NEWTON'S SECOND LAW

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Newton's Second Law

Force equals mass times acceleration.

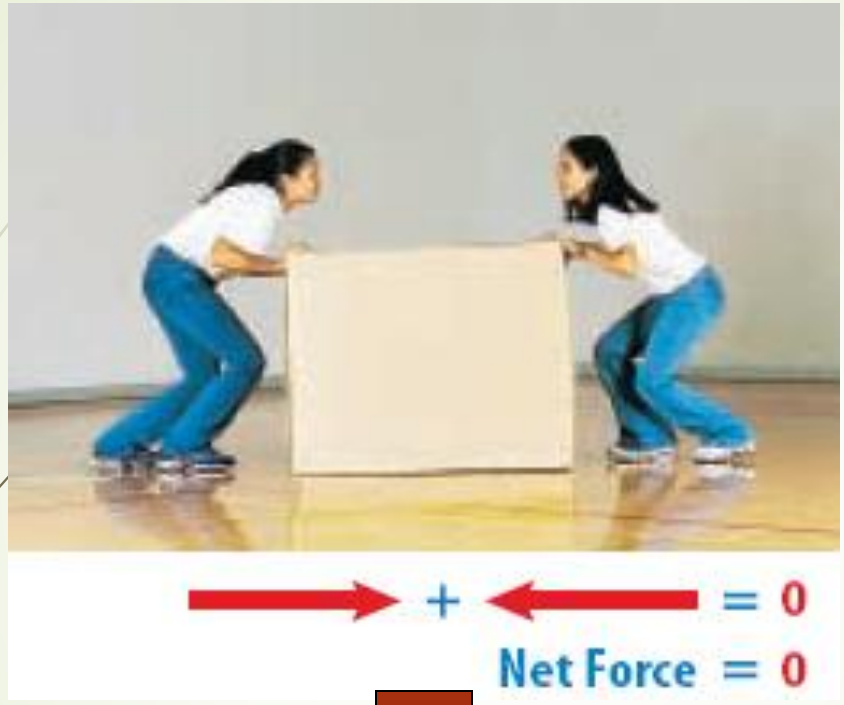
$$F = ma$$

Acceleration: a measurement of how quickly an object is changing speed.

Acceleration

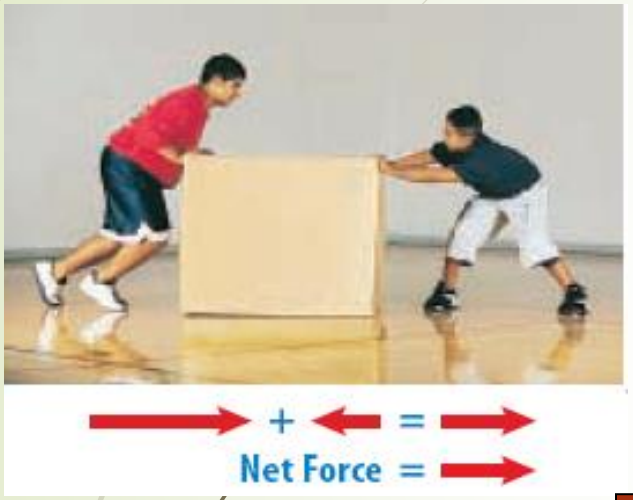
- An ***unbalanced force*** causes something to accelerate.
- A force can cause motion only if it is met with an ***unbalanced force***.
- Forces can be balanced or unbalanced.
- Depends on the **net force** acting on the object
- **Net force (F_{net}):** The sum total and direction of all forces acting on the object.
  - **Net forces: Always cause acceleration.**

Balanced Versus Unbalanced



Balanced forces cause no acceleration.

Balanced Versus Unbalanced



Unbalanced forces cause acceleration.

What does F = ma mean?

Force is *directly proportional* to mass and acceleration. Imagine a ball of a certain mass moving at a certain acceleration. This ball has a certain force.

Now imagine we make the ball twice as big (double the mass) but keep the acceleration constant. F = ma says that this new ball has *twice the force* of the old ball.

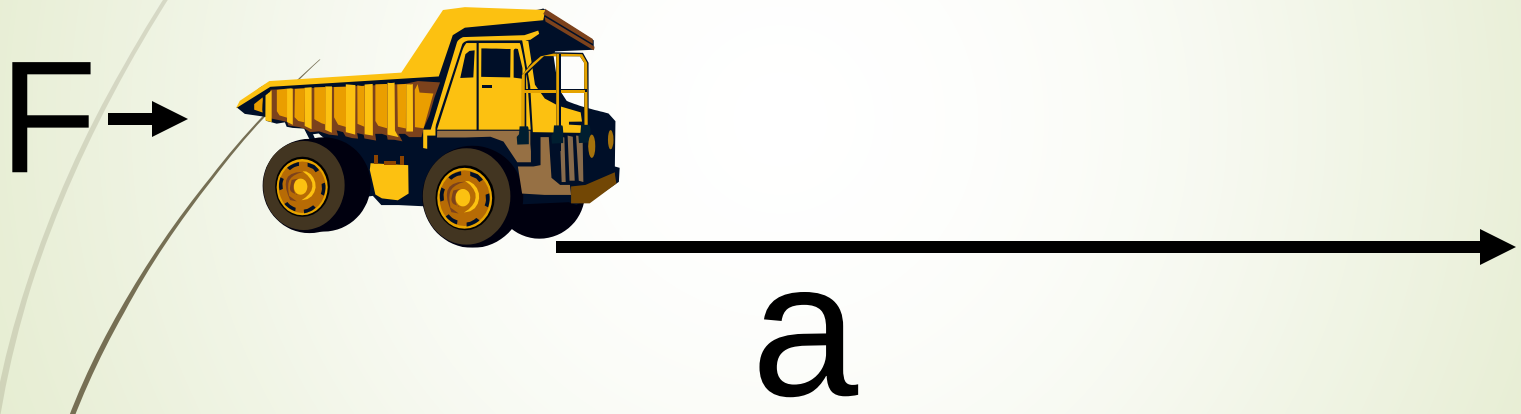
Now imagine the original ball moving at twice the original acceleration. F = ma says that the ball will again have *twice the force* of the ball at the original acceleration.

In Other Words…

Small Force = Small Acceleration

In Other Words…

Large Force = Large Acceleration



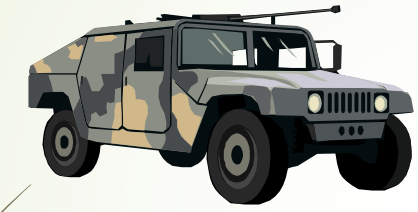
So….if you push twice as hard, it accelerates twice as much.

But there is a twist….

- Acceleration is INVERSELY related to the mass of the object.

In other words…..using the same amount of force….

F →



Large Mass

Small acceleration →

a

F →

Small Mass

Large acceleration →

a

What does F = ma say?

F = ma basically means that the force of an object comes from its mass and its acceleration.

Force is measured in

Newtons (N) = mass (kg) x acceleration (m/s^2)

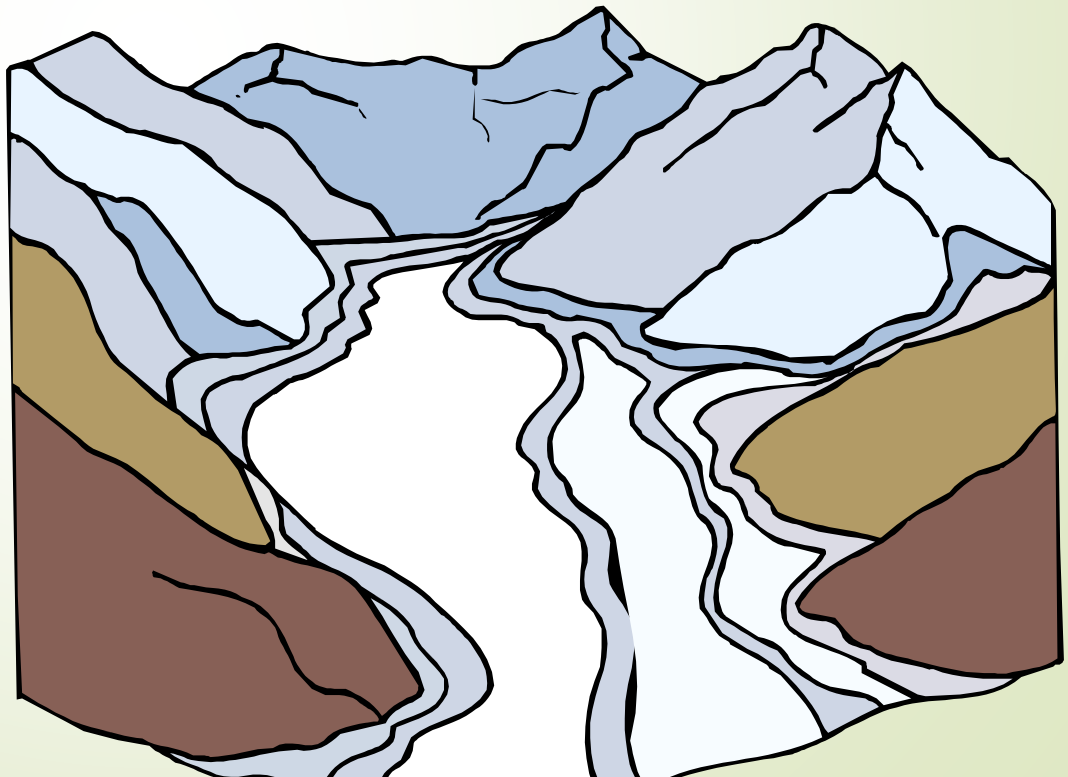
Or

kg m/s^2

$$1 \text{ Newton} = 1 \text{ kg} * \frac{m}{s^2}$$

High Mass

Something very massive (high mass) that's changing speed very slowly (low acceleration), like a glacier, can still have great force.



Low Mass

Something very small (low mass) that's changing speed very quickly (high acceleration), like a bullet, can still have a great force. Something very small changing speed very slowly will have a very weak force.

In Summary

- The acceleration of an object is directly proportional to the net force & inversely proportional to its mass.

- F = ma
- Force = Mass x Acceleration

How Does Weight Tie In?

- **Mass** is the quantity of matter in an object. More specifically, mass is a measure of the inertia, or "laziness," that an object exhibits in response to any effort made to start it, stop it, or otherwise change its state of motion.
- **Weight** is the force of gravity on an object.
- If force is equal to mass x acceleration then, Weight is equal to mass x acceleration due to gravity

Weight

- So on earth, your weight is
  - Your Mass x 9.8 m/s/s
- When you are drawing FBDs and the force of gravity factors i (almost always), you can figure out the value of that force
- For example, if I say a 2kg book is resting on a table…
  - The force due to gravity (weight) is 2 x 9.8
  - The normal force would be the same but opposite direction