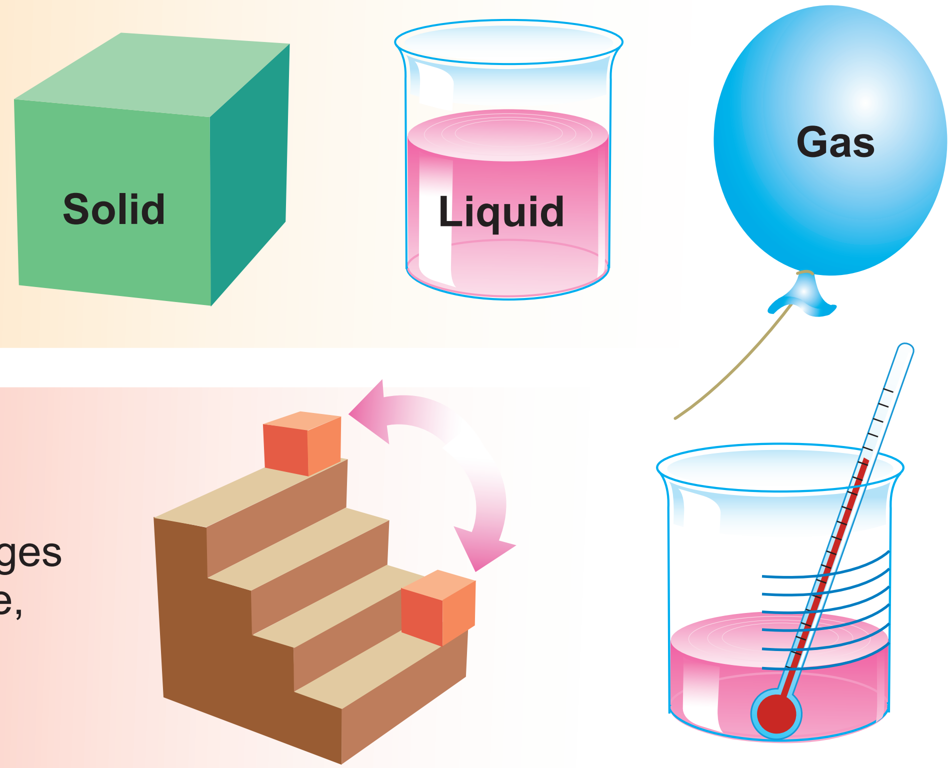
Matter and Energy

Matter

Material that has mass and takes up space

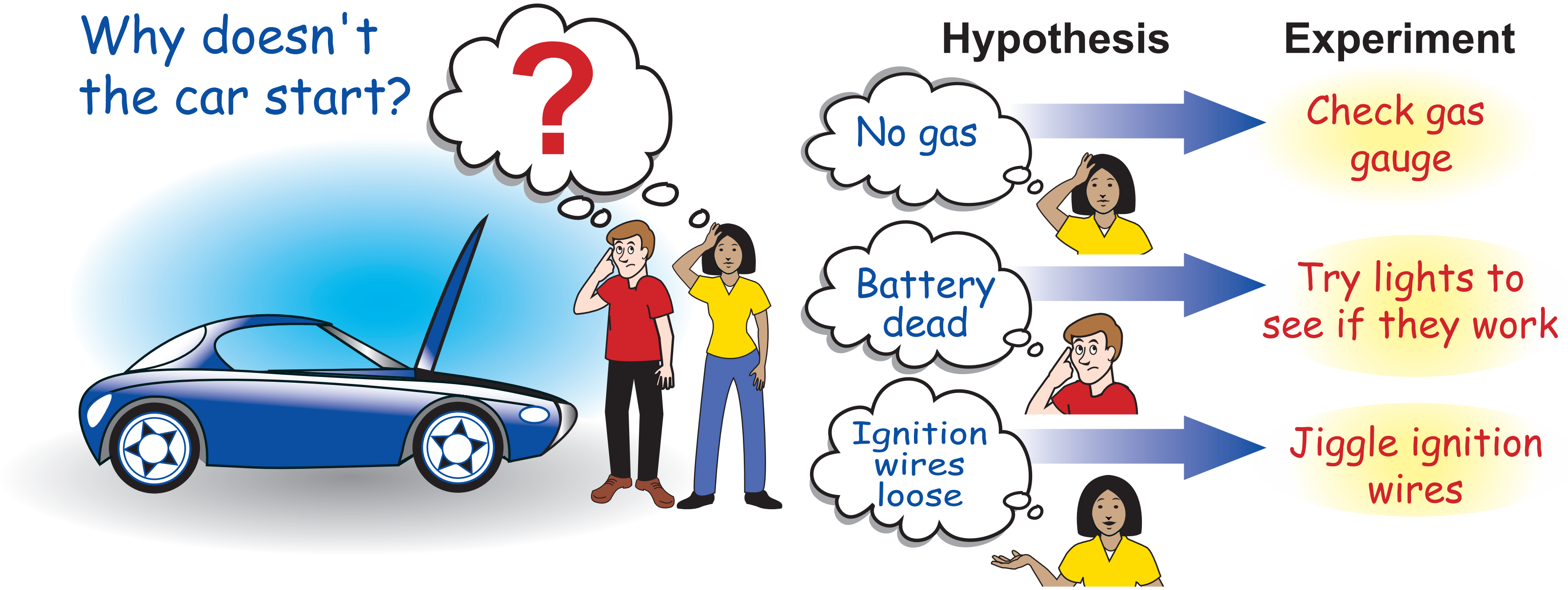
Energy

The ability to cause changes in factors like temperature, height, or speed



The universe contains matter and energy.

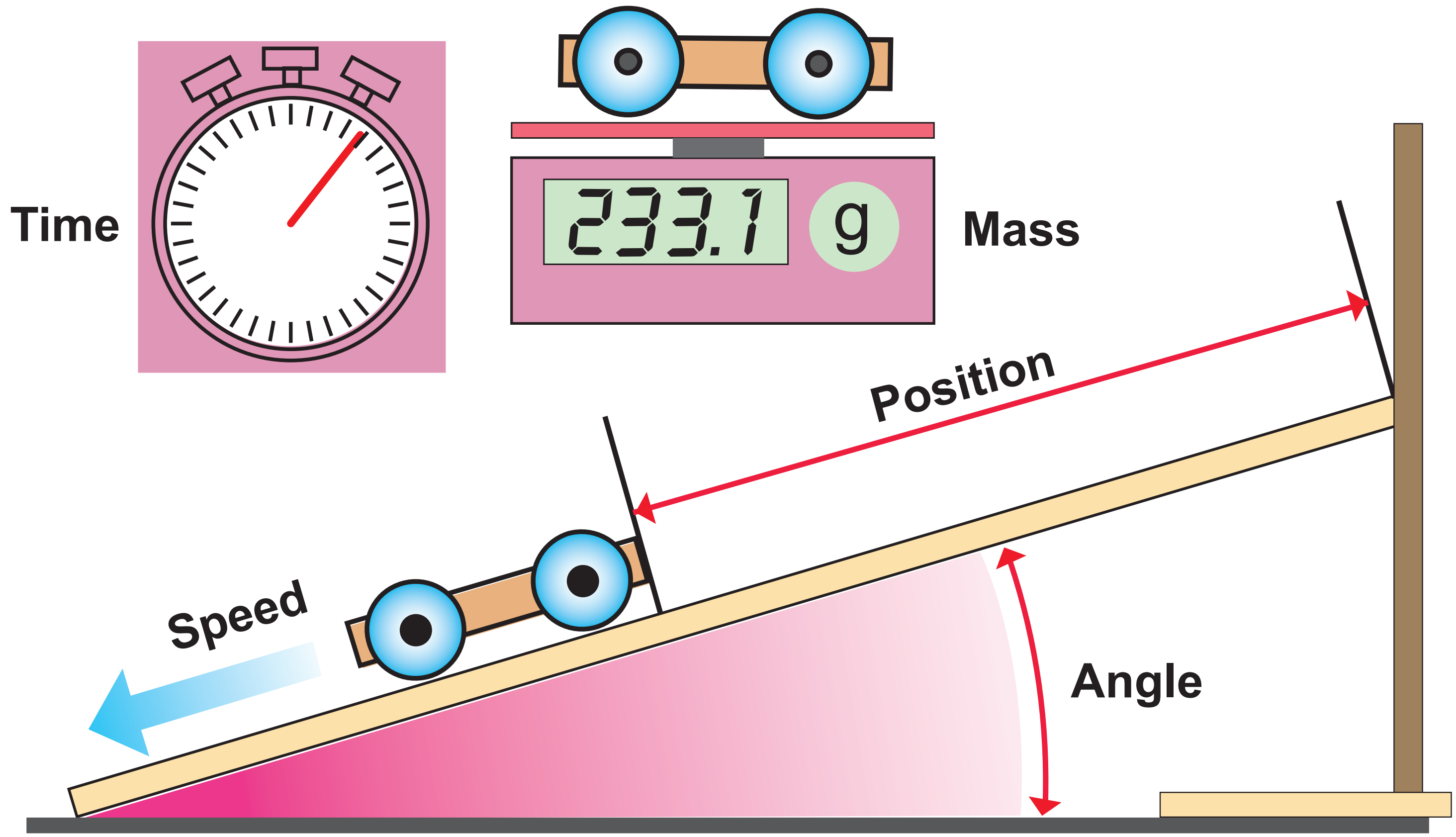
Scientific Method

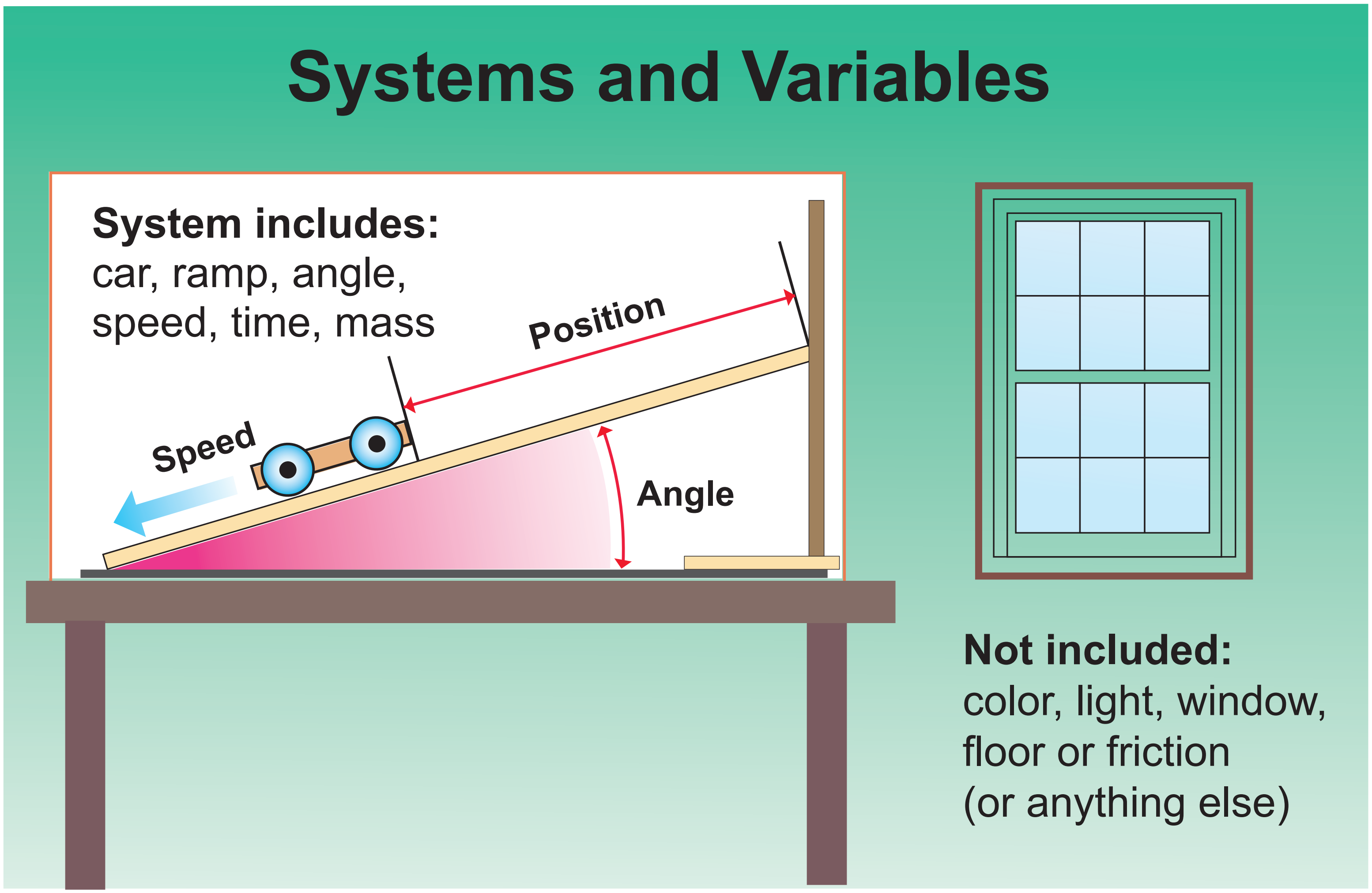


Steps in the scientific method

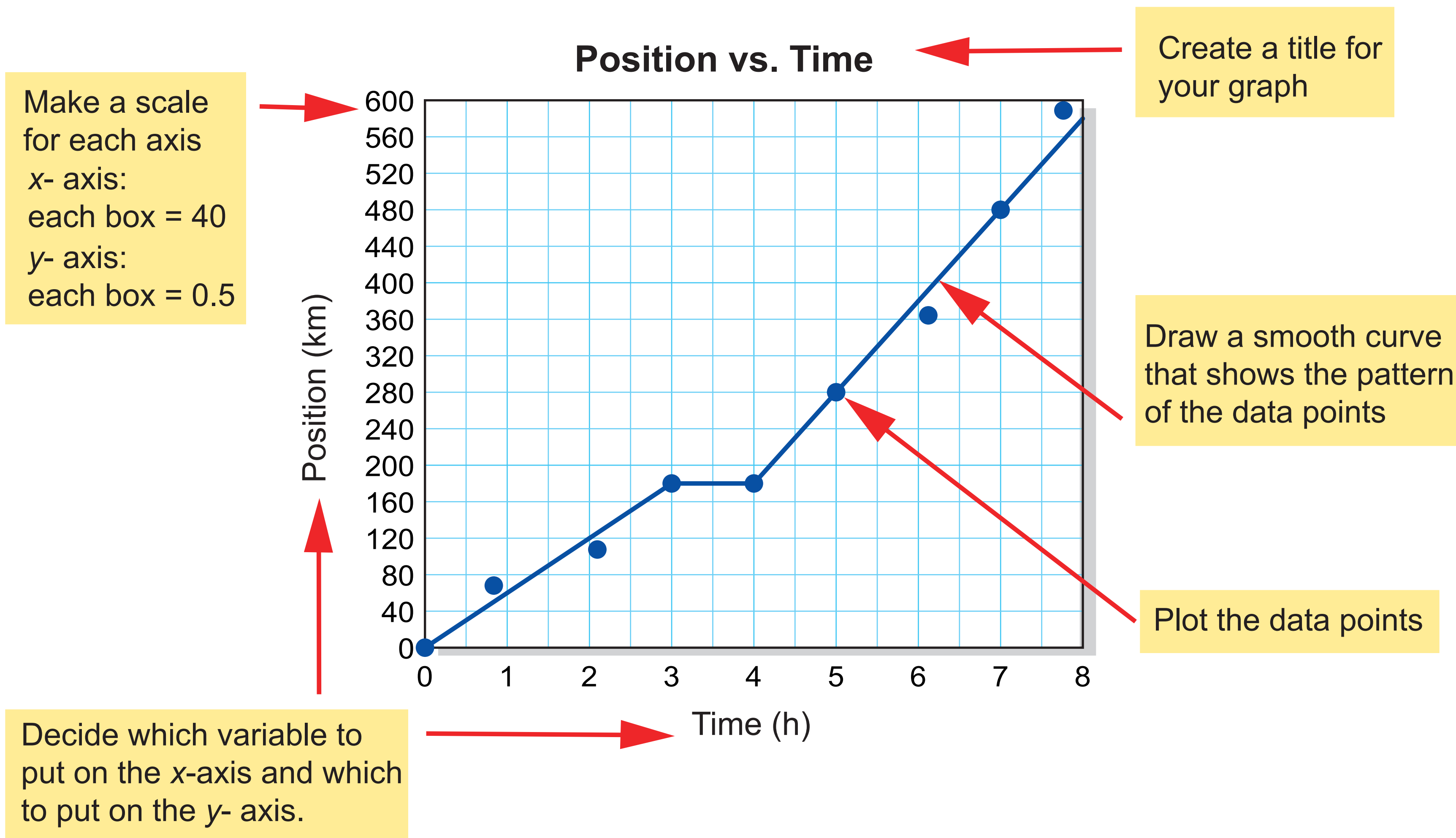
STEP	EXAMPLE
1. Ask a question.	1. Why doesn't the car start?
2. Formulate a hypothesis.	2. Maybe the battery is dead.
3. Design and conduct an experiment.	3. Turn the lights on to test the battery.
4. Collect and analyze data.	4. The lights go on.
5. Make a tentative conclusion.	5. Battery is OK.
6. Test conclusion, or if necessary, refine the question, and go through each step again.	6. Are the ignition wires loose or wet?

Some Important Variables in the System




Systems and Variables
System includes:
car, ramp, angle,
speed, time, mass
Position
Speed
Angle
Not included:
color, light, window,
floor or friction
(or anything else)

How to Make a Graph



Solving Problems

Identify what the problem is looking for

Calculating gravitational forces

Use the following information to calculate the force of gravity between Earth and the moon.
Mass of Earth: 5.97×10^{24} m Mass of moon: 7.34×10^{22} kg Distance between centers of Earth and moon: 3.84×10^{8} m

1. Looking for: You are asked for the force of gravity between Earth and the moon.

Identify the information you are given

2. Given: You are given their two masses in kilograms and the distance between their centers in meters.

Identify useful relationships

3. Relationships: $F_g = G\dfrac{m_1 m_2}{r^2}$

Solve the problem

4. Solution:

$$F_g = (6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2})\frac{(5.97\times10^{24}\ \text{kg})(7.34\times10^{22}\ \text{kg})}{(3.84\times10^{8}\ \text{m})^2}$$

$$F_g = (6.67\times10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2})\frac{(4.38\times10^{47}\ \text{kg}^2)}{(1.47\times10^{17}\ \text{m}^2)} = 1.99\times10^{20}\ \text{N}$$

Your turn...

a. Calculate the force of gravity on a 50-kilogram person on Earth (6.38×10^{6} m from its center). **Answer:** 489 N

b. Calculate the force of gravity on a 50-kilogram person on the moon (1.74×10^{6} m from its center). **Answer:** 81 N

Practice your problem-solving skills

Speed

$$v = \frac{d}{t}$$

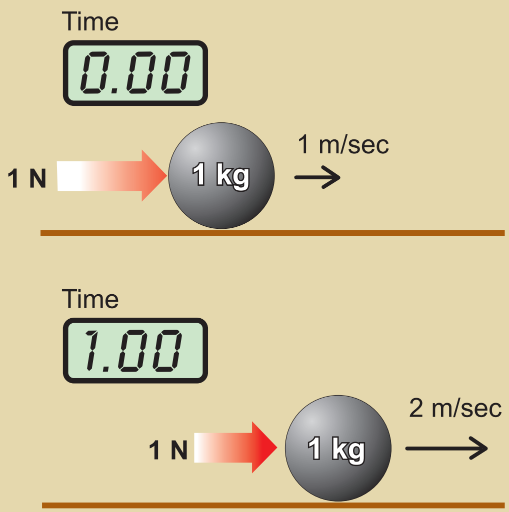
- *Speed* (m/sec): v
- *Distance traveled* (meters): d
- *Time taken* (seconds): t

You can calculate...	*if you know...*	*Equation*
speed	distance and time	$v = \frac{d}{t}$
distance	speed and time	$d = vt$
time	distance and speed	$t = \frac{d}{v}$

Units of Force

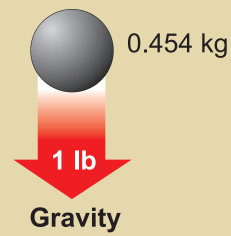
Newton

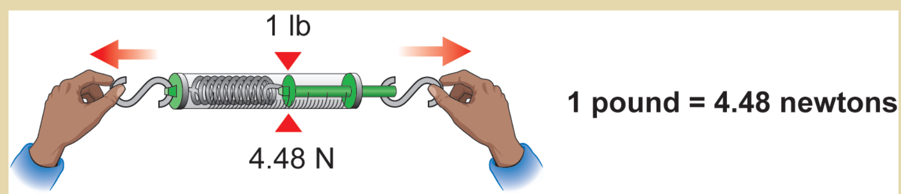
One newton (N) is the force it takes to change the speed of a 1 kg mass by 1 m/sec in 1 second.



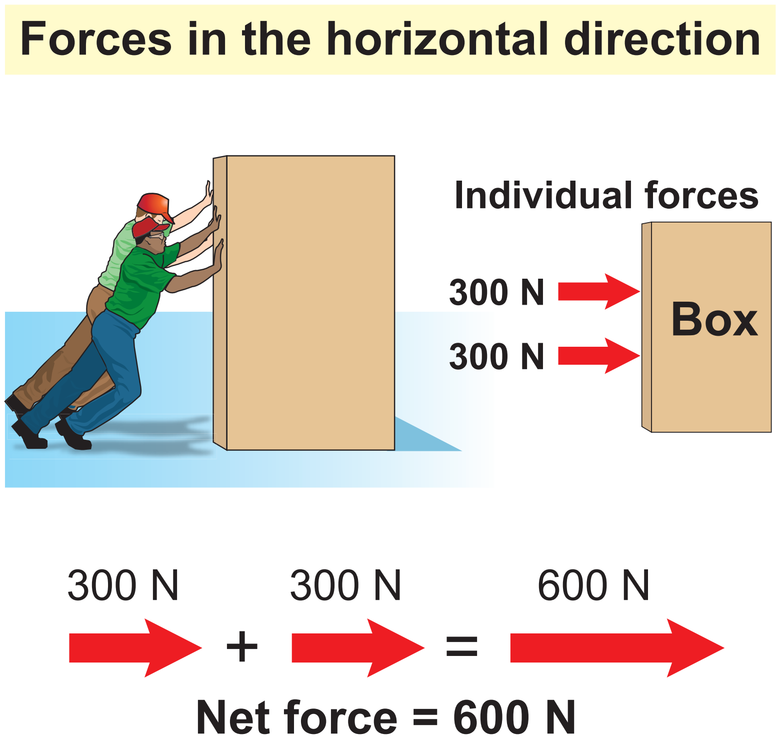
Pound

One pound (lb) is the force exerted by gravity on a mass of 0.454 kg.

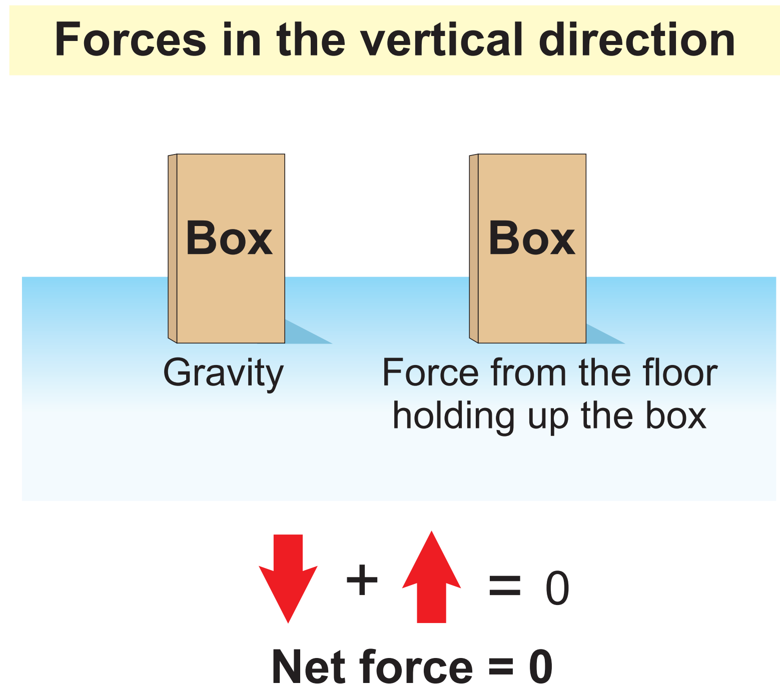




Net Force

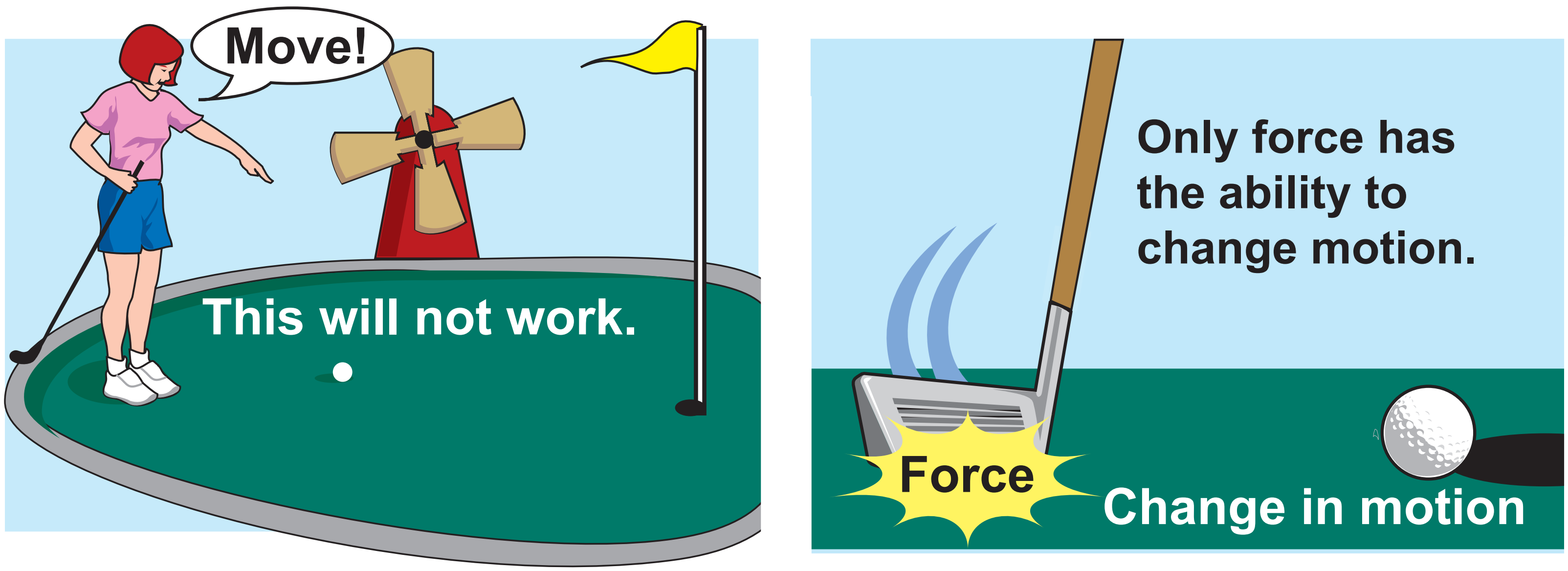


Forces in the horizontal direction
Individual forces
300 N
300 N
Box
300 N
300 N
600 N
+
=
Net force = 600 N



Forces in the vertical direction
Box
Box
Gravity
Force from the floor holding up the box
+
= 0
Net force = 0

Newton's First Law of Motion



An object at rest will stay at rest and an object in motion will continue in motion with the same speed and direction UNLESS acted on by a force.

Acceleration

Change in speed (m/sec)

Acceleration (m/sec^2) → $$a = \frac{v_2 - v_1}{t}$$ ← *Time* (sec)

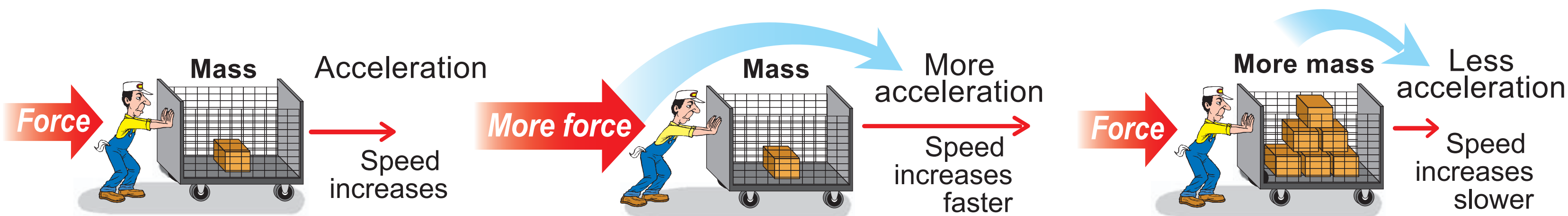
Acceleration = $\dfrac{\text{Change in speed}}{\text{Change in time}}$

How do we get units of m/sec^2 ?

Plug in values		***Clear the compound fraction***		***Final units***
$\dfrac{50\,\dfrac{\text{m}}{\text{sec}}}{\text{sec}}$	=	$50\,\dfrac{\text{m}}{\text{sec}} \times \dfrac{1}{\text{sec}} = 50\,\dfrac{\text{m}}{\text{sec} \times \text{sec}}$	=	$50\,\dfrac{\text{m}}{\text{sec}^2}$

Newton's Second Law of Motion

Acceleration (m/sec^2) → $$a = \frac{F}{m}$$ ← *Force* (N) / *Mass* (kg)



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

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

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

Average Speed

Average speed (m/sec)

Final speed (m/sec)

Initial speed (m/sec)

$$V_{avg} = \frac{v_f + v_i}{2}$$

Free Fall Distance

Distance (m)

Average speed (m/sec)

$$d = v_{avg}\, t$$

Time (sec)

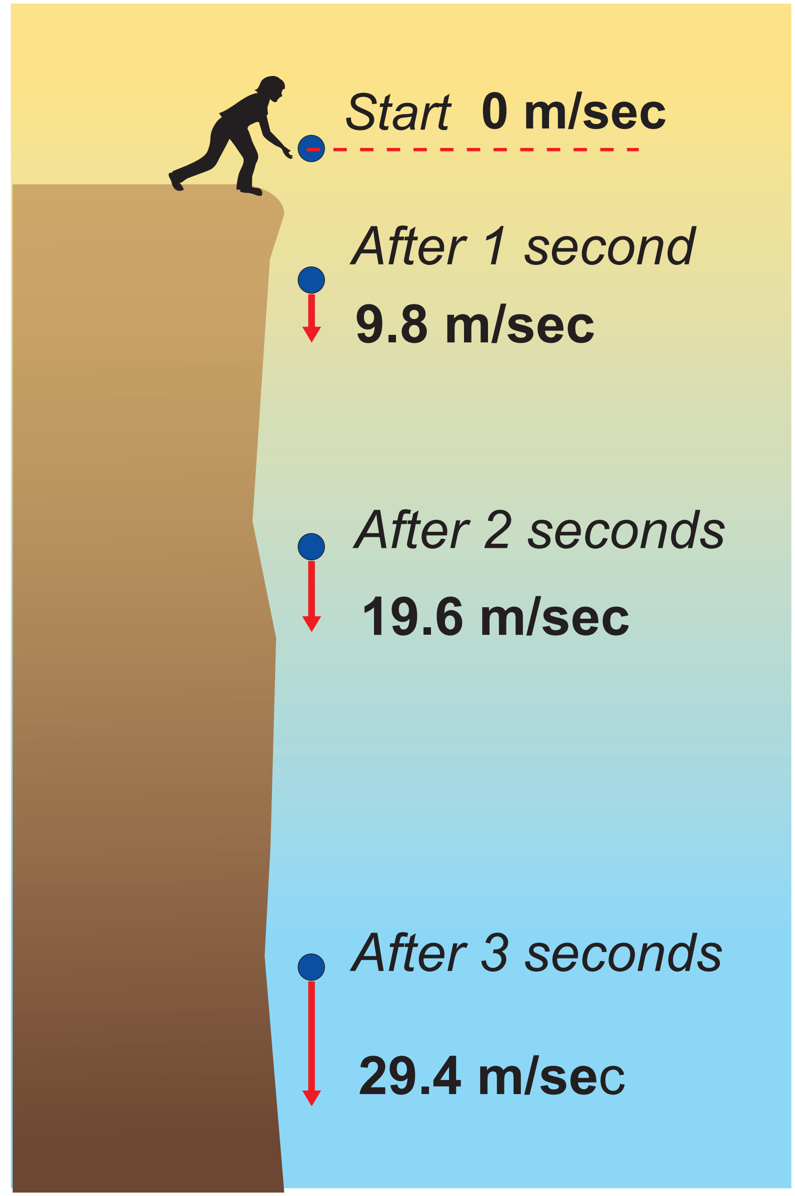
Free Fall Speed
(starting at rest)

Speed (m/sec)

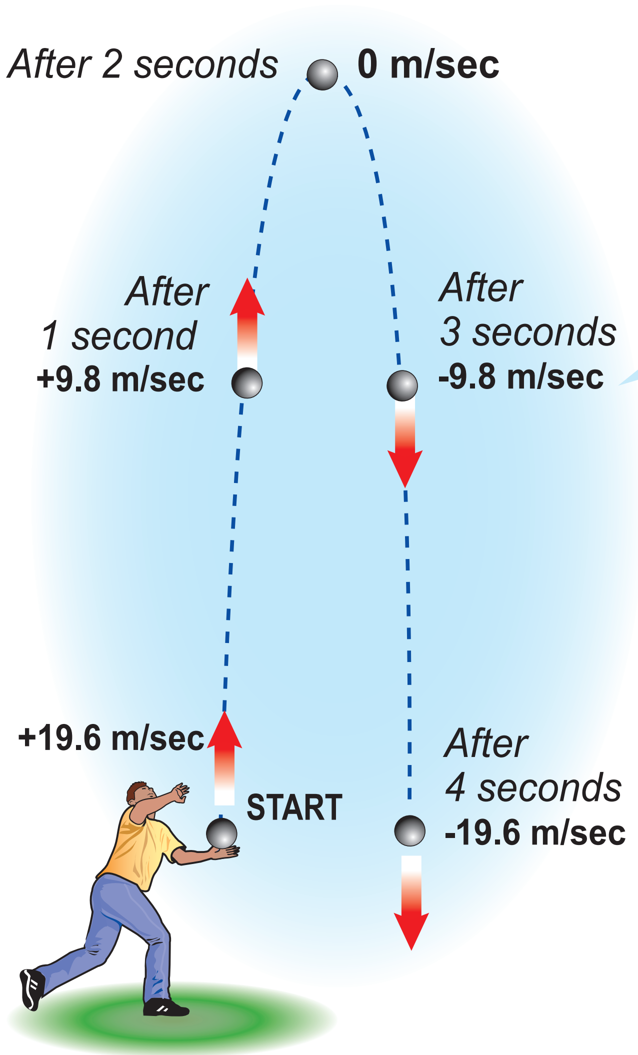
Acceleration due to gravity (m/sec^2)

Time (sec)

$$v = gt$$



Free Fall with Upward Motion



The speed changes by -9.8 m/sec every second

Time (sec)	Velocity (m/sec)	Height (m)
0.0	19.60	0.00
1.0	9.80	14.70
2.0	0.00	19.60
3.0	-9.80	14.70
4.0	-19.60	0.00

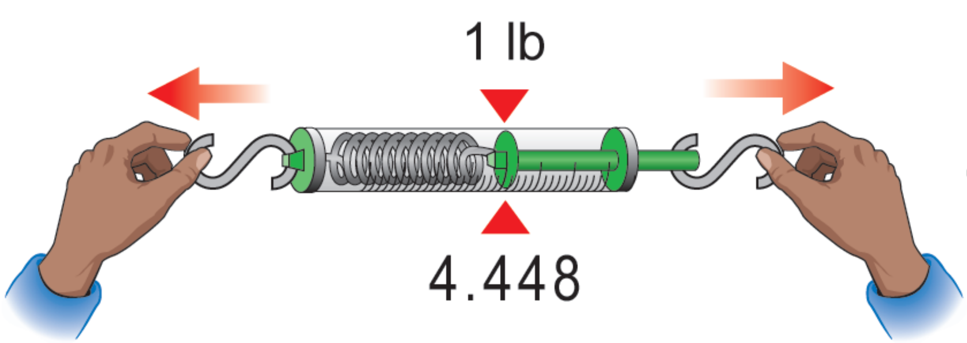
Weight

$$F_g = mg$$

Mass (kg)

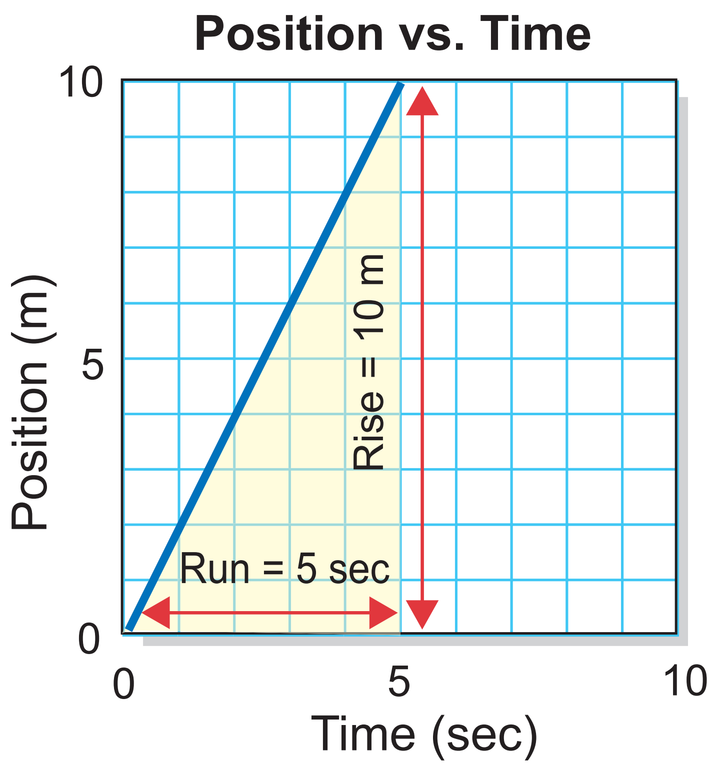
Strength of gravity (9.8 N/kg)

Weight or force of gravity (N)



1 pound = 4.448 newtons

Position vs. Time Graph

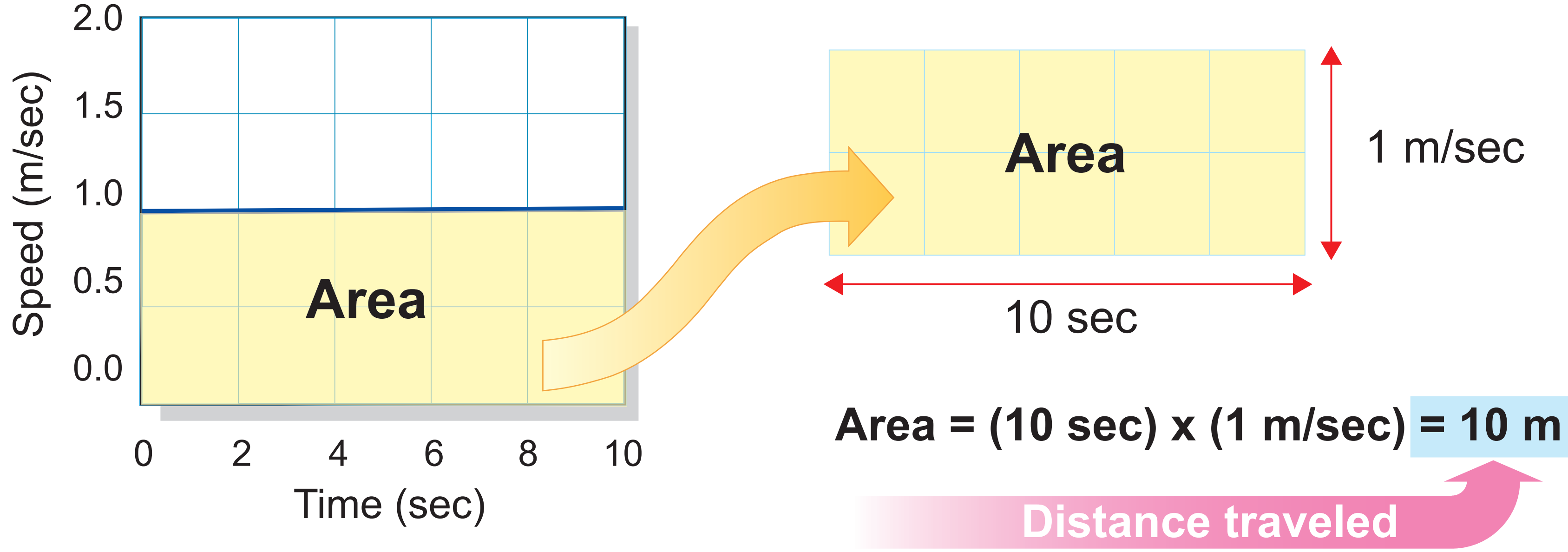


$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{10\text{ m}}{5\text{ sec}}$$

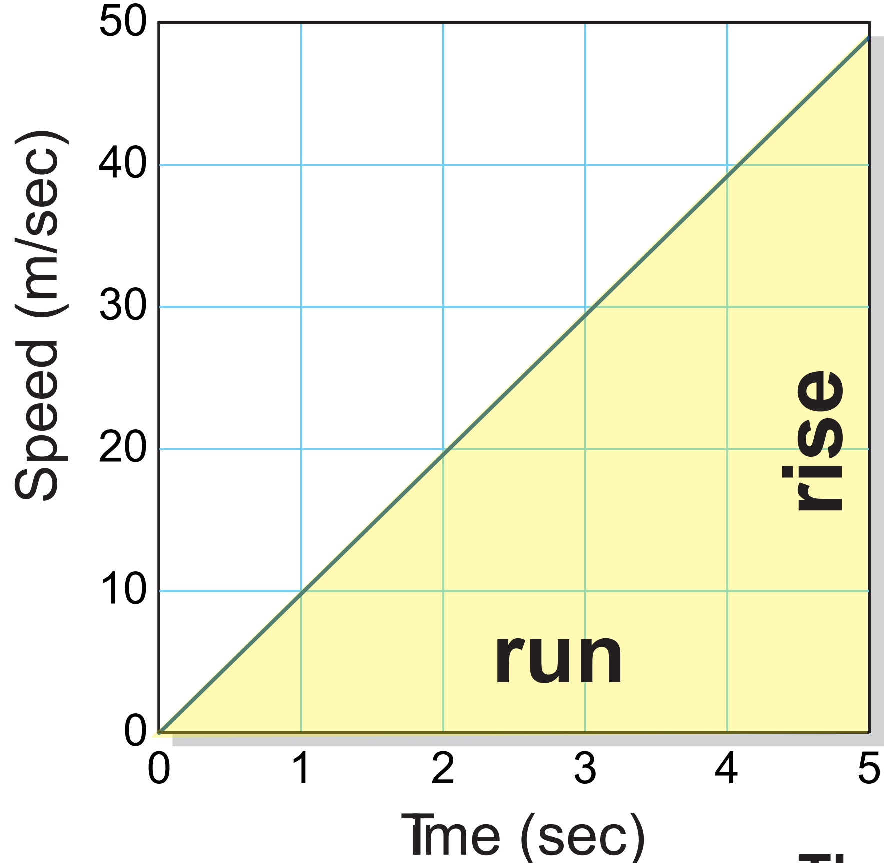
= 2 m/sec

The slope of position vs. time is the **speed.**

Speed and Distance Traveled



Speed vs. Time Graph



$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{49 \text{ m/sec}}{5 \text{ sec}}$$

$$= 9.8 \text{ m/sec}^2$$

The slope of speed vs. time is **acceleration**

Momentum

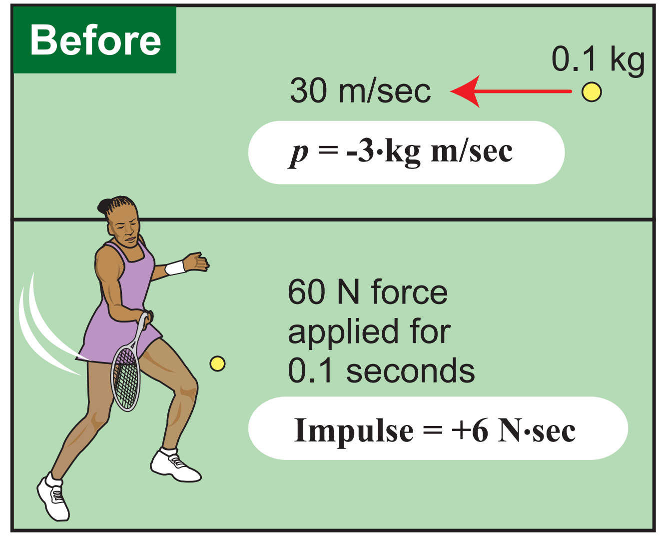
$$p = mv$$

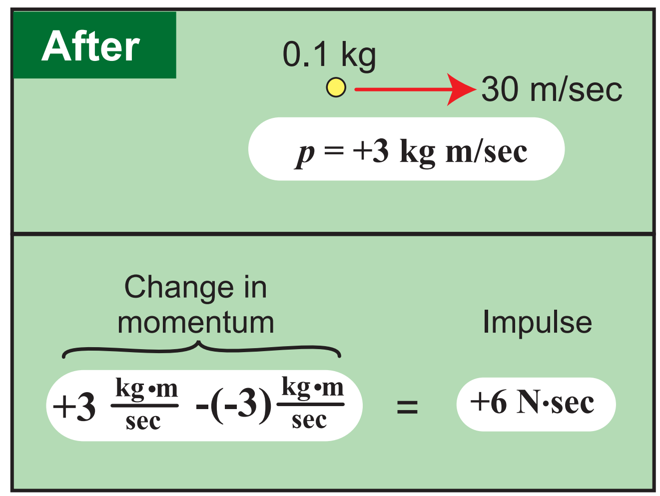
- *Momentum* (kg·m/sec) → p
- *Mass* (kg) → m
- *Velocity* (m/sec) → v

Impulse

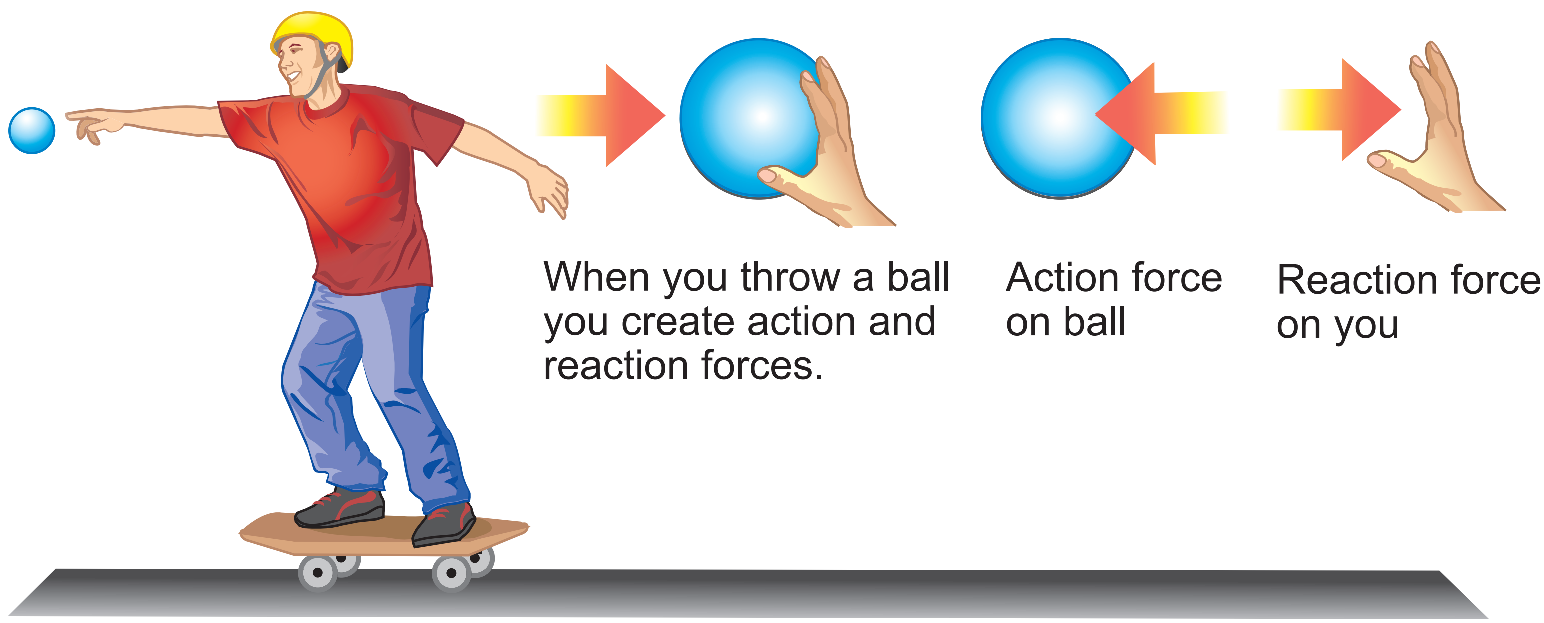
$$Ft = mv_2 - mv_1$$

- *Force* (N) → F
- *Time* (sec) → t
- *Mass* (kg) → m
- *Initial speed* (m/sec) → v_1
- *Final speed* (m/sec) → v_2
- Ft: *Impulse* (N·sec *or* kg·m/sec)





Newton's Third Law of Motion



For every action force, there is a reaction force equal in strength and opposite in direction.

Potential Energy

Potential energy (joules)

Mass (kg)

$$E_p = mgh$$

Height (meters)

Acceleration due to gravity (9.8 m/sec^2)

Kinetic Energy

Kinetic energy (joules)

Mass (kg)

$$E_k = \frac{1}{2}mv^2$$

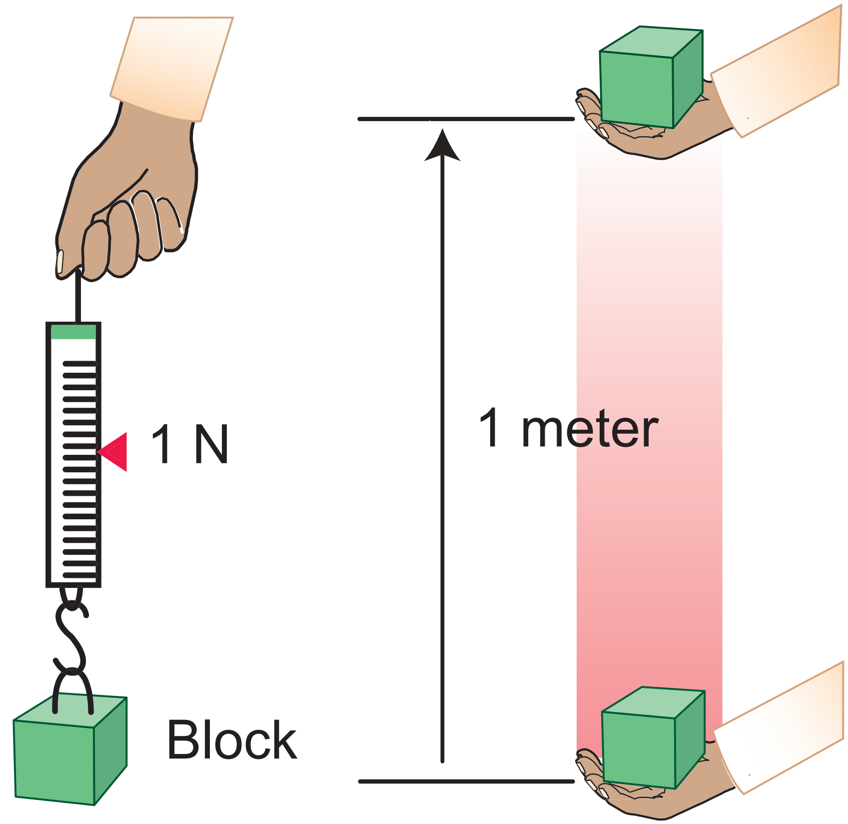
Speed (m/sec)

Work

Work (joules) *Force* (newtons)

$$W = Fd$$

Distance (meters)
in the direction of the force



Lifting the 1 newton block 1 meter requires 1 joule of work.