Momentum Conservation

During collisions

- in a collision, all the momentum before = all the momentum after

- Momentum is conserved

Collision Types

- hit and stick, objects collide and remain together

$$m_1 \vec{v}_1 + m_2 \vec{v}_2 = (m_1 + m_2)\vec{v}'_{1 \text{ and } 2}$$

Mass object 1

Velocity of # 1 before

Mass object 2

Velocity of # 2 before

Mass object 1+ 2

Velocity of # 1 and 2 **AFTER collision**

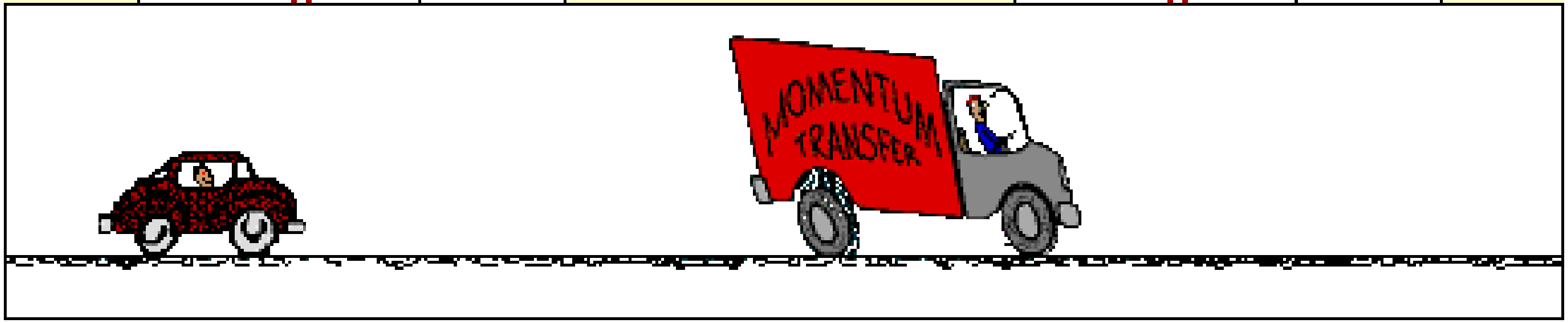
Hit and Stick

Car

mass (kg)	1000
vel. (m/s)	20.0
mom. (kg m/s)	20 000

Truck

mass (kg)	3000
vel. (m/s)	0.0
mom. (kg m/s)	0



Example

Chainsaw the cat (m = 2.50 kg) is running east at 4.90 m/s when it collides with Fluffy the poodle (m = 3.41 kg) walking west at 4.90 m/s . If the 2 remain together, determine their velocity after the collision.

Solution

- m_1 = 2.50 kg m_2 = 3.41 kg
- v_1 = 4.90 m/s east v_2 = 1.00 m/s west

$$m_1 \vec{v}_1 + m_2 \vec{v}_2 = (m_1 + m_2)\vec{v}'_{1 \text{ and } 2}$$

- 2.50(4.90) + 3.41(-1.00) =(2.50+3.41)$v'_{1 \text{ and } 2}$
- 12.25 + -3.41 = 5.91$v'_{1 \text{ and } 2}$
- 8.84 = 5.91$v'_{1 \text{ and } 2}$
- $v'_{1 \text{ and } 2}$ = 1.50 m/s east

Hit and bounce

- objects collide and do not remain together

$$m_1 \vec{v}_1 + m_2 \vec{v}_2 = m_1 \vec{v}'_1 + m_2 \vec{v}'_2$$

Hit and Bounce

The momentum before a collision = momentum afterwards

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1' + m_2\vec{v}_2'$$

(800kg)(+5.00m/s) + (900kg)(-5.00m/s)=(800kg)(-1.00m/s)+(900kg)(+3.00m/s)

-500 kg•m/s = -500 kg•m/s

Explosions and Recoil

- 1 object breaks into 2 pieces

$$(m_1 + m_2)\vec{v}_{1\text{and } 2} = m_1\vec{v}'_1 + m_2\vec{v}'_2$$

Total mass before explosion

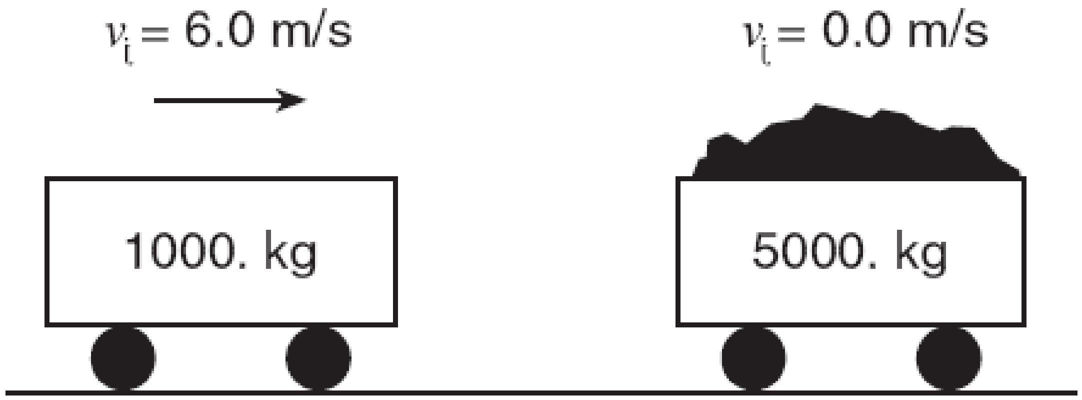
Velocity before explosion

Mass and velocity of piece 1 **AFTER**

Mass and velocity of piece 2 **AFTER**

Example

- A 1000 kg railway car moving at 6.0 m/s to the right collides with a 5000 kg car at rest. If the two remain together, determine their final velocity. (Hit and stick collision)



m_1 =1000 kg
v_1 = 6.0 m/s right
m_2 = 5000 kg
v_2 = 0
v'_{1+2} = ?

$$m_1 \vec{v}_1 + m_2 \vec{v}_2 = (m_1 + m_2)\vec{v}'_{1 \text{ and } 2}$$

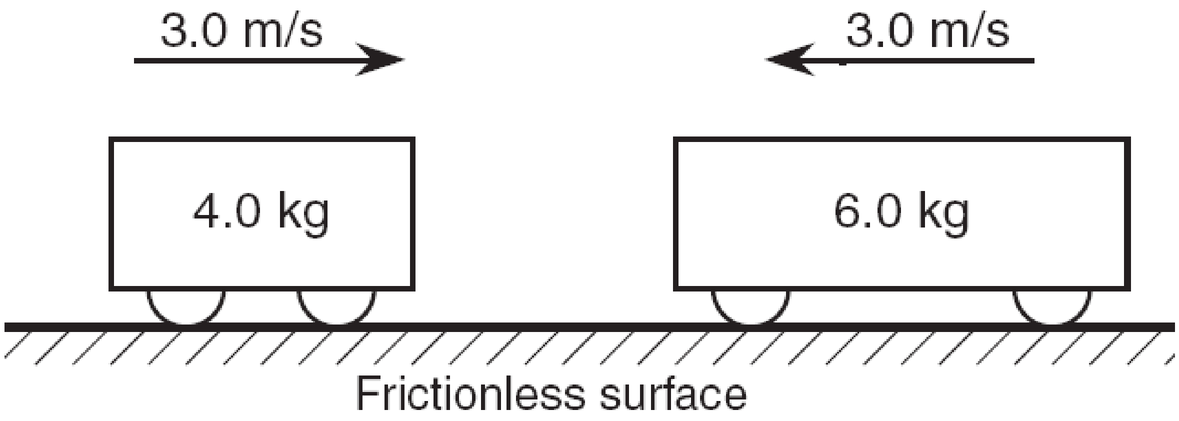
$$1000\text{kg}(6.0\text{m/s}) + 0 = (1000\text{kg} + 5000\text{kg})\vec{v}'_{1 \text{ and } 2}$$

$$6000\text{kg} \bullet \text{m/s} = (6000\text{kg})\vec{v}'_{1 \text{ and } 2}$$

$$\frac{6000\text{kg} \bullet \text{m/s}}{(6000\text{kg})} = \vec{v}'_{1 \text{ and } 2} = 1.0\text{m/s right}$$

Example

- Two carts are moving as shown. When they collide they remain together. Determine their velocity after the collision.



Watch the vector directions

$$m_1 \vec{v}_1 + m_2 \vec{v}_2 = (m_1 + m_2)\vec{v}'_{1\ and\ 2}$$

Watch the vector directions

Right + left -

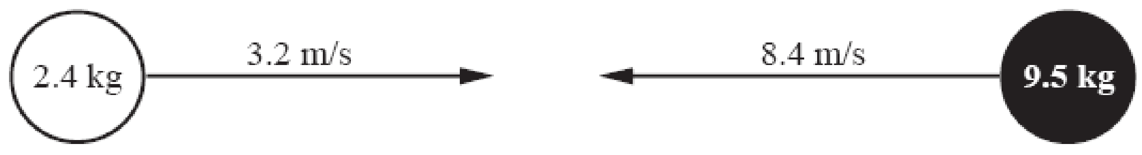
$$4.0kg(3.0m/s) + 6.0kg(-3.0m/s) = (4.0 + 6.0kg)\vec{v}'_{1\ and\ 2}$$

$$12.0kg \bullet m/s + -18kg \bullet m/s = (10kg)\vec{v}'_{1\ and\ 2}$$

$$\frac{-6.0kg \bullet m/s}{(10kg)} = \vec{v}'_{1\ and\ 2} = -0.60m/s$$

$v'_{1\ and\ 2}$ = 0.60 m/s left

Example



The two objects shown above collide head-on. The velocity of the 9.5 kg object after collision is 5.4 m/s to the left.

- Determine the velocity of the 2.4 kg mass after the collision.
- Hit and bounce, watch the vector directions

$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}'_1 + m_2\vec{v}'_2$$

$$2.4kg(3.2m/s) + 9.5kg(-8.4m/s) = 2.4kg\,\vec{v}'_1 + 9.5kg(-5.4m/s)$$

$$7.68kg \bullet m/s + -79.8kg \bullet m/s = 2.4kg\,\vec{v}'_1 + -51.3kg \bullet m/s$$

$$-72.12kg \bullet m/s = 2.4kg\,\vec{v}'_1 + -51.3kg \bullet m/s$$

$$-72.12kg \bullet m/s + 51.3kg \bullet m/s = 2.4kg$$

$$-20.82kg \bullet m/s = 2.4kg\,\vec{v}'_1$$

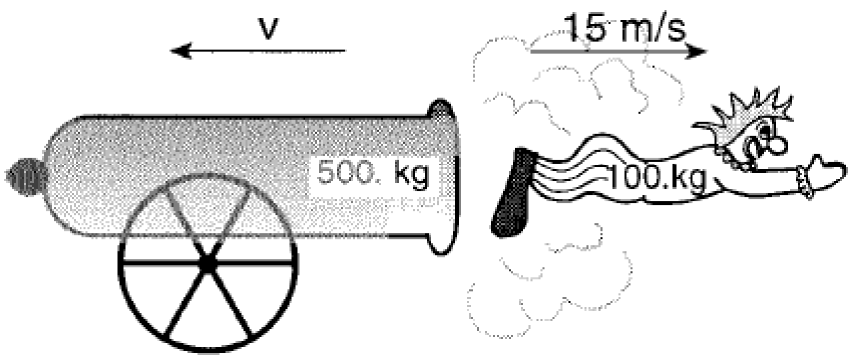
$$\frac{-20.82kg \bullet m/s}{2.4kg} = \vec{v}'_1 = -8.675m/s$$

$v'_1 = 8.7$ m/s left

Explosions & Recoil

Example

- A 100 kg clown is fired from a 500 kg cannon at rest. If the clown's velocity is 15 m/s afterwards, determine the recoil velocity of the cannon.



$v_{1 \text{ and } 2} = 0$ m/s

$m_1 = 100$ kg

$m_2 = 500$ kg

$v'_1 = 15$ m/s forward

$v_{1 \text{ and } 2} = 0$ m/s

$m_1 = 100$ kg

$m_2 = 500$ kg

$v'_1 = 15$ m/s forward

$$(m_1 + m_2)\vec{v}_{1 \text{and } 2} = m_1 \vec{v'}_1 + m_2 \vec{v'}_2$$

$$(100 + 500) \times 0 = 100(15) + 500\vec{v'}_2$$

$$0 = 1500 + 500\vec{v'}_2$$

$$-1500 = 500\vec{v'}_2$$

$$\frac{-1500}{500} = \vec{v'}_2 = -3.00 m/s$$

the cannon moves backwards at 3.00 m/s

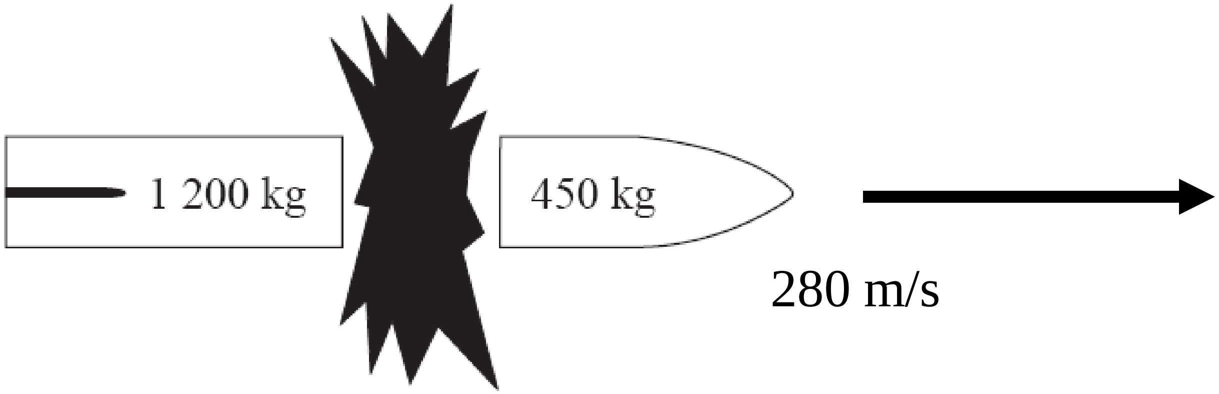

PATROLMAN
Rescue Humor
The fun side of Police
Fire and EMS

[redacted]

Example

A space vehicle made up of two parts is travelling at 230 m/s as shown.

An explosion causes the 450 kg part to separate and travel with a final velocity of 280 m/s as shown.



- Determine the velocity of the 1200 kg part after the explosion.
- Watch the vector directions

$$(m_1 + m_2)\vec{v}_{1 \text{ and } 2} = m_1 \vec{v}'_1 + m_2 \vec{v}'_2$$

$$(1200 + 450)x230 = 450(280) + 1200\vec{v}'_2$$

$$379500 = 126000 + 1200\vec{v}'_2$$

$$253500 = 1200\vec{v}'_2$$

$$\frac{25300}{1200} = \vec{v}'_2 = 211 m/s$$

What direction is positive?

211 m/s forward (or to the right)

Practice

- P 271: #4, 5, 6, 7, 8