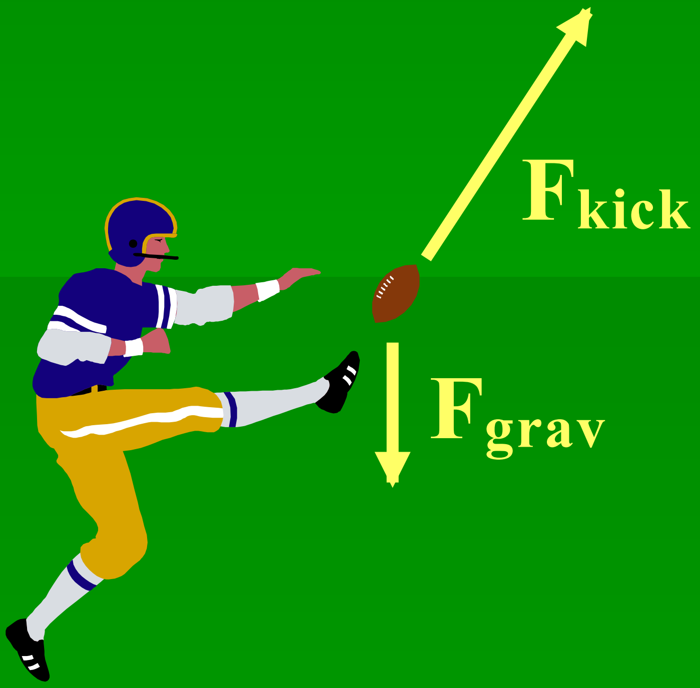
Forces & Physics Review

Force

- **Force**
  - a push or pull that one body exerts on another
  - What forces are being exerted on the football?



Measuring Forces

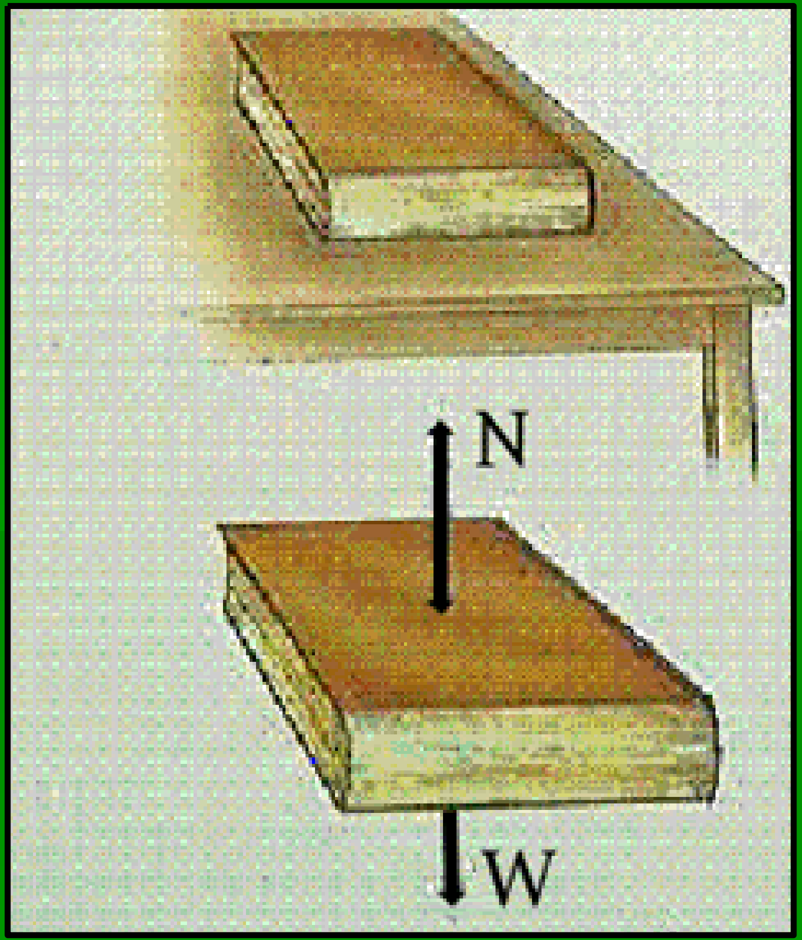
- Forces are measured in newtons

($kg \cdot m/s^2$).

- Forces are measured using a spring scale.

Force

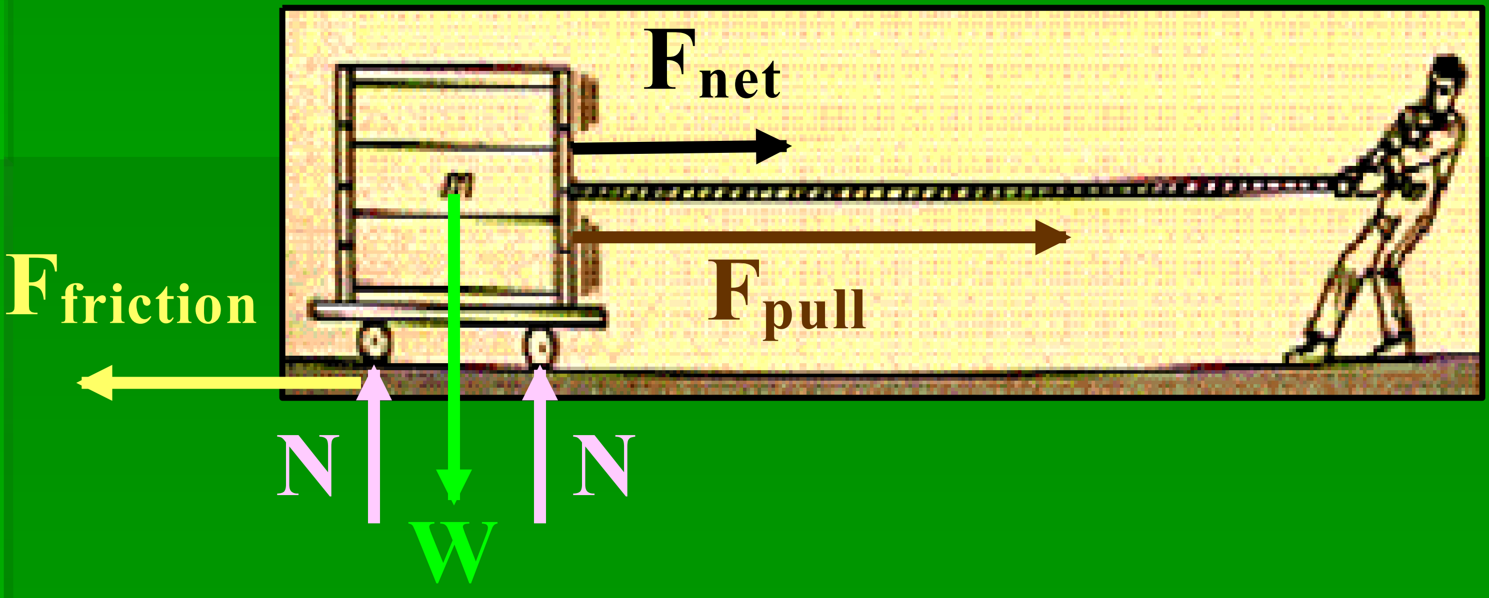
- **Balanced Forces**



- forces acting on an object that are opposite in direction and equal in size
- no change in velocity

Force

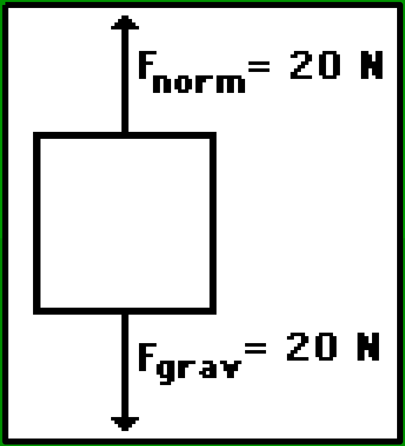
- **Net Force**
  - unbalanced forces that are not opposite and equal
  - velocity changes (object accelerates)



ConcepTest 1

TRUE or FALSE?

The object shown in the diagram must be at rest since there is no net force acting on it.



FALSE! A net force does not cause motion. A net force causes a <u>change</u> in motion, or acceleration.

Taken from "The Physics Classroom" © Tom Henderson, 1996-2001.

ConcepTest 2

You are a passenger in a car and not wearing your seat belt.

Without increasing or decreasing its speed, the car makes a sharp left turn, and you find yourself colliding with the right-hand door.

Which is the correct analysis of the situation? ...

ConcepTest 2

1. Before and after the collision, there is a rightward force pushing you into the door.

2. Starting at the time of collision, the door

2. Starting at the time of collision, the door exerts a leftward force on you.

4. neither of the above

Friction

- **Friction**
  - force that opposes motion between 2 surfaces
  - depends on the:
    - types of surfaces
    - force between the surfaces

Friction

- **Four Types of Friction**
  - ✓*Static Friction* – force that acts on objects that are not moving. (Couch Potato)
  - ✓*Sliding Friction* - force that opposes the direction of motion of an object as it slides over a surface. (Ice skating or bobsledding)
  - ✓*Rolling Friction* – friction force that acts on rolling objects. (Rollerblading)
  - ✓*Fluid Friction* – force that opposes the motion of an object through a fluid. (Planes flying or submarines traveling)

Friction

- **Friction is greater...**
  - between rough surfaces
  - when there’s a greater force between the surfaces (e.g. more weight)

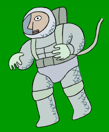
Gravity

- **Gravity**
  - force of attraction between any two objects in the universe
  - increases as...
    - mass increases
    - distance decreases

Gravity

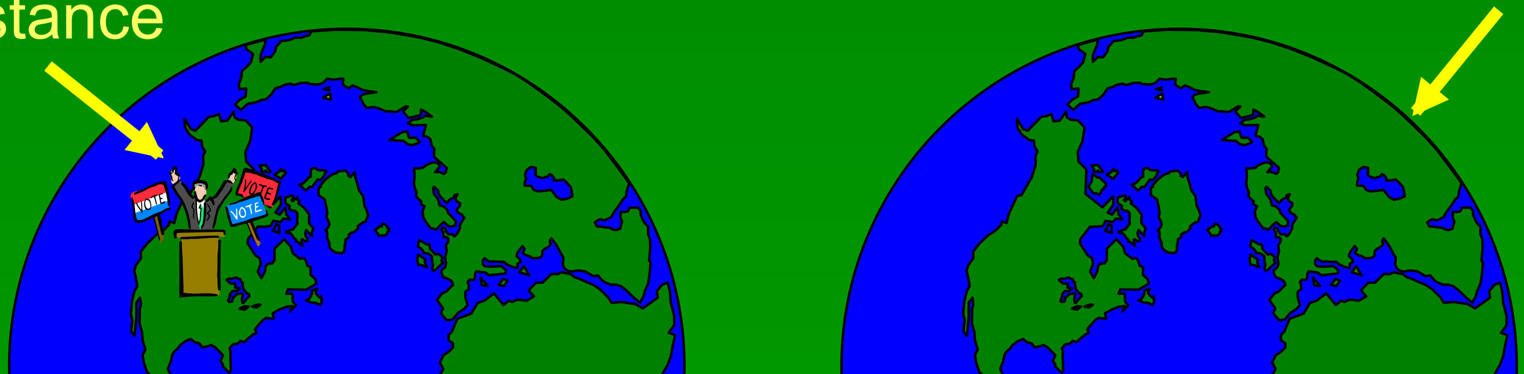
- Who experiences more gravity - the astronaut or the politician?
  - Which exerts more gravity -

    the Earth or the moon?



less distance

more mass



Gravity

- **Weight**
  - the force of gravity on an object

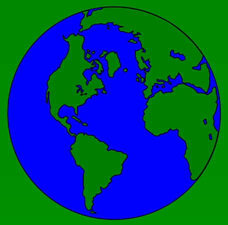
$$W = mg$$

W: weight (N)
m: mass (kg)
g: acceleration due to gravity (m/s^2)

MASS	**WEIGHT**
always the same (kg)	*depends on gravity (N)*

Gravity

- Would you weigh more on Earth or Jupiter?
  - Jupiter because...



greater mass

↓

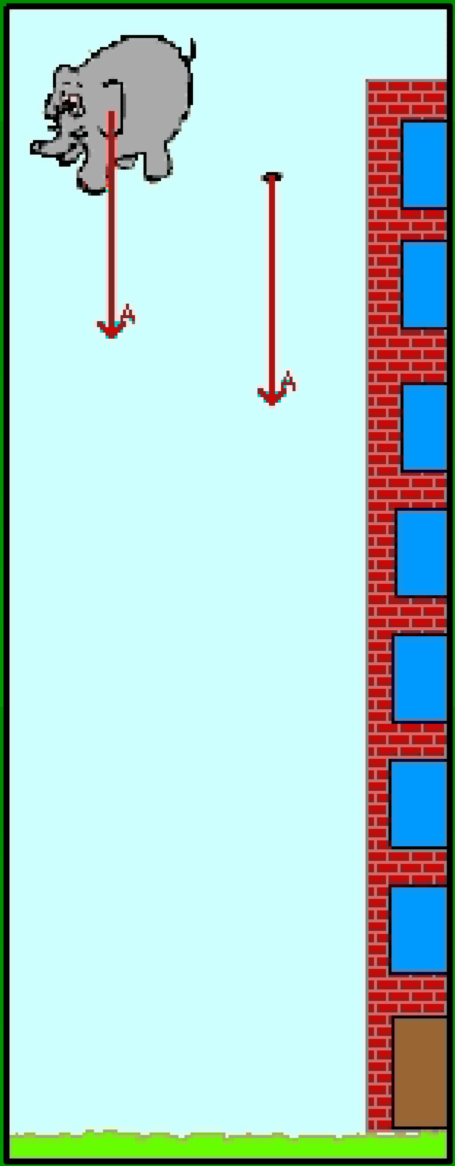
greater gravity

↓

greater weight

Gravity

- **Accel. due to gravity *(g)***
  - In the absence of air resistance, all falling objects have the same acceleration!
  - On Earth: $g = 9.8 \text{ m/s}^2$



$$g = \frac{W}{m}$$

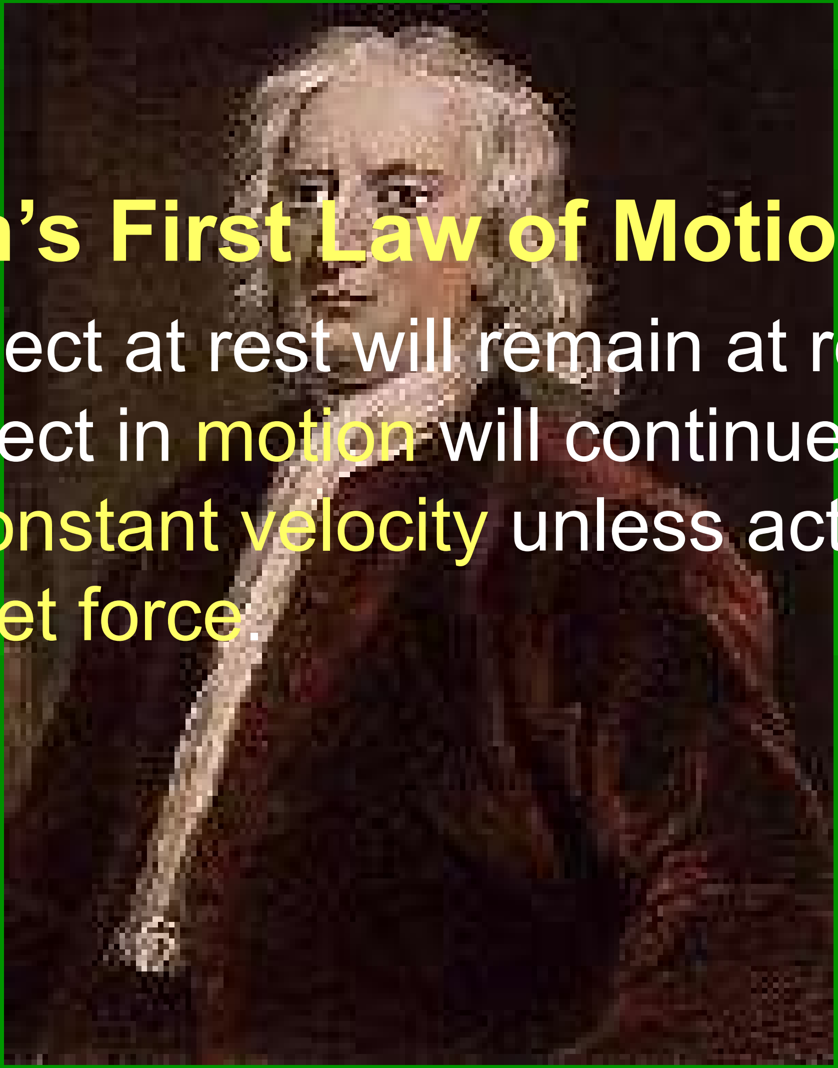
elephant

$$g = \frac{W}{m}$$

feather

Animation from "Multimedia Physics Studios."

Newton's First Law



- **Newton's First Law of Motion**
  - An object at rest will remain at rest and an object in motion will continue moving at a constant velocity unless acted upon by a net force.

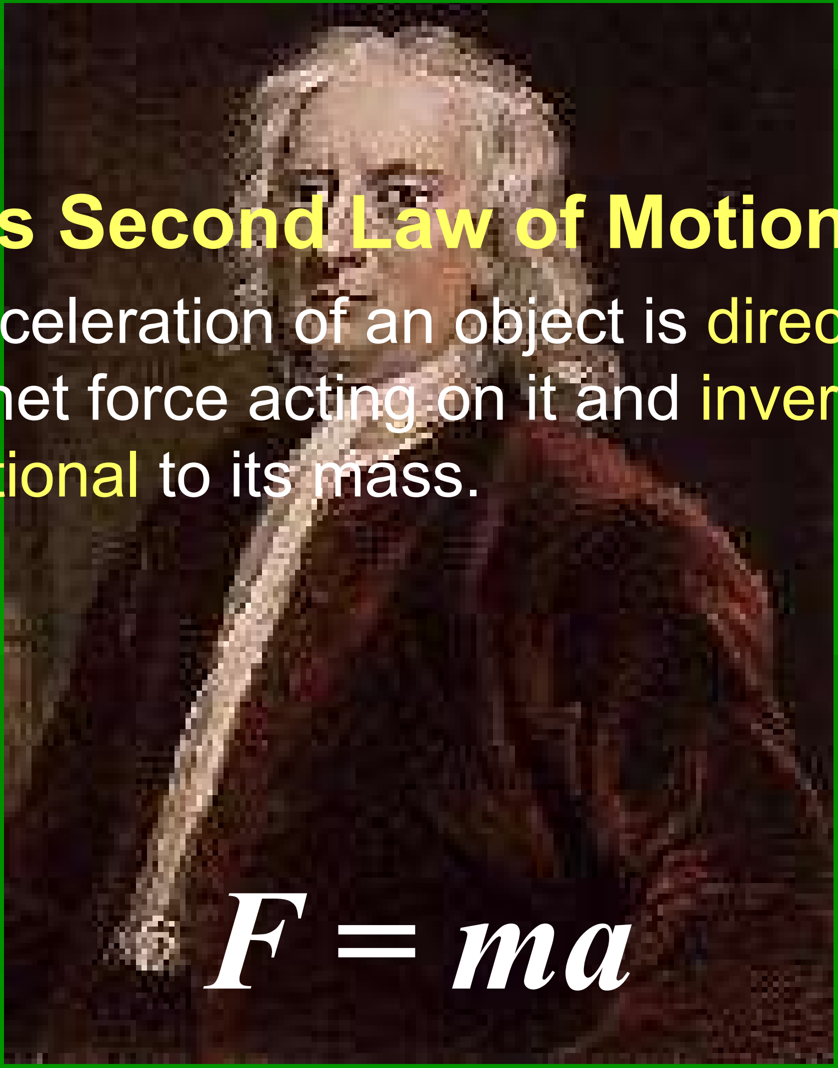
Newton's First Law

- **Newton's First Law of Motion**
  - "Law of Inertia"

- **Inertia**
  - tendency of an object to resist any change in its motion
  - increases as mass increases

Newton's Second Law

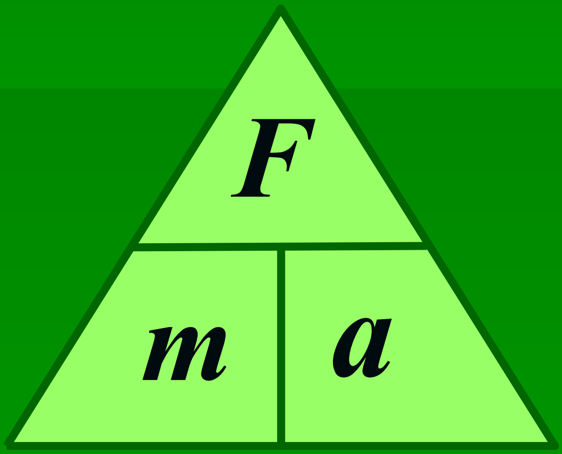
- **Newton's Second Law of Motion**
  - The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.



$$F = ma$$

Newton's Second Law

$$a = \frac{F}{m}$$



$$F = ma$$

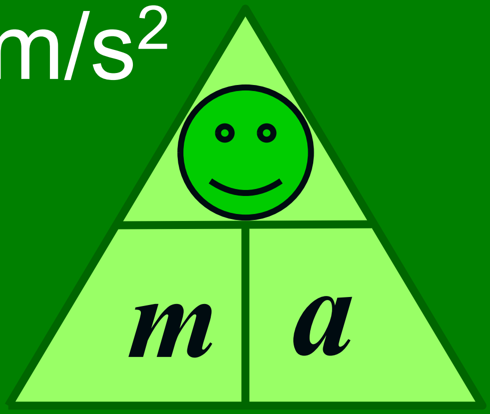
F: force (N)
m: mass (kg)
a: accel (m/s^2)

$1\ N = 1\ kg \cdot m/s^2$

Calculations

- What force would be required to accelerate a 40 kg mass by 4 m/s^2?

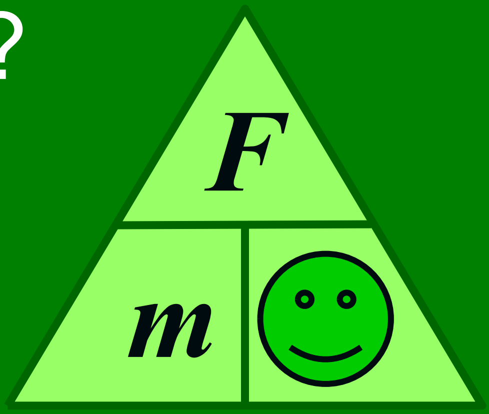
GIVEN:	WORK:
$F = ?$	$F = ma$
$m = 40\ kg$	$F = (40\ kg)(4\ m/s^2)$
$a = 4\ m/s^2$	**$F = 160\ N$**



Calculations

- A 4.0 kg shotput is thrown with 30 N of force. What is its acceleration?

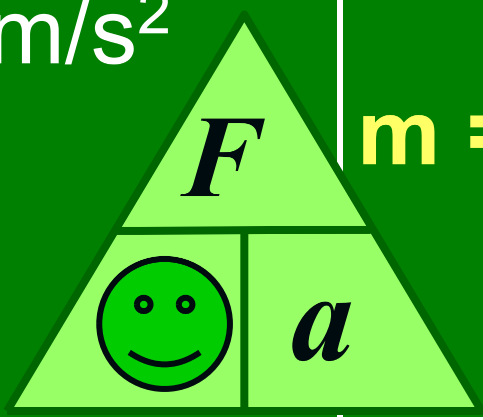
GIVEN:	WORK:
m = 4.0 kg F = 30 N a = ?	a = F ÷ m a = (30 N) ÷ (4.0 kg) **a = 7.5 m/s²**



Calculations

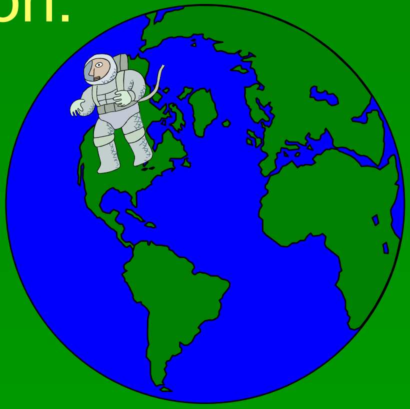
- Mr. Keller weighs 745 N. What is his mass?

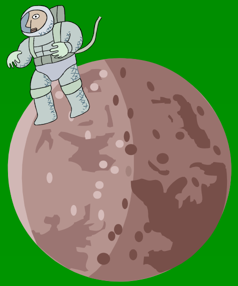
GIVEN:	WORK:
F(W) = 745 N	$m = F \div a$
m = ?	$m = (745\ N) \div (9.8\ m/s^2)$
a(**g**) = $9.8\ m/s^2$	**m = 76.0 kg**



ConcepTest

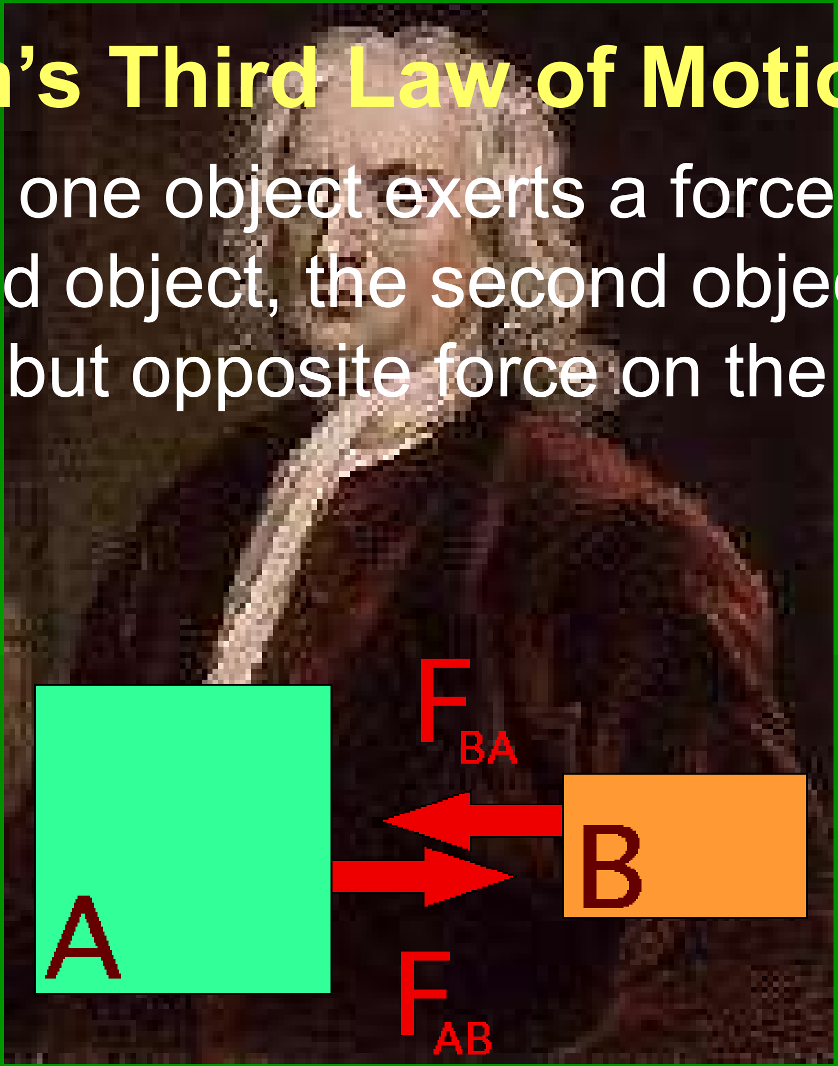
- Is the following statement true or false?
  - An astronaut has less mass on the moon since the moon exerts a weaker gravitational force.
    - False! Mass does not depend on gravity, weight does. The astronaut has less <u>weight</u> on the moon.





Newton's Third Law

- **Newton's Third Law of Motion**
  - When one object exerts a force on a second object, the second object exerts an equal but opposite force on the first.



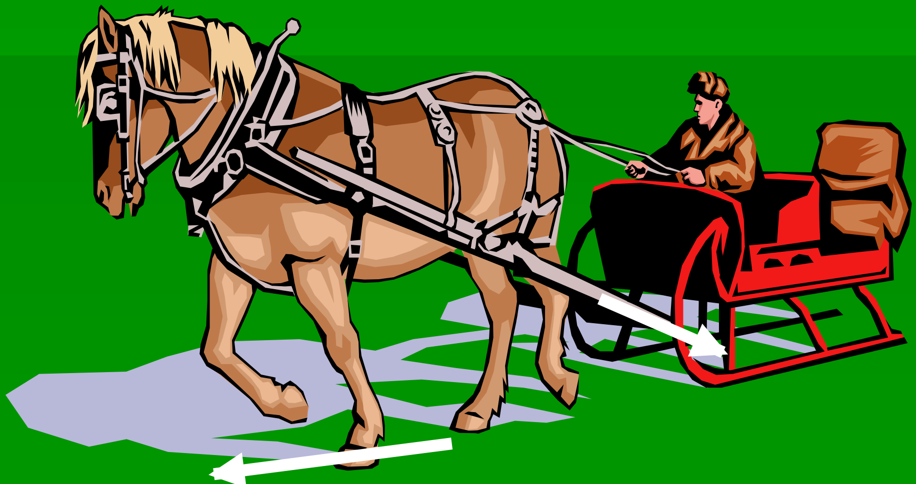
Newton's Third Law

- **Problem:**
  - How can a horse pull a cart if the cart is pulling back on the horse with an equal but opposite force?

  - Aren't these "balanced forces" resulting in no acceleration?

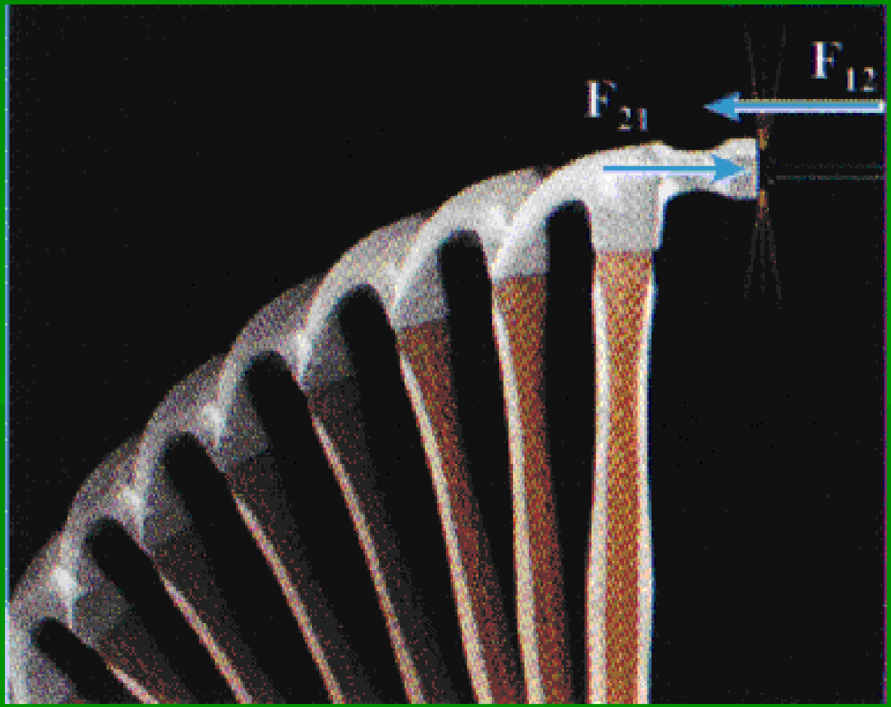
Newton's Third Law

- **Explanation:**
  - forces are equal and opposite but act on <u>different</u> objects
  - they are not "balanced forces"
  - the movement of the horse depends on the forces acting on the horse



Newton's Third Law

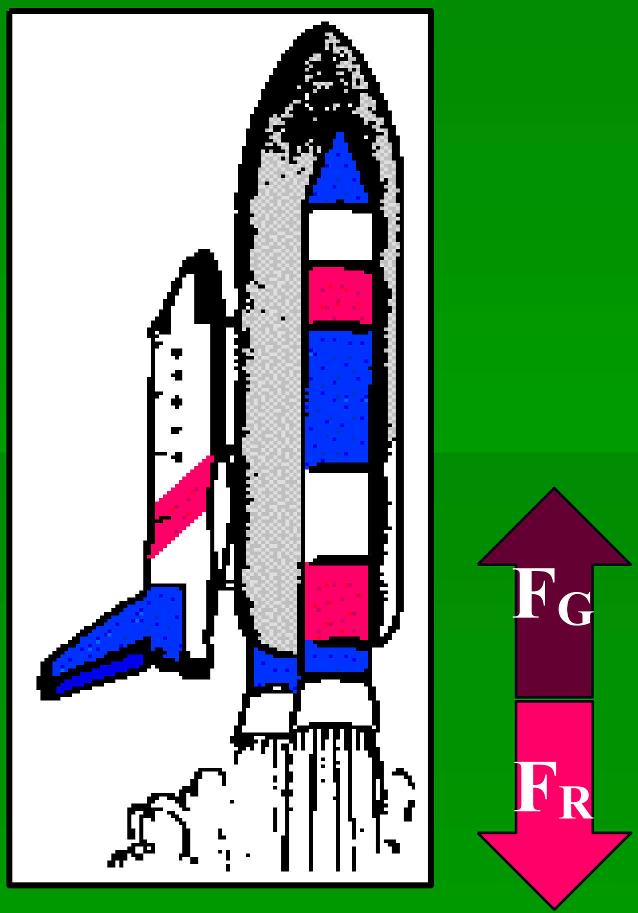
- Action-Reaction Pairs



- The hammer exerts a force on the nail to the right.
- The nail exerts an equal but opposite force on the hammer to the left.

Newton's Third Law

- **Action-Reaction Pairs**



  - The rocket exerts a downward force on the exhaust gases.
  - The gases exert an equal but opposite upward force on the rocket.

Newton's Third Law

- **Action-Reaction Pairs**
  - Both objects accelerate.
  - The amount of acceleration depends on the mass of the object.

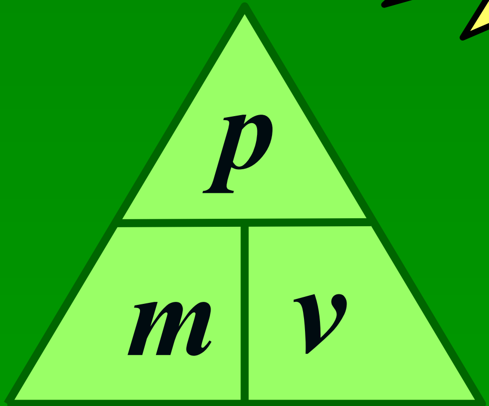
$$a = \frac{F}{m}$$

  - Small mass $\Rightarrow$ more acceleration
  - Large mass $\Rightarrow$ less acceleration

Momentum

- **Momentum**
  - quantity of motion

$$p = mv$$

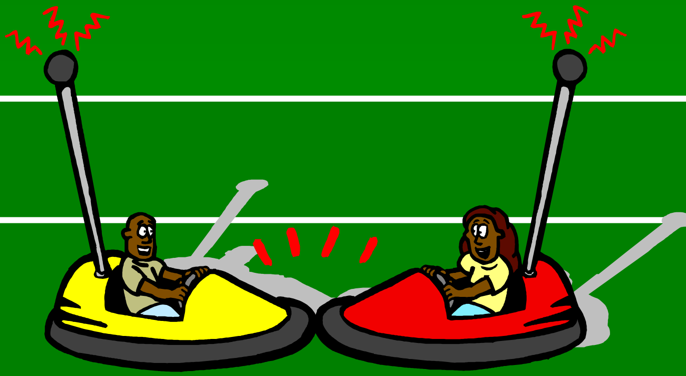


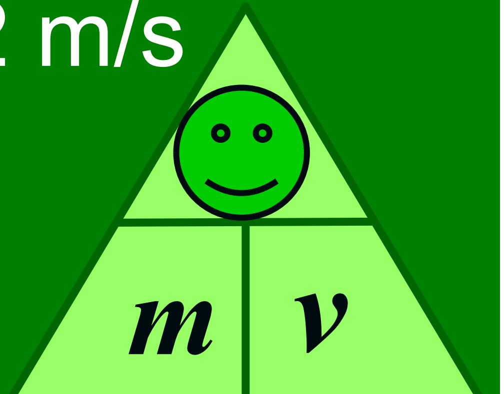
p:momentum (kg ·m/s)
m:mass (kg)
v:velocity (m/s)

Momentum

- Find the momentum of a bumper car if it has a total mass of 280 kg and a velocity of 3.2 m/s.

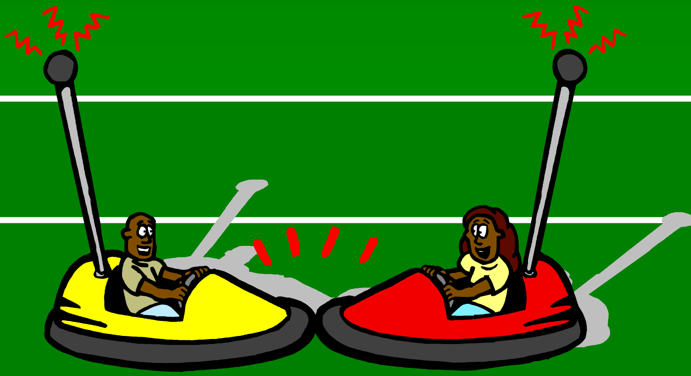
GIVEN:	WORK:
$p = ?$	$p = mv$
$m = 280\ kg$	$p = (280\ kg)(3.2\ m/s)$
$v = 3.2\ m/s$	**$p = 896\ kg \cdot m/s$**



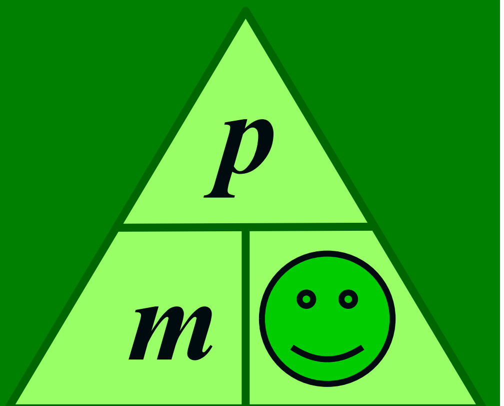


Momentum

- The momentum of a second bumper car is 675 kg·m/s. What is its velocity if its total mass is 300 kg?

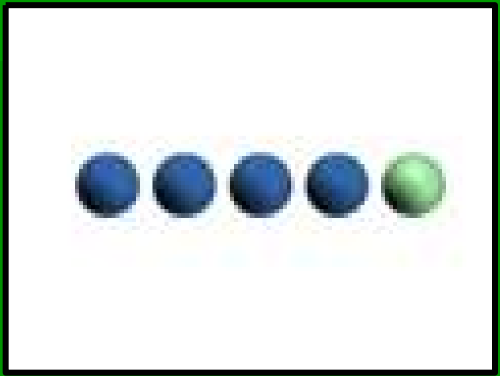


GIVEN:	WORK:
p = 675 kg·m/s	v = p ÷ m
m = 300 kg	v = (675 kg·m/s)÷(300 kg)
v = ?	**v = 2.25 m/s**



Conservation of Momentum

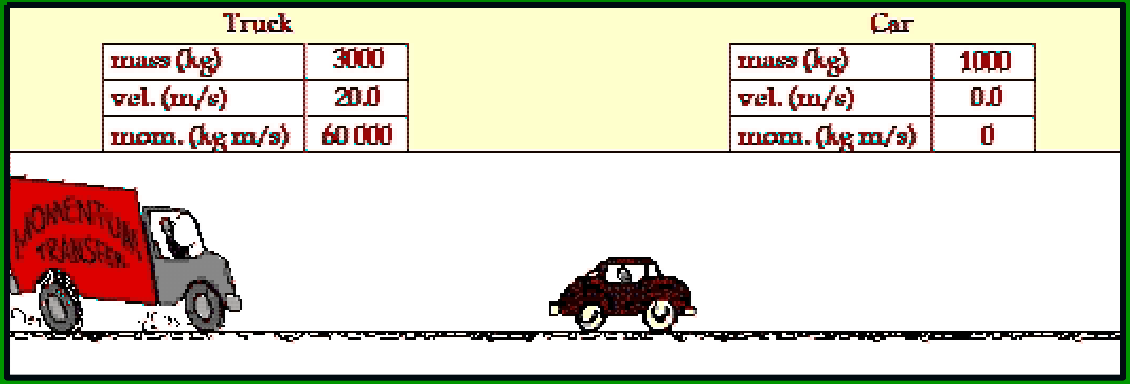
- **Law of Conservation of Momentum**
  - The total momentum in a group of objects doesn't change unless outside forces act on the objects.



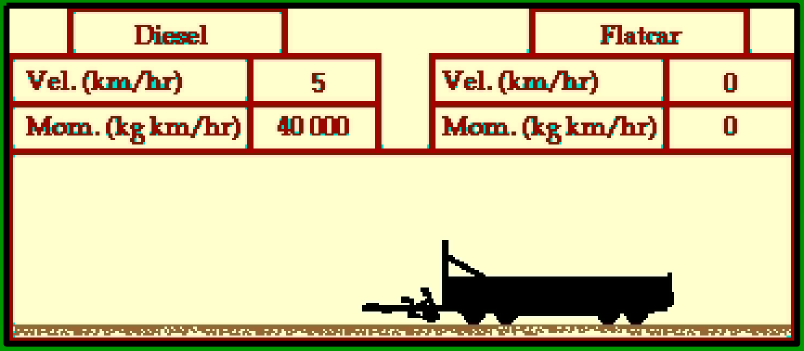
$$p_{before} = p_{after}$$

Conservation of Momentum

- **Elastic Collision**
  - KE is conserved



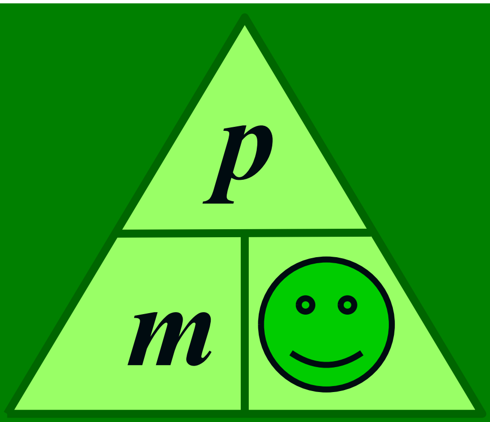
- **Inelastic Collision**
  - KE is not conserved



Conservation of Momentum

- A 5-kg cart traveling at 4.2 m/s strikes a stationary 2-kg cart and they connect. Find their speed after the collision.

BEFORE	AFTER
Cart 1: $p = 21$ kg·m/s $m = 5$ kg $v = 4.2$ m/s Cart 2 : $p = 0$ $m = 2$ kg $v = 0$ m/s	Cart 1 + 2: $m = 7$ kg $v = ?$ $v = p \div m$ $v = (21$ kg·m/s$) \div (7$ kg$)$ **$v = 3$ m/s**
$p_{before} = 21$ kg·m/s →	$p_{after} = 21$ kg·m/s



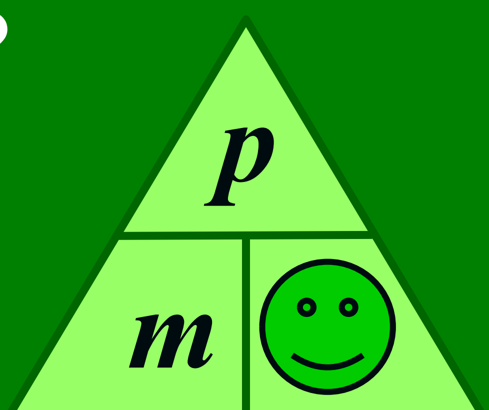
Conservation of Momentum

- A 50-kg clown is shot out of a 250-kg cannon at a speed of 20 m/s. What is the recoil speed of the cannon?

BEFORE	AFTER
Clown: $p = 0$ $m = 50$ kg $v = 0$ m/s	Clown: $p = 1000$ kg·m/s $m = 50$ kg $v = 20$ m/s
Cannon: $p = 0$ $m = 250$ kg $v = 0$ m/s	Cannon: $p = -1000$ kg·m/s $m = 250$ kg $v = ?$ m/s
$p_{before} = 0$ →	$p_{after} = 0$

Conservation of Momentum

- So…now we can solve for velocity.

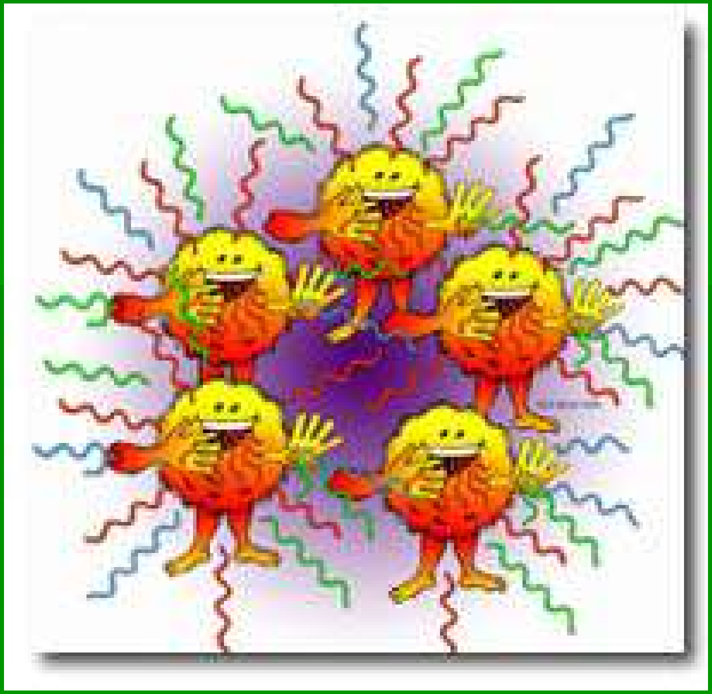
GIVEN:	WORK:
p = -1000 kg·m/s m = 250 kg v = ?  	v = p ÷ m v = (-1000 kg·m/s)÷(250 kg) **v = - 4 m/s** **(4 m/s backwards)**

Universal Forces

- *Electromagnetic Forces* – are associated with charged particles. The only force to attract and repel.

Universal Forces

- *Nuclear Forces* – act within the nucleus of an atom to hold it together, strong and weak.



Universal Forces

- *Gravitational Forces* – attractive forces that act between any two masses.
- "Every object in the universe attracts every other object." – Newton's Law of Universal Gravitation.

Centripetal Force

- *Centripetal force is a center-directed force that continuously changes the direction of an object to make it move in a circle. This explains how the moon and satellites stay in orbit*

"The Tide Is High…"

- *The gravitational pull from the moon produces two bulges in the Earth's oceans. One is on the side closest to the moon, and the other is on the side farthest away from the moon.*