How do forces affect the motion of an object?
How do Newton's Laws of Motion allow us to make predictions and draw conclusions dealing with the motion of an object?

Force & Acceleration

Changing Velocity

Describe how the net force on an object affects motion.
Explain Newton's second law of motion in terms of force, mass, and acceleration.

Force and Acceleration

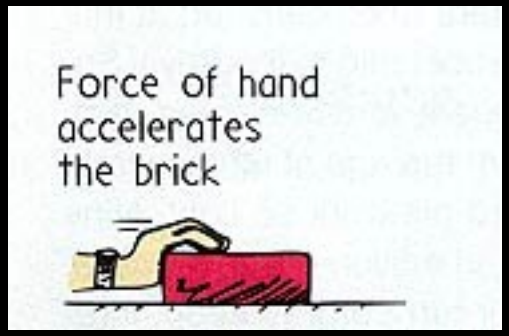
- An **unbalanced force** is required to change an object's velocity.
- The acceleration of an object depends on the **net force** acting on the object.
- In the space below, draw two free body diagrams that represent objects with unbalanced forces acting on them.

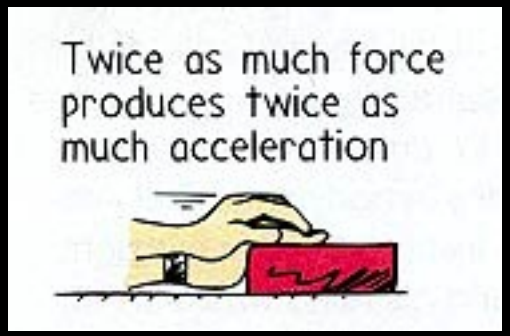
Force and Acceleration

- Newtons's **2nd Law** of Motion describes the relationship between the amount of net force acting on an object and the acceleration the object experiences.

Force and Acceleration

- Force and Acceleration are **directly** related.



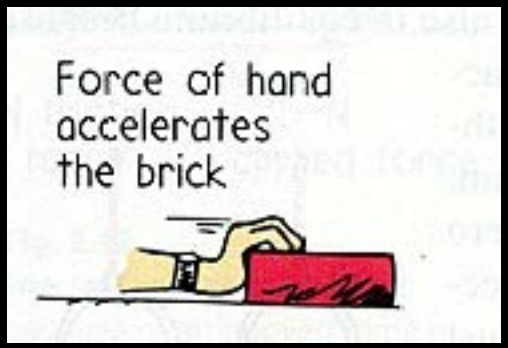


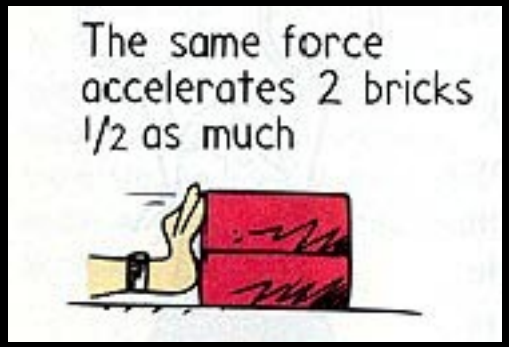
Mass and Acceleration

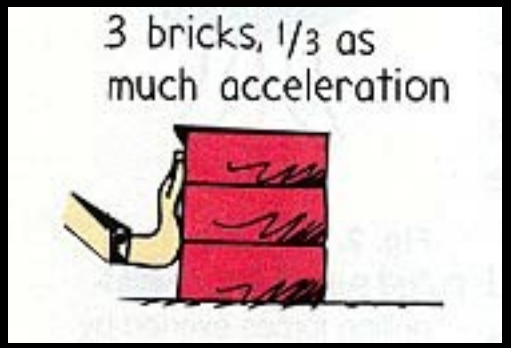
- The 2nd Law also describes how the acceleration of an object depends on the **mass** of the object.

Mass and Acceleration

- Mass and acceleration are **inversely** related.







Force, Mass & Acceleration

- F = ma
  - F = **force**, measured in **Newtons**
  - m = **mass**, measured in **kilograms**
  - a = **acceleration**, measured in **m/s^2**

What is a Newton?

- A Newton is the standard unit of **force**
- F = ma
  - **N = kg m/s^2**
  - A Newton is the force required to accelerate **1 kilogram** at a rate of **1 m/s^2**
  - On Earth, 1 kg = **2.2 pounds** = **9.8 N**

Calculations

m

1. Calculate the acceleration of a 25.0 kg object being pulled with 1.5 N of force.

F

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

$$a = \frac{1.5\ N}{25.0\ kg} = 0.06\ m/s^2$$

Calculations

F

2. An object is pulled with a force of 30. N. It begins to accelerate at a rate of 5 m/s^2. Calculate the mass of the object. a

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

$$m = \frac{30\ N}{5\ m/s^2} = 6\ kg$$

Calculations

3. What force is required to accelerate a 100. kg object at a rate of 2m/s^2?

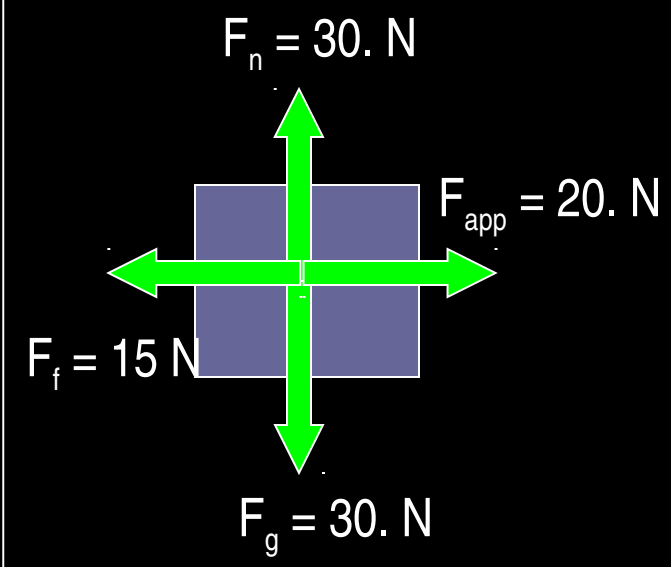
m a

$F = m \times a$

$F = 100\ kg \times 2\ m/s^2 = 200\ N$

Calculations

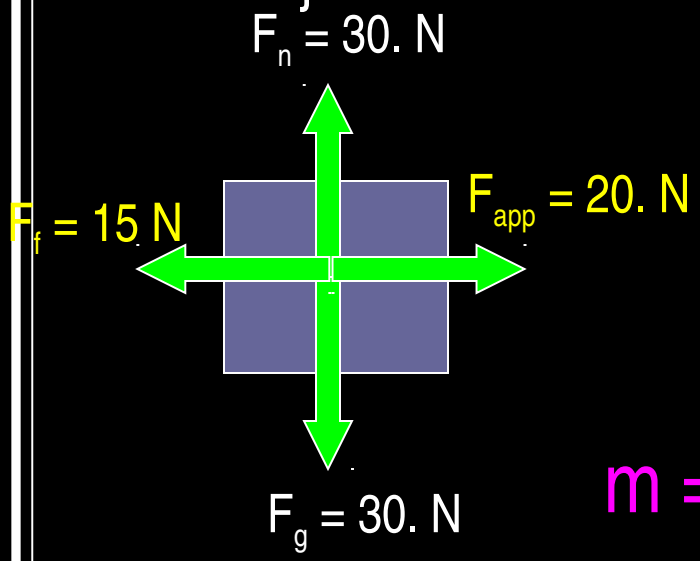
- It is the **net force** on an object that determines the acceleration.



Note: The force of gravity and the support force cancel out.
The net force on the object is 5 N Right.

Calculations

1. Calculate the net force
   - $\Sigma F = 5N$ Right
1. Use this force, along with the mass, to calculate the acceleration of the object.



$m = 2.5\ kg$

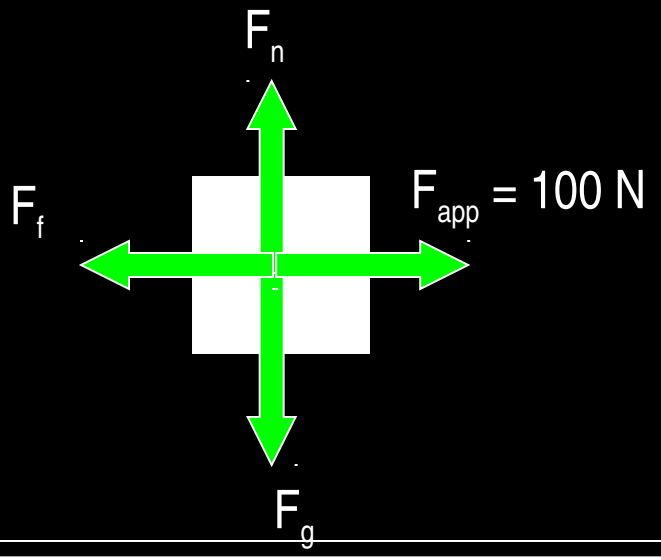
$$a = \frac{F}{m}$$

$$a = \frac{5\ N}{2.5\ kg}$$

$$= 2\ m/s^2$$

Gravity Graham

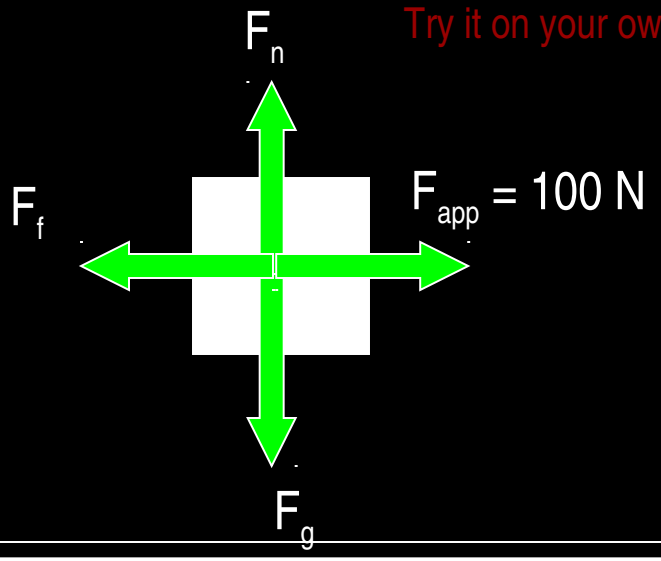
- Graham Gravity is pushing the crate with a force of 100 N. The crate does not move. Draw a free body diagram that includes all **four** forces acting on the crate. Label each of these forces.



Gravity Graham

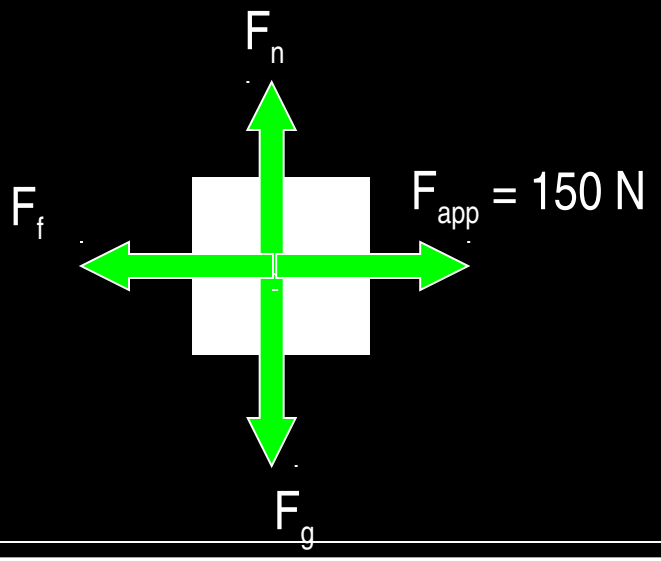
- What is the magnitude of the friction for the above scenario? 100 N
- What type of equilibrium is this? static

Try it on your own!



Gravity Graham

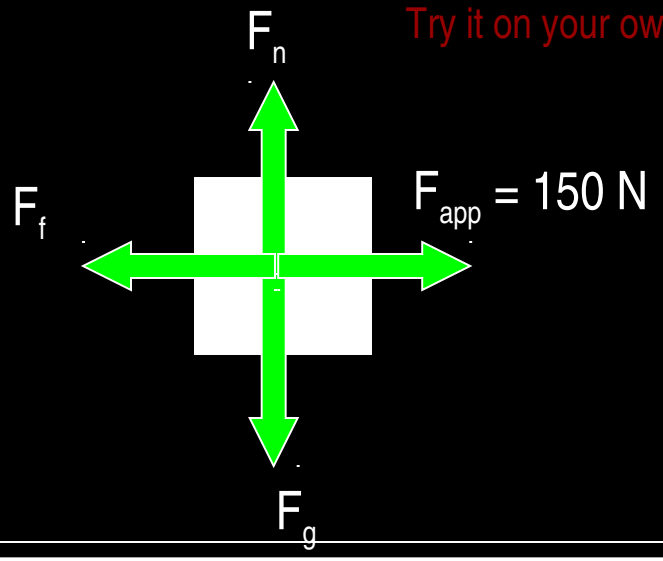
- Graham Gravity is pulling the crate with a force of 150 N. The crate moves at a **constant velocity.** Draw a free body diagram that includes all **four** forces acting on the crate. Label each of these forces.



Gravity Graham

- What is the magnitude of the friction for the above scenario? 150 N
- What type of equilibrium is this? dynamic

Try it on your own!



Gravity Graham

Gravity Graham pulls the crate harder and the crate begins to **accelerate**. The force of friction is at its maximum of **200N**. The mass of the crate is **25 kg.**

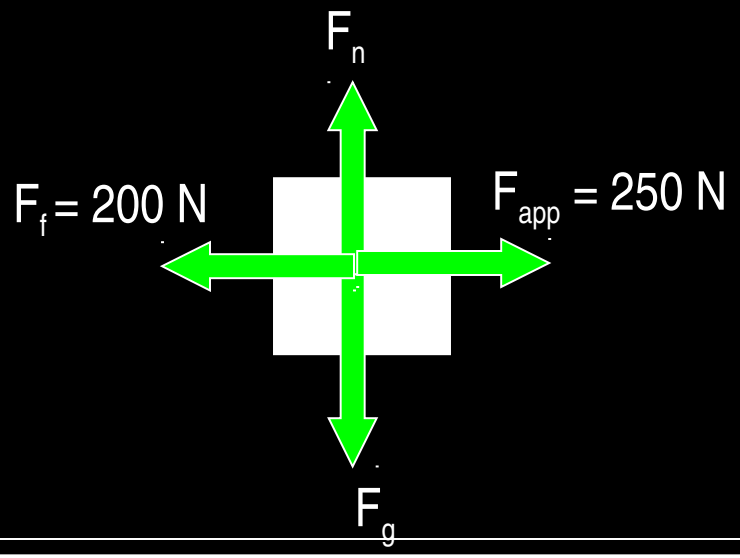
Gravity Graham

Gravity Graham pulls the crate harder and the crate begins to **accelerate**. The force of friction is at its maximum of **200N**. The mass of the crate is **25 kg**.

Graham Gravity is pulling the crate with a force of 250 N. The crate is accelerating.

Draw a free body diagram that includes all **four** forces acting on the crate.

Label each of these forces.



Determine the net force on the crate.

$\Sigma F = 50$ N right

Determine the acceleration on the crate.

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

$$a = \frac{50\ N}{25\ kg} = 2\ m/s^2$$

Gravity Graham

Gravity Graham pulls the crate harder and the crate begins to **accelerate**. The force of friction is at its maximum of **200N**. The mass of the crate is **25 kg**.

Graham Gravity is pulling the crate with a force of 450 N. The crate is accelerating.
Draw a free body diagram that includes all **four** forces acting on the crate.
Label each of these forces.

Determine the net force on the crate.

$\Sigma F = 250$ N right

Determine the acceleration on the crate.

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

$$a = \frac{250\ N}{25\ kg} = 10\ m/s^2$$