Newton's 2nd Law

Outcome:

S2-3-06 Describe qualitatively how force is related to motion. *Include: no force, constant force, F=ma*

More on Forces

How is the applied **FORCE** **RELATED** to the subsequent **MOTION** of the object? Does the size of the force affect the motion?

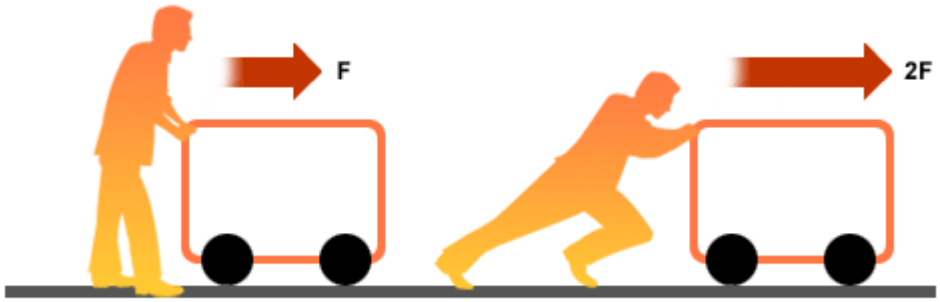
Force is proportional to acceleration.

- If we apply a **GREATER FORCE** we will have a **GREATER ACCELERATION** (including speeding up and slowing down).

Force is proportional to mass.

- **MORE MASSIVE OBJECTS** require **MORE FORCE** to accelerate (change speed).

Force can change the direction of motion.



Newton's Second Law

Looks at the relationship between an object's **MASS** and its **ACCELERATION**.

- The **MASS** of an object is not simply the **QUANTITY** of **MATTER** but is actually a measure of **INERTIA** of an object. What does this mean?
  - The **MORE MASS** an object has, the **MORE DIFFICULT** it becomes to **CHANGE** the **OBJECT'S** state of **MOTION**.

Example:
It is more difficult to budge a **PIANO** from rest than a **PIANO BENCH**. This is because the piano has much **MORE** mass than the bench does and there for much more **INERTIA**.

Newton's Second Law

Newton's second law is often stated as

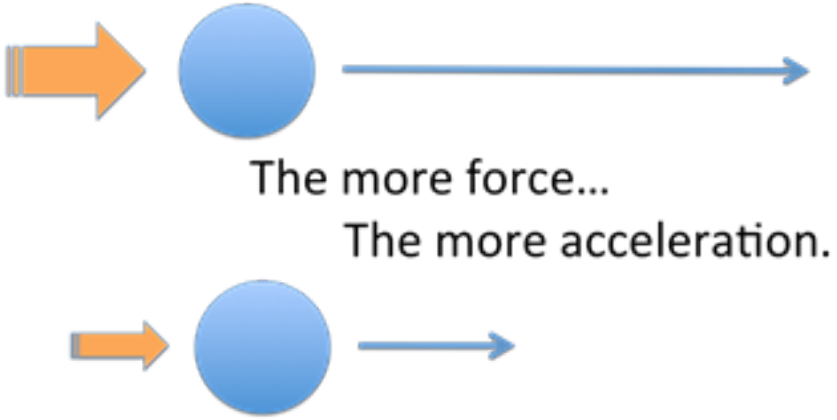
$$F = ma$$

Where:

F = Force, measured in Newtons (N) – 1N=1kg/m·s²
m = Mass, measured in Kilograms (Kg)
a = Acceleration, measured in m/s²

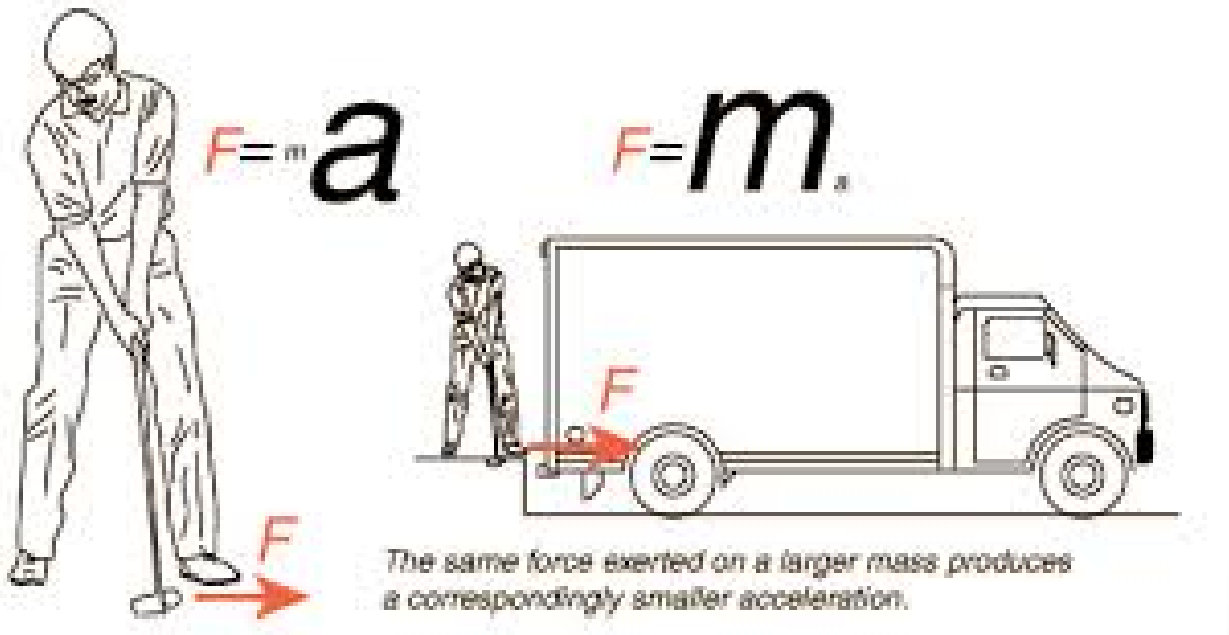
This law states that

- **ACCELERATION** is **PROPORTIONAL** to the applied **FORCE**.
  - → If we apply a **GREATER FORCE**, there will be a **GREATER ACCELERATION** (either speeding up or slowing down).



Newton's Second Law

- To achieve **ACCELERATION**, the amount of applied **FORCE** is **RELATED** to the **MASS** of an object.
  - → The **MORE MASSIVE** an object becomes, the **GREATER** the **FORCE NECESSARY** to change its speed

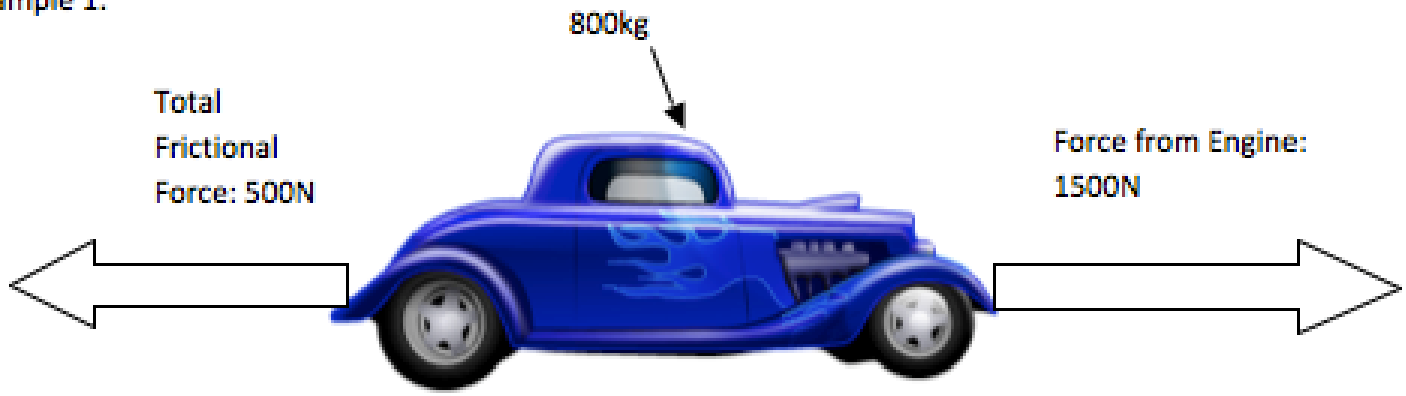


The same force exerted on a larger mass produces a correspondingly smaller acceleration.

Newton's Second Law

- a **FORCE** is **CAPABLE** of **CHANGING** the **DIRECTION** of **MOTION** on an **OBJECT**.
  → If an unbalanced force is applied to an object, the object will **ACCELERATE** in the **DIRECTION** of the **UNBALANCED FORCE**.

Example 1.



Reminder:

- A force is any kind of **PUSH** or **PULL** on an object.
- **FORCE** is a **VECTOR** quantity.

Newton's Second Law

$F = ma$

Example Problems:

1. How fast will a 700kg car accelerate if a force of 400N is applied by stepping on the gas?

$m = 700kg$

$F = 400N$

$a = ?$

$F = ma$

$400N = (700kg)(a)$

$a = \frac{400N}{700kg} = 0.57 m/s^2$

2. You are driving along at 100km/hr, and a deer jumps out in front of you. If you slam on the breaks and stop in 5s, find the following:

   a. Your acceleration (in m/s^2)

$100km/hr \div 3.6 = 27.8 m/s$

$a = \frac{V_2 - V_1}{\Delta t}$

$= \frac{0 m/s - 27.8 m/s}{5s} = -5.56 m/s^2$

   b. If your car has a mass of 900 kg, what force did your breaks have to apply to stop the car?

$F = ma$

$F = (900kg)(-5.56 m/s^2)$

$F = (5004N)$

Newton's Second Law

Example Problems:

3. Find the mass of an object that accelerates at a rate of $3 m/s^2$ when a force of 1000N is applied.

$F = 1000N$

$a = 3 m/s^2$

$m = ?$

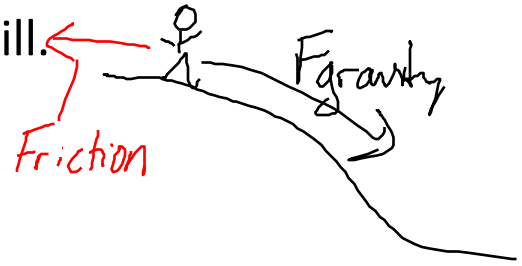
$F = ma$

$1000N = m(3 m/s^2)$

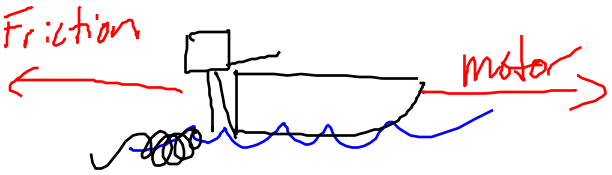
$m = 333.3\ kg$

4. Draw a diagram showing all the forces in the following situations:

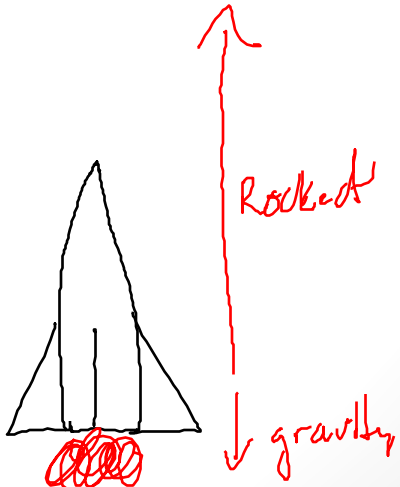
   a. A skier goes down the hill.



   b. A boat is moving at a constant speed.



   c. A rocket is launched.



Newton's Second Law

Try these ones…

1. You are pushing a stalled car. Describe how acceleration would change if:
   a. Applied more force.

acceleration ↑

   b. The car was heavier.

acceleration ↓

2. Calculate the force required to throw a football (1kg) with an acceleration of 2.5m/s^2

$F = ma$

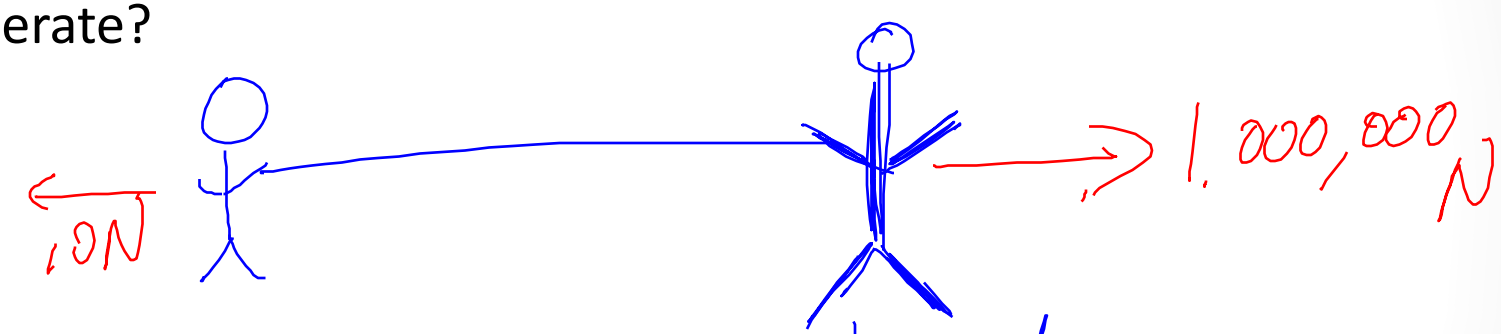
$= (1\,kg)(2.5\,m/s^2)$

$= 2.5\,N$

Newton's Second Law

Try these ones…

3. Hayward and Kangas are having a tug-of-war. If Hayward can pull with a force of 1,000,000 N and Kangas can only pull with a force of 10 N, and Kangas has a mass of 60kg, how fast will Mr. Kangas accelerate?



$1{,}000{,}000\,N - 10\,N = 999{,}990\,N$ (unbalanced)

$F = ma$

$999\,990\,N = 60\,kg\,(a)$

$a = 16{,}666\ m/s^2$