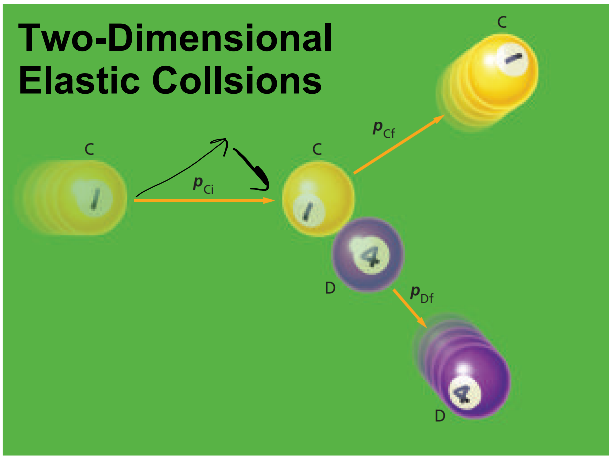
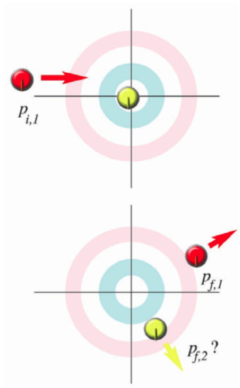


CURLING

The great Canadian sport of curling is all about collisions. A player slides a 42 lb granite "stone" about 35-40 m down the ice into a target area (house). The teams take turns sliding stones, and the stone closest to the bull's eye in the end wins. When a stone of the other team is the closest, the other team attempts to knock that stone out of the way.

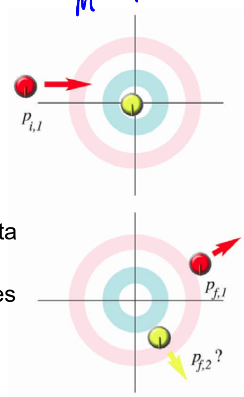


Curling

EXAMPLE

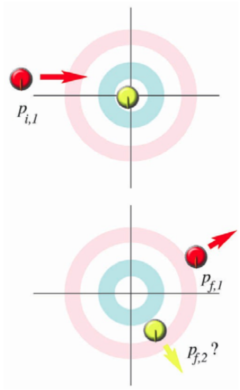
M = 42lbs

6. Suppose that the red stone shown here had an initial velocity of 1.6 m/s in horizontal direction and got deflected to an angle of 32° to the left. The yellow stone gets deflected at an angle of 58° in the other direction.
   a) What are the final momenta for each stone?
   b) What are the final velocities for each stone?



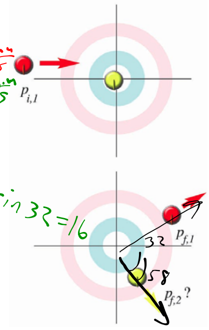
EXAMPLE

OBJECTS	MOMENTUM BEFORE (kg·m/s)	MOMENTUM AFTER (kg·m/s)
RED	(19 kg)(1.6 m/s) = **30.4 kg·m/s**	$(19)V_{f,R}$
YELLOW	(19 kg)(0 m/s) = 0 kg·m/s	$(19)V_{f,Y}$
TOTAL	30.4 kg·m/s	



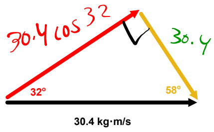
EXAMPLE

OBJECTS	MOMENTUM BEFORE (kg·m/s)	MOMENTUM AFTER (kg·m/s)
RED	(19 kg)(1.6 m/s) = **30.4 kg·m/s**	$(19)V_{f,R} = 26 \frac{kg \cdot m}{s}$
YELLOW	(19 kg)(0 m/s) = 0 kg·m/s	$(19)V_{f,Y} = 16 \frac{kg \cdot m}{s}$
TOTAL	30.4 kg·m/s	30.4



$26 = 30.4 \cos 32$

$30.4 \sin 32 = 16$



$V_{f,R} = 1.4 \, m/s$

$V_{f,Y} = 0.84 \, m/s$