Momentum & Newton's 3 Laws

- **Mass** - The amount of matter (stuff) in something.
  - Symbol: **m**
  - Example: **the mass of a rock is 2 kg**.
- **Velocity** – How fast (speed) and which direction something is moving.
  - Symbol: **v**
  - Example: **the rock is falling down with a speed of 2 m/s**.
- **Momentum** – Mass in motion
  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., **p** = **mv**.
  - Example: **the rock is falling down with momentum (2 kg) x (2 m/s) = 4 kg m/s**
- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Momentum & Newton's 3 Laws

- **Vocabulary:**
  - **Mass** - The amount of matter (stuff) in something.
  - **Velocity** – How fast (speed) and which direction something is moving.
  - **Momentum** – Mass in motion
  - **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Momentum & Newton's 3 Laws

- **Mass** - The amount of matter (stuff) in something.
  - Symbol: **m**
  - Example: **the mass of a rock is 2 kg**.

m = 1

m = 10

Momentum & Newton's 3 Laws

- **Velocity** – How fast (speed) and which direction something is moving.
  - Symbol: **v**
  - Example: **the rock is falling down with a speed of 2 m/s**.

$\vec{v}$ = 1

Slow

Momentum & Newton's 3 Laws

- **Velocity** – How fast (speed) and which direction something is moving.
  - Symbol: **v**
  - Example: **the rock is falling down with a speed of 2 m/s**.

$\vec{v} = 1$

Slow

$\vec{v} = 5$

Fast

Momentum & Newton's 3 Laws

- **Velocity** – How fast (speed) and which direction something is moving.
  - Symbol: **v**
  - Example: **the rock is falling down with a speed of 2 m/s**.

v = 1

Slow

v = 5

Fast

v = -3

Medium, oposite direction

Momentum & Newton's 3 Laws

- **Momentum** – Mass in motion
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v = 2 → **m** = 1

p = ?

Momentum & Newton's 3 Laws

- **Momentum** – Mass in motion
  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., $p = mv$.

$\vec{v} = 2$ $m = 1$

$p = m v = 1 \times 2 = 2$ →

Momentum & Newton's 3 Laws

- **Momentum** – Mass in motion
  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., **p** = **mv**.

v = 2 **m** = 1

p = **m v** = **1** x **2** = **2**

v = 5 **m** = 1

p = ?

Momentum & Newton's 3 Laws

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  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., **p** = **mv**.

v = 2 **m** = 1

p = **m v** = **1** x **2** = **2**

v = 5 **m** = 1

p = **m v** = **1** x **5** = **5**

Momentum & Newton's 3 Laws

- **Momentum** – Mass in motion
  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., **p** = **mv**.

v = 2 **m** = 1

p = **m** **v** = **1** x **2** = **2**

v = 5 **m** = 1

p = **m** **v** = **1** x **5** = **5**

v = 2 **m** = 10

p = ?

Momentum & Newton's 3 Laws

- **Momentum** – Mass in motion
  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., **p** = **mv**.

v = 2 **m** = 1

p = **m v** = **1** x **2** = **2**

v = 5 **m** = 1

p = **m v** = **1** x **5** = **5**

v = 2 **m** = 10

p = **m v** = **10** x **2** = **20**

Momentum & Newton's 3 Laws

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  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., $p = mv$.

$v = 2$ $m = 1$

$p = m\,v = 1 \times 2 = 2$

$v = 5$ $m = 1$

$p = m\,v = 1 \times 5 = 5$

$v = 2$ $m = 10$

$p = m\,v = 10 \times 2 = 20$

$v = -5$ $m = 1$

$p = ?$

Momentum & Newton's 3 Laws

- **Momentum** – Mass in motion
  - Symbol: **p**
  - Momentum equals mass times velocity, i.e., **p** = **mv**.

$v = 2$ $m = 1$

$p = m\,v = 1 \times 2 = 2$

$v = 5$ $m = 1$

$p = m\,v = 1 \times 5 = 5$

$v = 2$ $m = 10$

$p = m\,v = 10 \times 2 = 20$

$v = -5$ $m = 1$

$p = m\,v = 1 \times (-5) = -5$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Elastic Collision

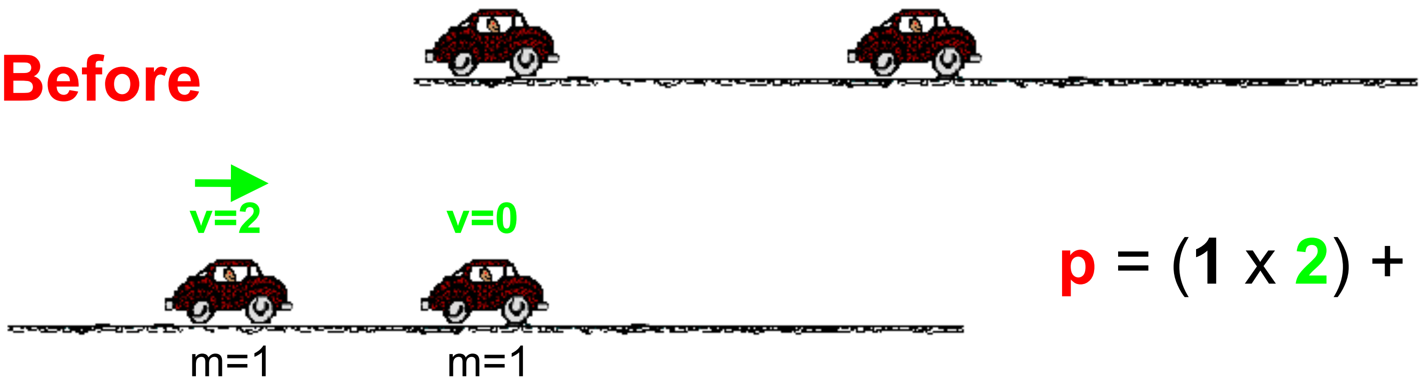
$p = mv$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Elastic Collision

Before

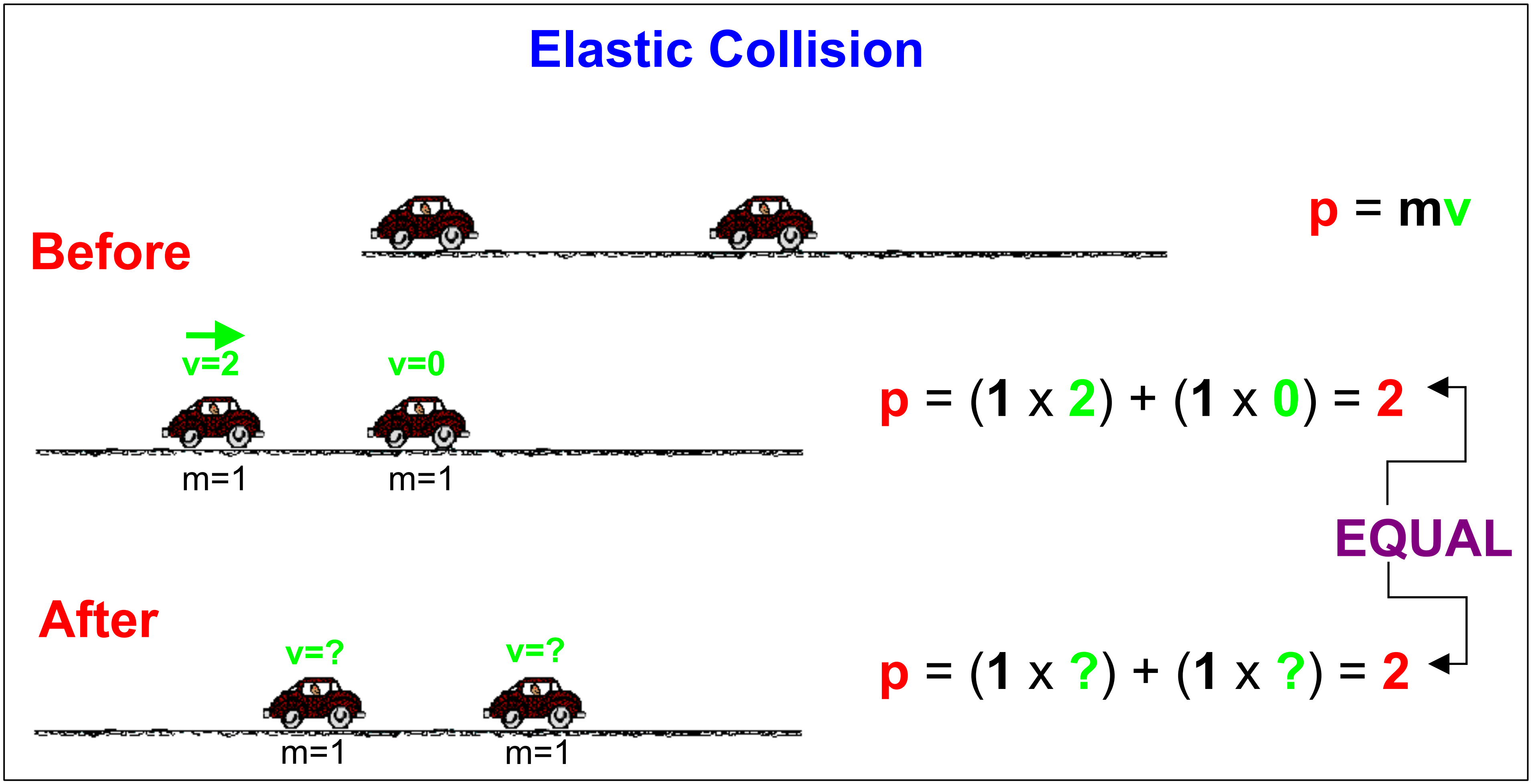


$p = mv$

$p = (1 \times 2) + (1 \times 0) = 2$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)



Momentum & Newton's 3 Laws

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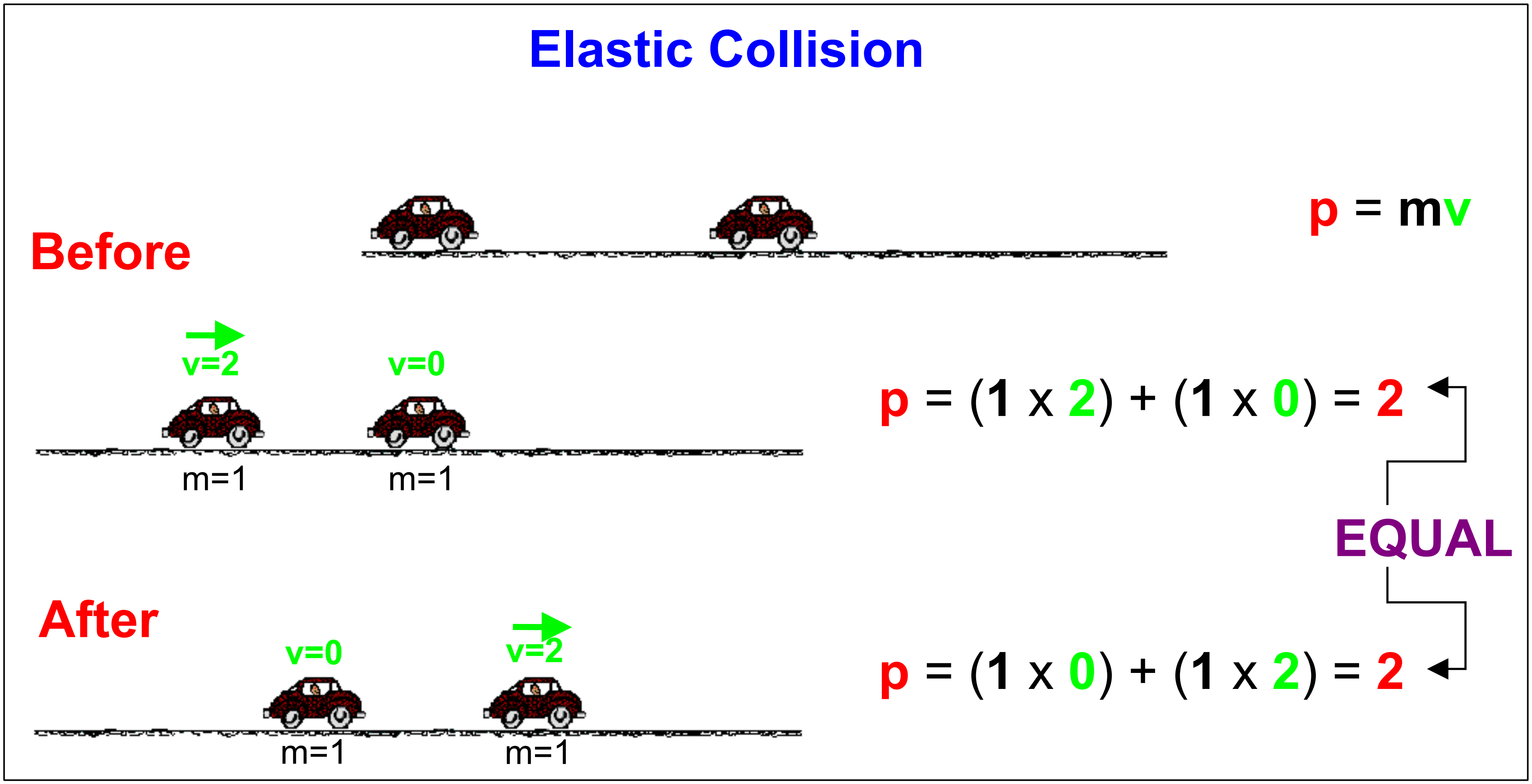

Momentum & Newton's 3 Laws

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Inelastic Collision 1

$p = mv$

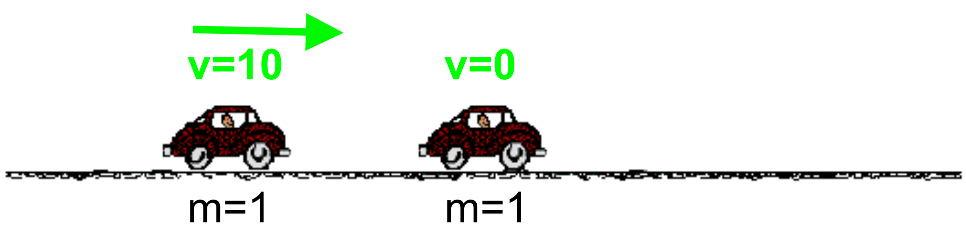
Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Inelastic Collision 1

Before

$p = mv$

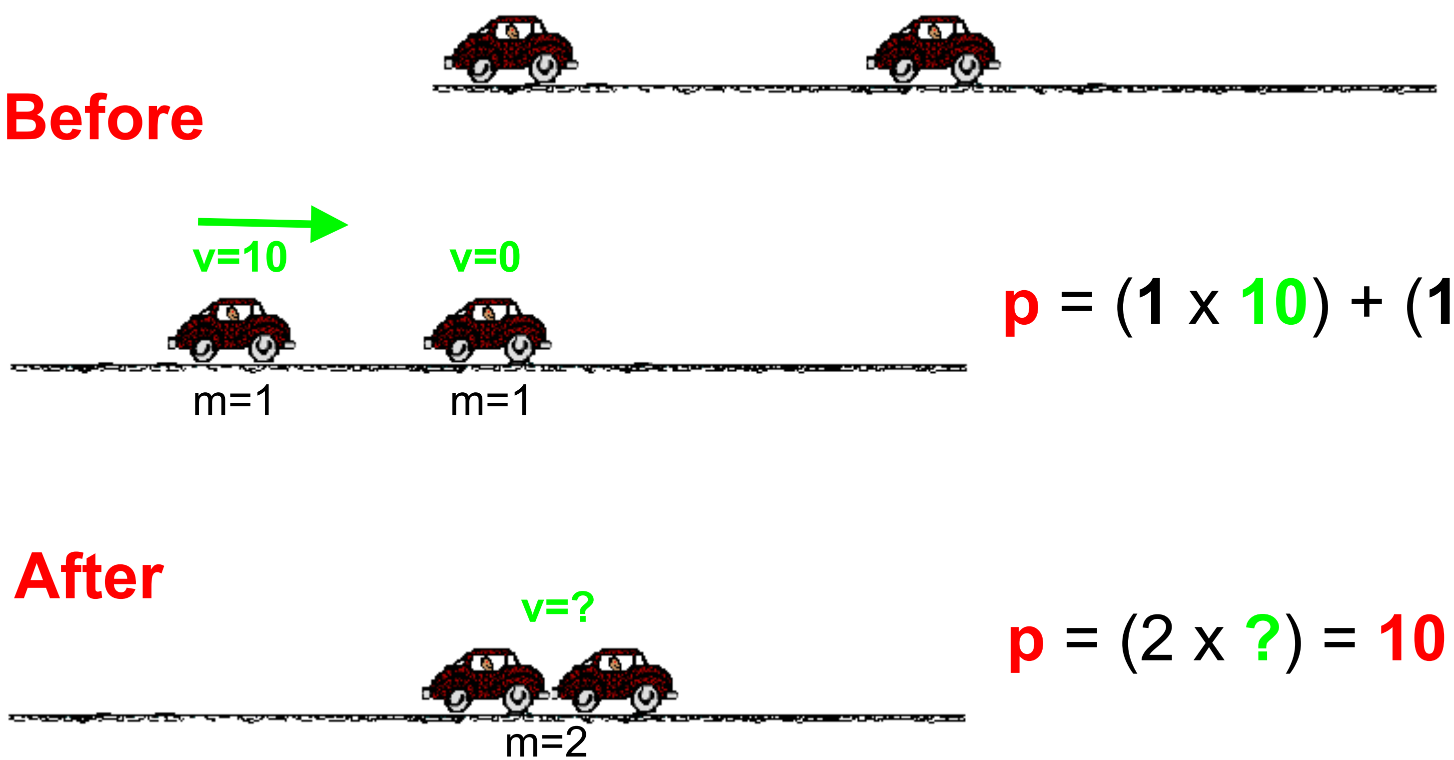


$p = (1 \times 10) + (1 \times 0) = 10$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Inelastic Collision 1



$p = mv$

$p = (1 \times 10) + (1 \times 0) = 10$

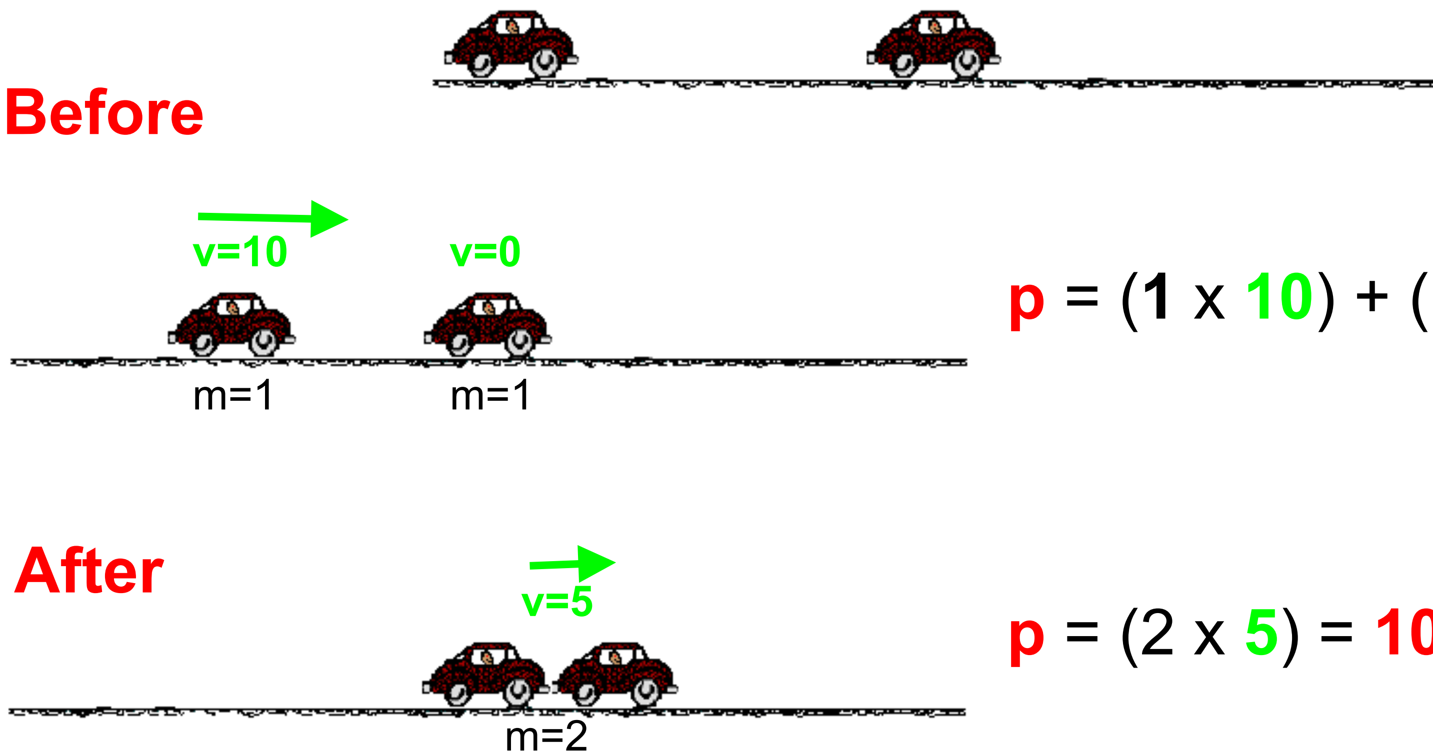
EQUAL

$p = (2 \times ?) = 10$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Inelastic Collision 1



$p = mv$

$p = (1 \times 10) + (1 \times 0) = 10$

EQUAL

$p = (2 \times 5) = 10$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

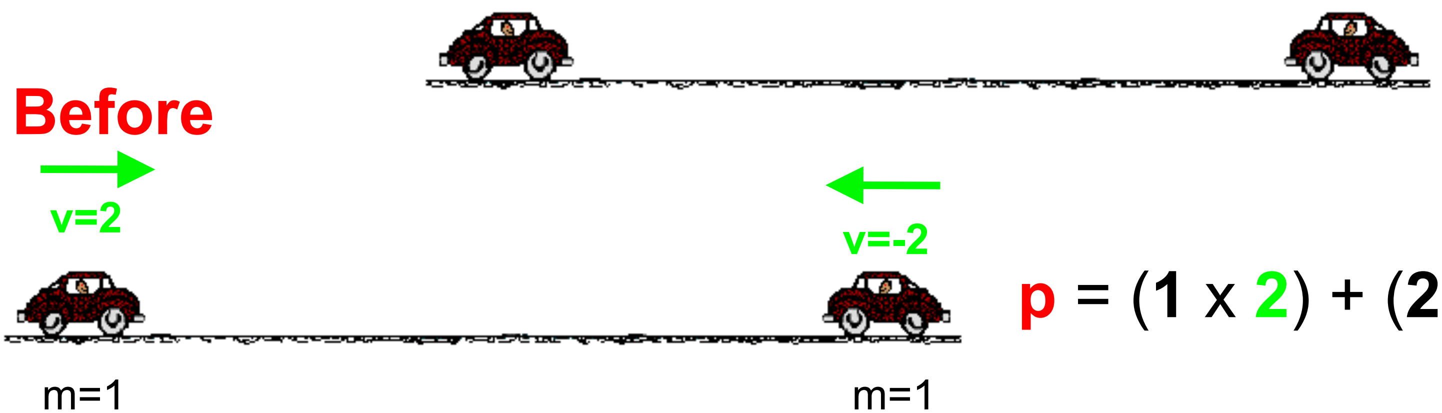
Inelastic Collision 2

$p = mv$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Inelastic Collision 2



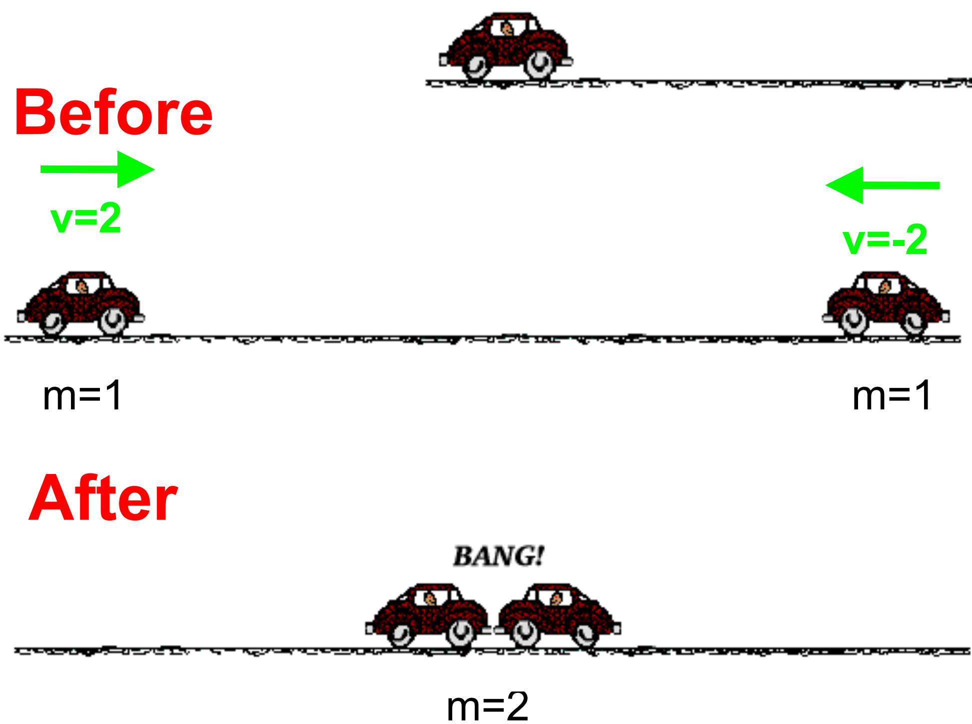
$p = mv$

$p = (1 \times 2) + (2 \times -2) = 0$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Inelastic Collision 2



$p = mv$

$p = (1 \times 2) + (2 \times -2) = 0$

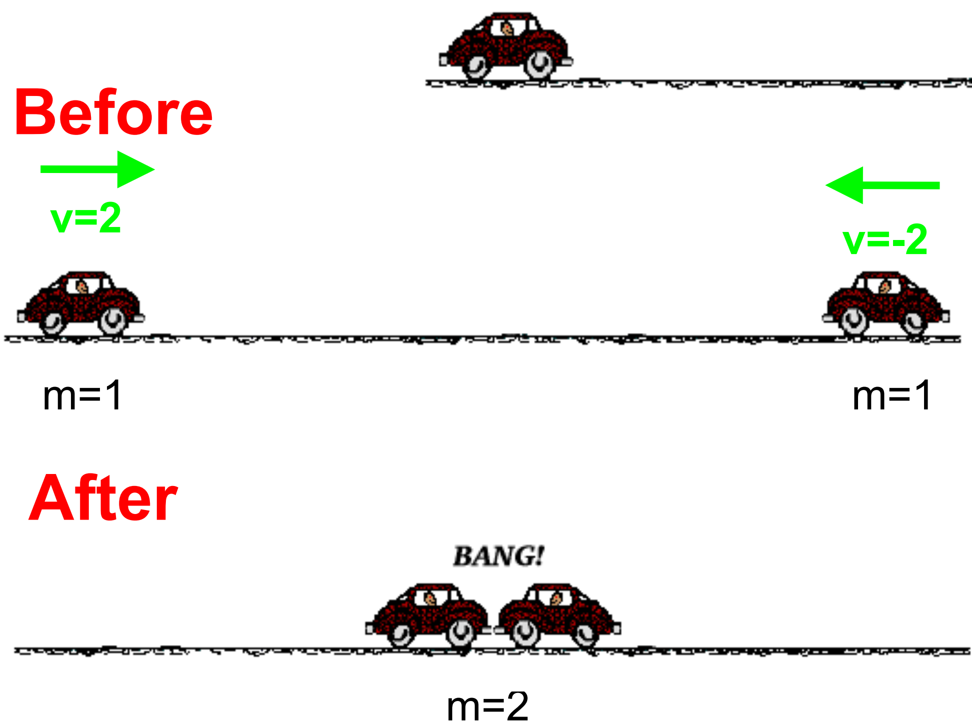
EQUAL

$p = (2 \times ?) = 0$

Momentum & Newton's 3 Laws

- **Conservation** – Saving something. The total momentum of a group of objects (that is not in contact with other objects) is always conserved (always stays the same)

Inelastic Collision 2



$p = mv$

$p = (1 \times 2) + (2 \times -2) = 0$

EQUAL

$p = (2 \times 0) = 0$

The massive car moves less

P

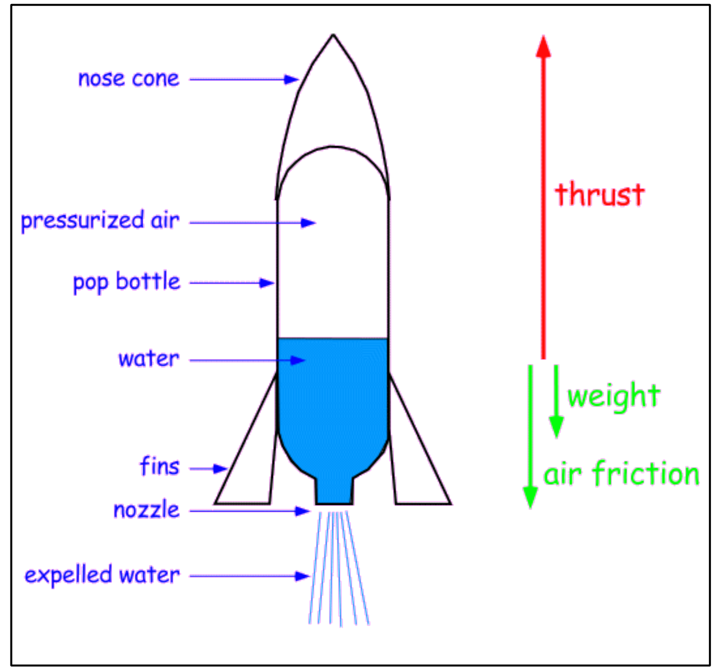
M v

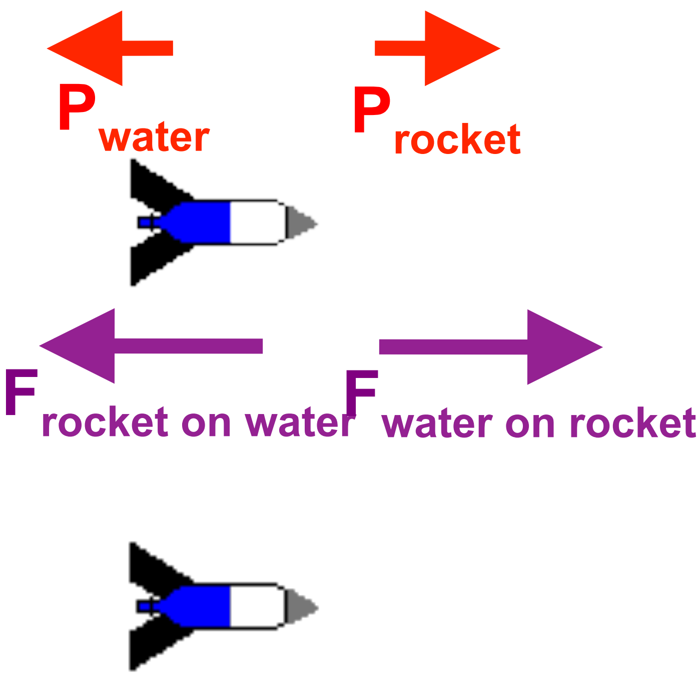
P

m V

Momentum & Newton's 3 Laws

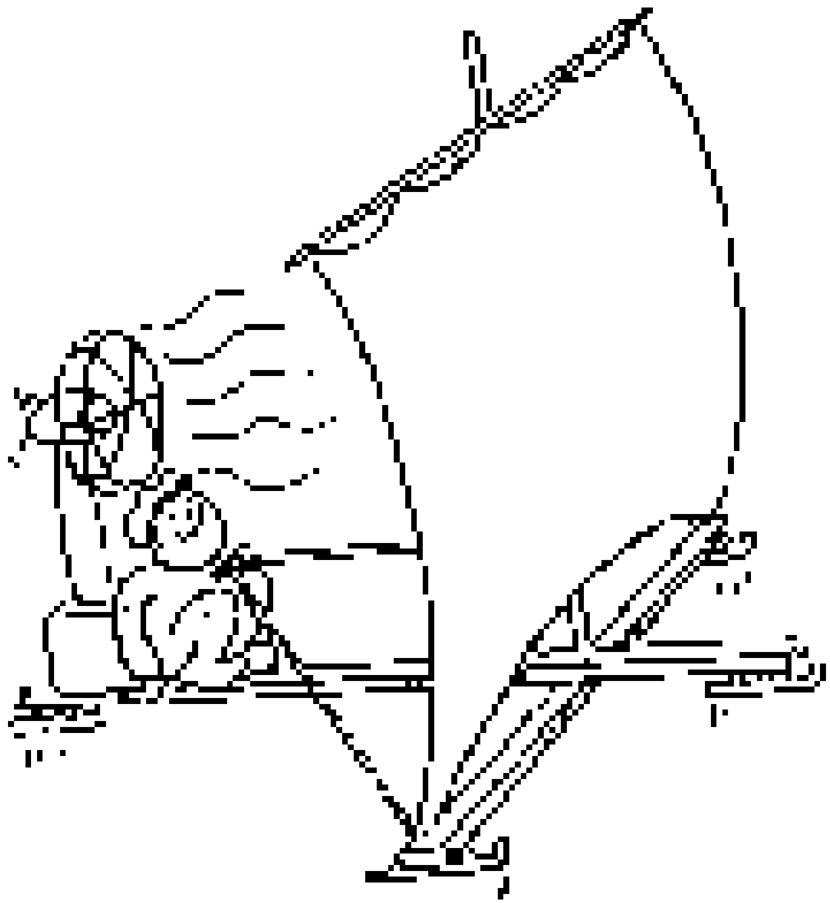
- Water Rocket:
  - Forces: Force of rocket on water is equal and opposite the force of water on rocket
  - Momentum: Momentum before is equal to momentum after



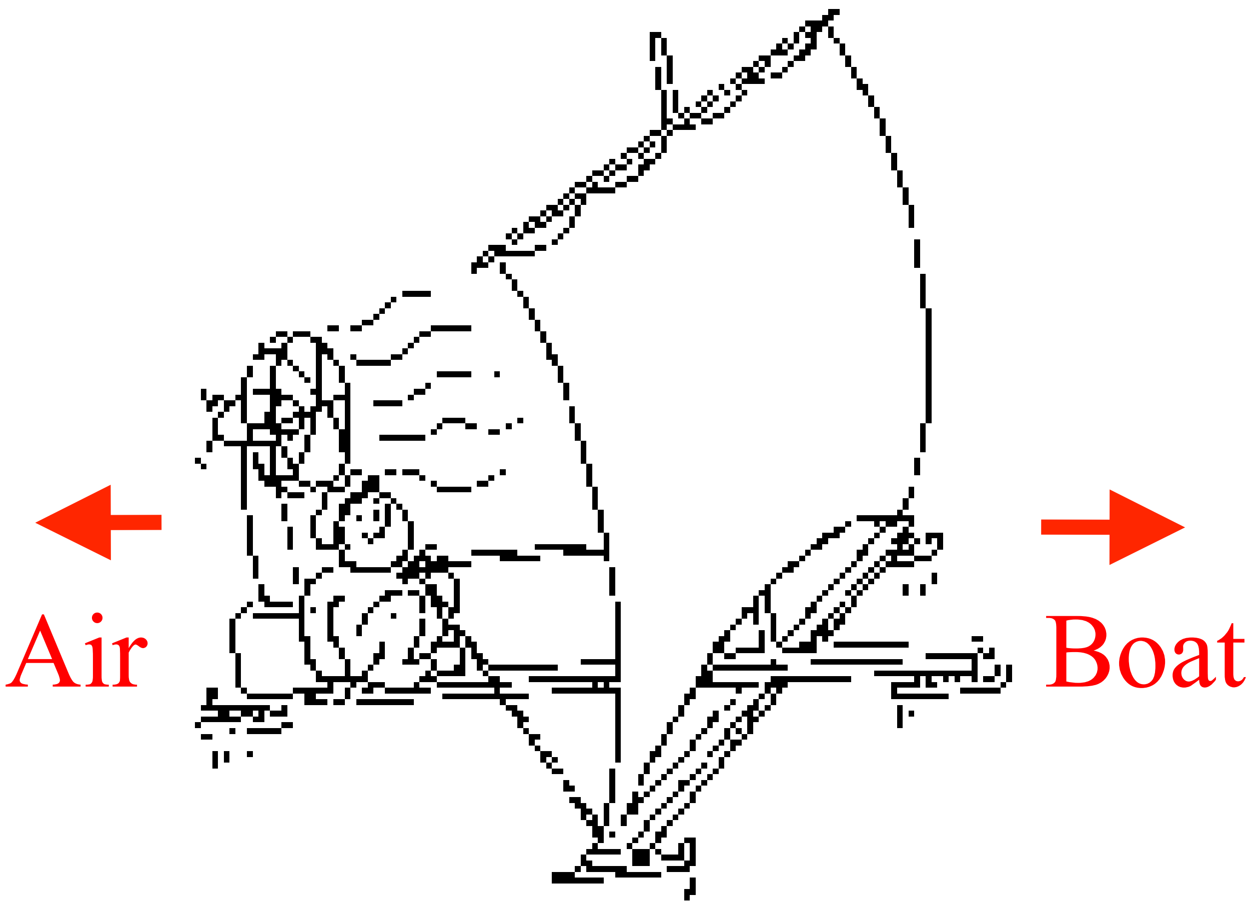


Gif from: http://www.seeds2lrn.com/rocketSoftware.html

Which way does the sailboat go?

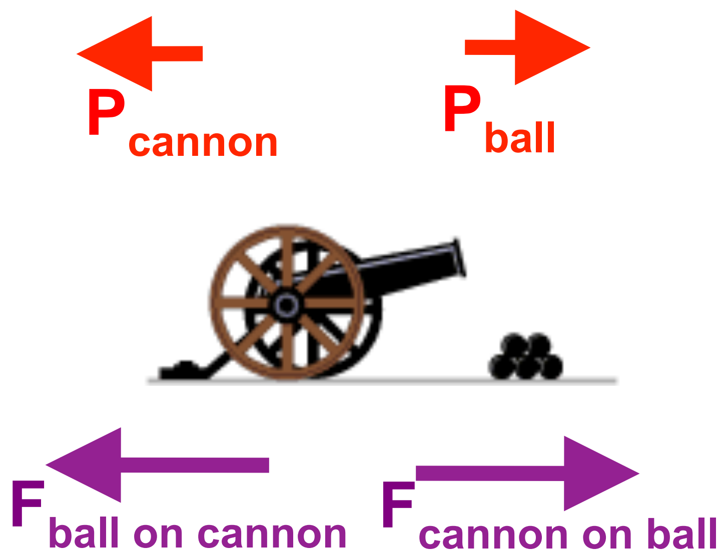


Which way does the sailboat go?



Momentum & Newton's 3 Laws

- Liquid Nitrogen Cannon:
  - **Forces: Force of ball on cannon is equal and opposite the force of cannon on ball**
  - **Momentum: Momentum before shot is equal to momentum after shot**



Review: What is mass?

- (A) The amount of matter (stuff) in something.
- (B) How fast something is moving
- (C) Something heavy that is moving fast

Review: What is mass?

- (A) The amount of matter (stuff) in something.
- (B) How fast something is moving
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A rifle fires a bullet. What is the same afterwards?

- (A) The mass of the rifle and the mass of the bullet are the same
- (B) The speed of the rifle and the speed of the bullet are the same
- (C) The momentum of the rifle and the momentum of the bullet are the same (but in opposite directions)

A rifle fires a bullet. What is the same afterwards?

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