Chapter Six: Newton's Laws of Motion

- 6.1 Newton's First Law
- 6.2 Newton's Second Law
- 6.3 Newton's Third Law and Momentum

Chapter 6.2 Learning Goals

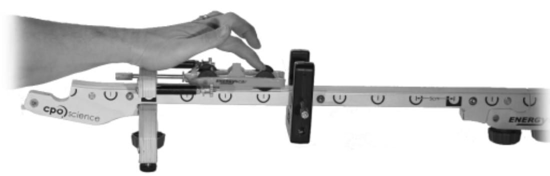
- Define Newton's second law by relating force, mass, and acceleration.
- Apply Newton's second law quantitatively.
- Describe the relationship between net force and acceleration.

Investigation 6A

Newton's First and Second Laws

- **Key Question:**

What is the relationship between force and motion?

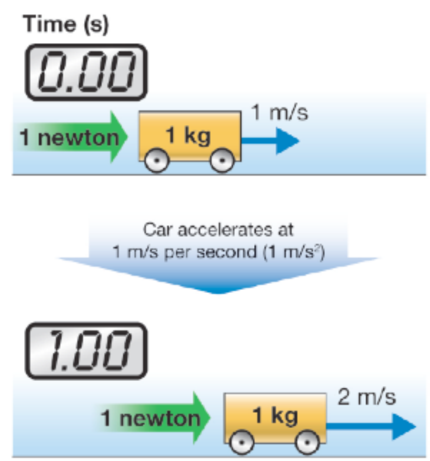


6.2 Newton's second law

- Newton's first law tells us that motion cannot change without a net force.
- According to Newton's second law, the amount of acceleration depends on both the force and the mass.

6.2 The newton

- The S.I. unit of force (newton) is defined by the second law.
- A newton is the amount of force needed to accelerate a 1 kg object by 1m/s.

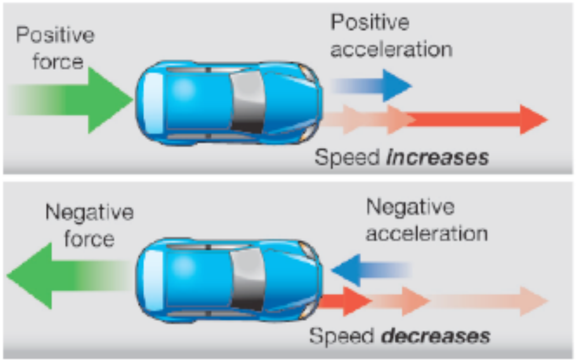


6.2 Newton's second law

- There are three main ideas related to Newton's Second Law:

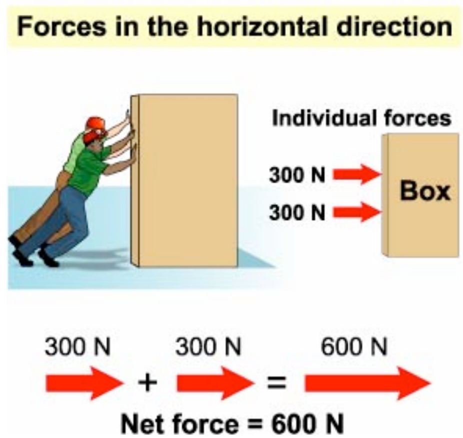
1. Acceleration is the result of unbalanced forces.
2. A larger force makes a proportionally larger acceleration.
3. Acceleration is inversely proportional to mass.

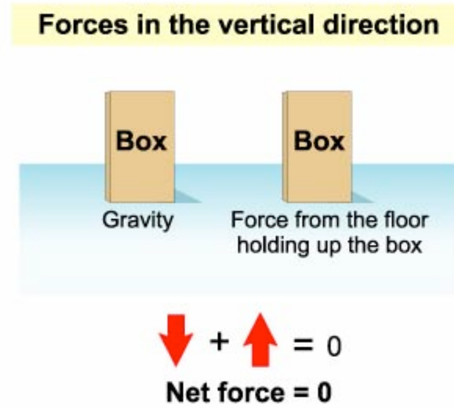
6.2 Newton's second law



- **Unbalanced forces cause changes in speed, direction, or both.**

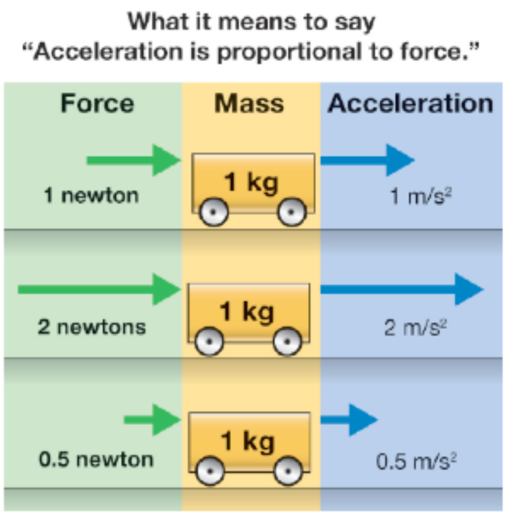
Net Force


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

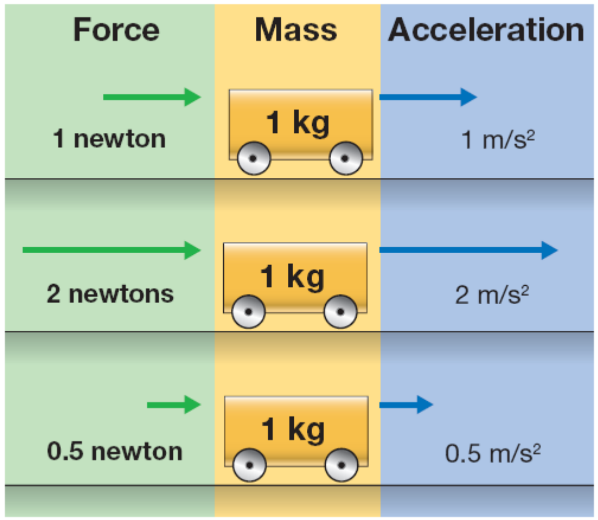
6.2 Acceleration and force

- The second law says that acceleration is proportional to force.
- If force is increased or decreased, acceleration will be increased or decreased by the same factor.



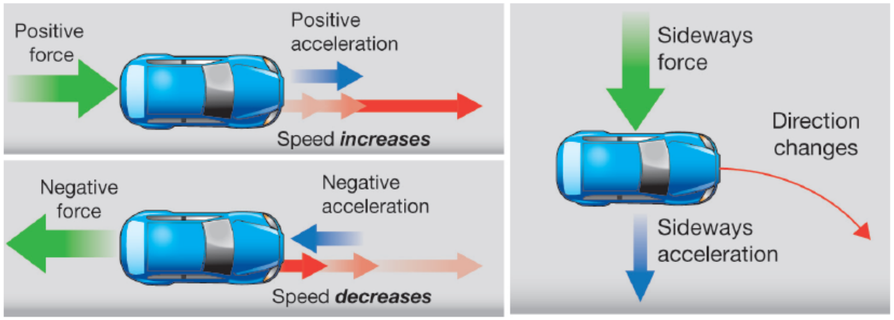
Acceleration and Force

What it means to say
"Acceleration is proportional to force."



6.2 Acceleration and direction

- Another important factor of the second law is that the acceleration is always in the same direction as the net force.



6.2 Acceleration and mass

- The greater the mass, the smaller the acceleration for a given force.
- This means acceleration is inversely proportional to mass.

The same force acting on more mass causes less acceleration.

6.2 Acceleration, force and mass

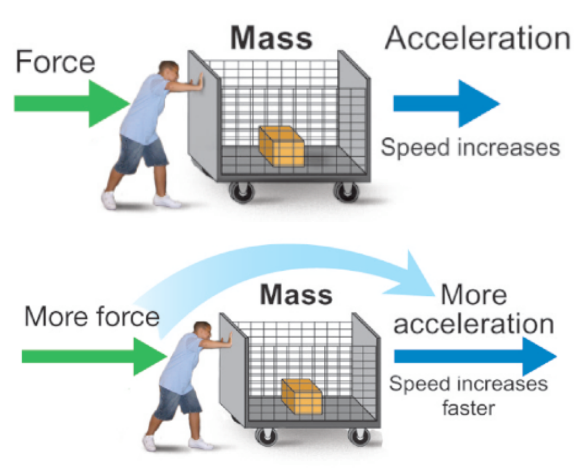
- The acceleration caused by a force is proportional to force and inversely proportional to mass.

NEWTON'S SECOND LAW

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

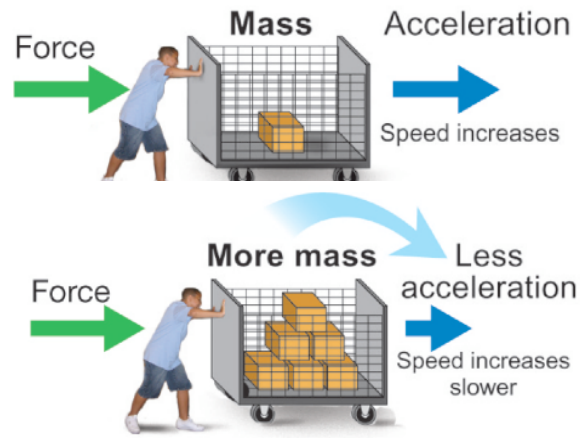
- **Acceleration** (m/s²) — a
- **Force** (N) — F
- **Mass** (kg) — m

- The <u>stronger</u> the force on an object, the <u>greater</u> its acceleration.
  - Force is directly proportional to acceleration.
  - If twice the forc is applied, the acceleration is twice as great.



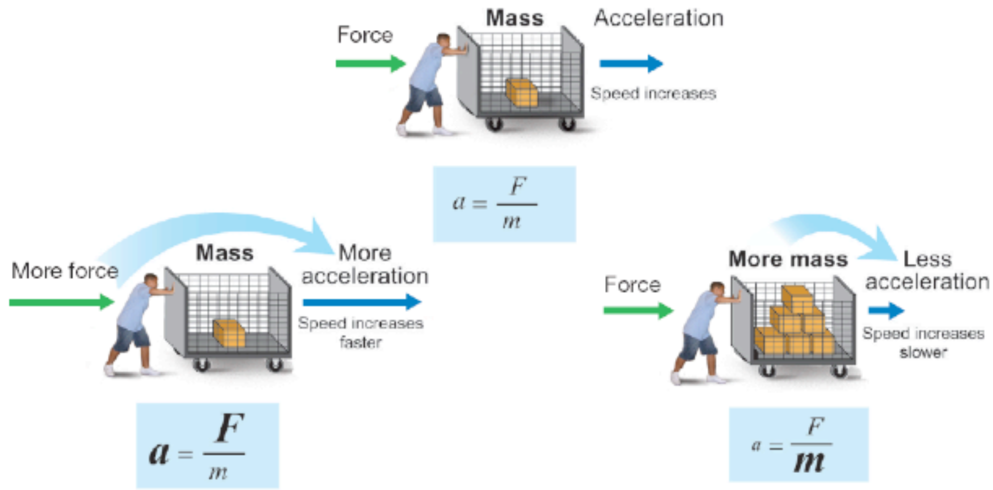
$$a = \frac{F}{m}$$

- The greater the mass, the smaller the acceleration for a given force.
  - Mass is inversely related to force.
  - An object with twice the mass will have half the acceleration if the same force is applied.



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

Force, Mass, and Acceleration



6.2 Applying the second law

Keep the following important ideas in mind:

1. The net force is what causes acceleration.
2. If there is no acceleration, the net force must be zero.
3. If there is acceleration, there must also be a net force.
4. The force unit of newtons is based on kilograms, meters, and seconds.

Use...	... if you want to find...	... and you know...
$a = \frac{F}{m}$	accel. (a)	force (F) and mass (m)
$F=ma$	force (F)	acceleration (a) and mass (m)
$m = \frac{F}{a}$	mass (m)	acceleration (a) and force (F)

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Solving Problems

A car has a mass of 1,000 kilograms. If a net force of 2,000 N is exerted on the car, what is its acceleration?

1. **Looking for:**
   - …car's acceleration
2. **Given**
   - …mass = 1,000 kg; net force = 2,000 N
3. **Relationships:**
   - a = F / m
4. **Solution:**
   - 2, 000 N ÷ 1,000 kg = 2 N/kg = 2 m/s^2