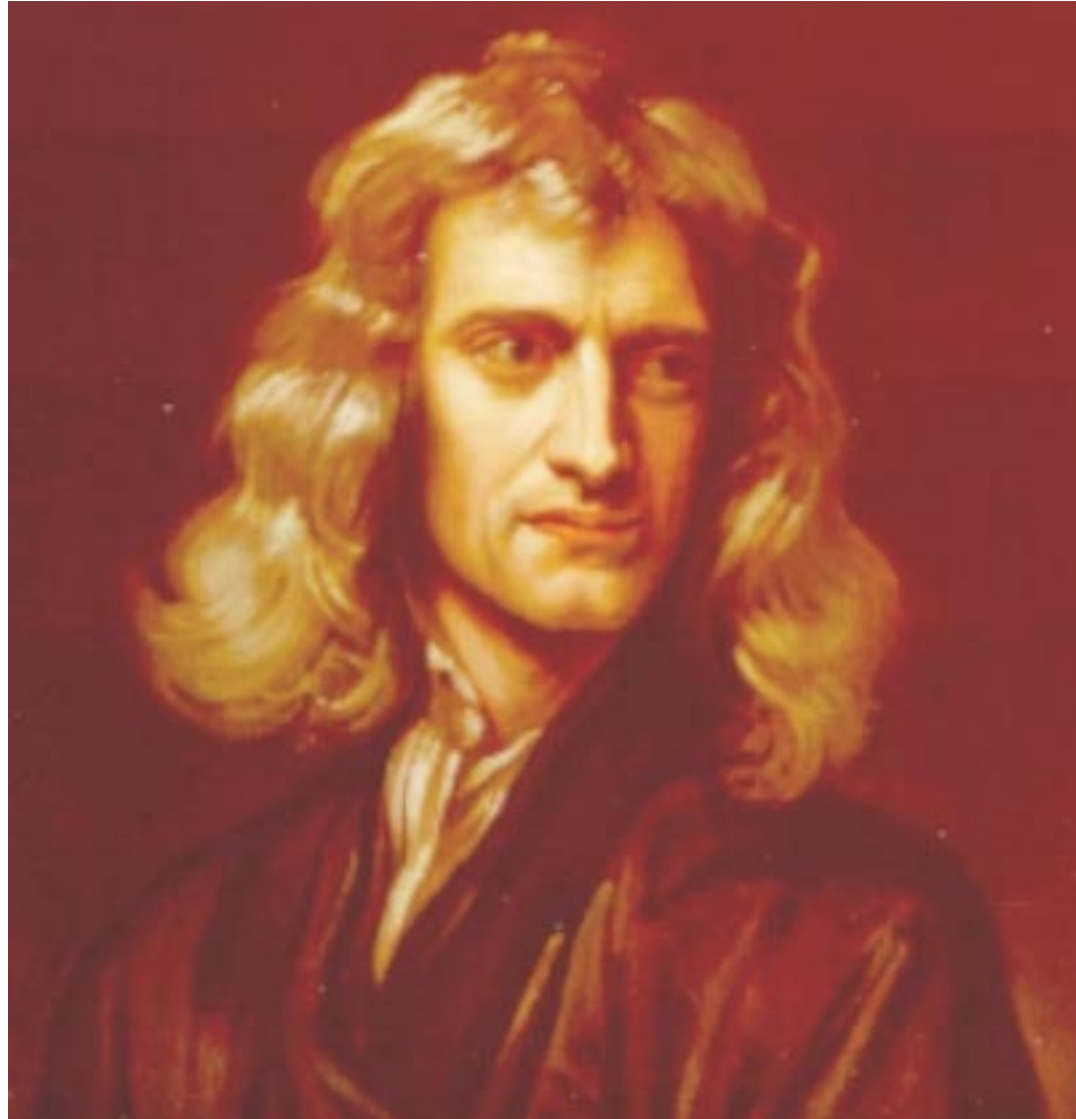


# Chapter 5: Newton's Laws of Motion



**Isaac Newton**

Some figures are from Pearson Physics by Walker. Used with permission.

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Here are a couple of links:

[Very brief life of Isaac Newton](#)

<https://www.youtube.com/watch?v=PCxP24qj2UQ>

[Very brief look at the three laws of motion](#)

[https://www.youtube.com/watch?v=JGO\\_zDWmkvk](https://www.youtube.com/watch?v=JGO_zDWmkvk)

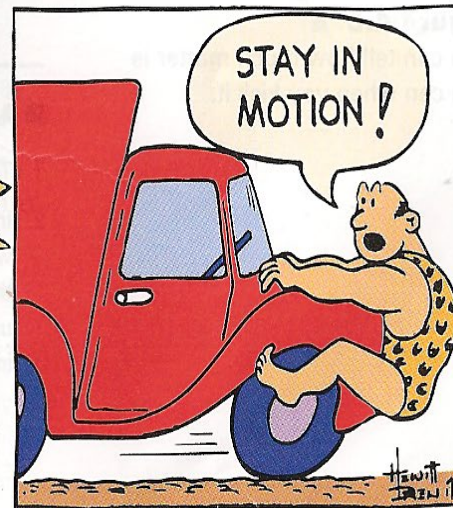
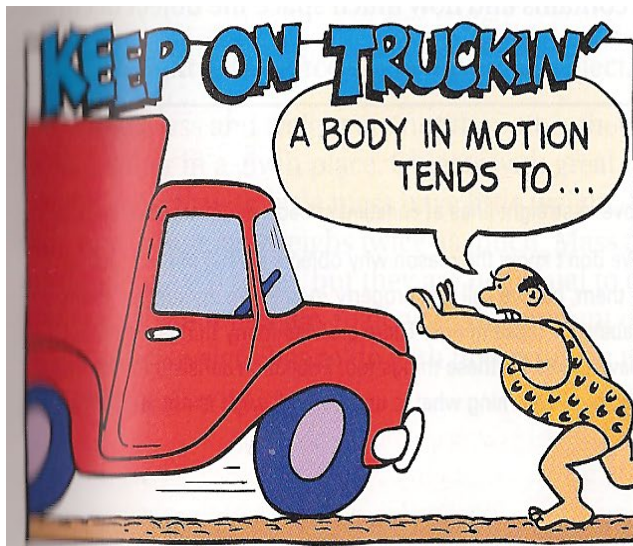
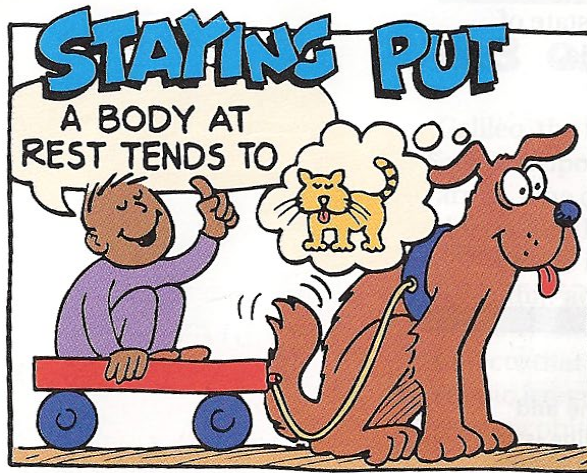
# First Law of Motion



## Inertia

An object continues in a state of rest, or of motion in a straight line at constant speed, unless it is compelled to change that state by forces exerted upon it.

If  $\Sigma F = 0$  then  $a=0$



Mass -

A Measure of the inertia of an object

Mass vs. Volume

Inertia vs Space occupied

Mass vs. Weight

Inertia vs Force of Gravity on an object

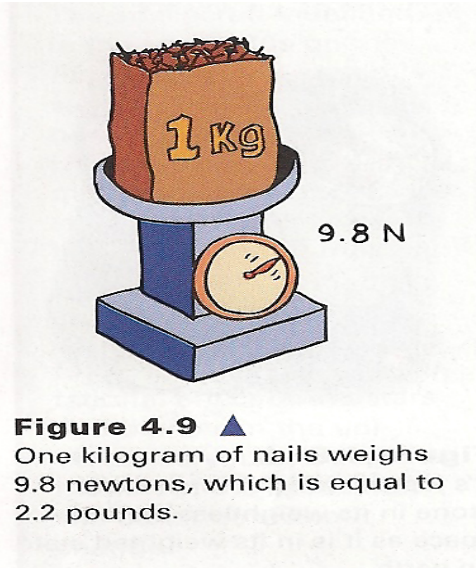
**Table 5.1 Typical Masses in Kilograms (kg)**

Earth	$5.97 \times 10^{24}$
Space shuttle	2,000,000
Blue whale (largest animal on Earth)	178,000
Whale shark (largest fish)	18,000
Elephant (largest land animal)	5400
Automobile	1200
Human (adult)	70
Gallon of milk	3.6
Quart of milk	0.9
Baseball	0.145
Honeybee	0.00015
Bacterium	$10^{-15}$

# Mass vs. Weight

## Inertia vs Force of Gravity on an object

The force of gravity is proportional to the mass but the proportionality constant is a function of location.



**Figure 4.9** ▲  
One kilogram of nails weighs 9.8 newtons, which is equal to 2.2 pounds.

In space the rock has no weight but it still has the same inertia.

## Relative Gravities

- Mercury- .378
- Venus- .907
- Earth - 1
- Mars- .377
- Jupiter- 2.364
- Saturn- .916
- Uranus- .889
- Neptune- 1.125
- Pluto (not a planet)- .067
- Moon- .166
- Sun- 27.551

1 kilogram weighs 9.8 Newtons

1 kilogram weighs 2.2 pounds

The Newton - Force (Metric System)

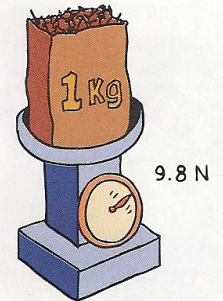
The Pound - Force (British System)

Net Force - Vector Sum

Equilibrium

Which weighs more  
a pound of lead or a pound of  
feathers?

1. Would a 2 kilogram piece of lead have
  - a. twice as much mass as a 1 kilogram piece of lead?
  - b. twice as much inertia at a 1 kilogram piece of lead?
  - c. twice as much weight as a 1 kilogram piece of lead (assuming they were weighed at the same location)
  - d. twice as much volume as a 1 kilogram piece of lead?
  
2. Compare 2 kilograms of bananas to 2 kilograms of bread
  - a. in terms of how much Mass is each has
  - b. in terms of how much inertia each has
  - c. in terms of how much volume each has
  - d. in terms of how much weight each has



**Figure 4.9 ▲**  
One kilogram of nails weighs 9.8 newtons, which is equal to 2.2 pounds.



Explain in terms of weight AND ALSO in terms of mass.



What happens when you lift the sledgehammer?

What happens when you stop lifting the sledgehammer?

What happens when you bring it down?



Questions:

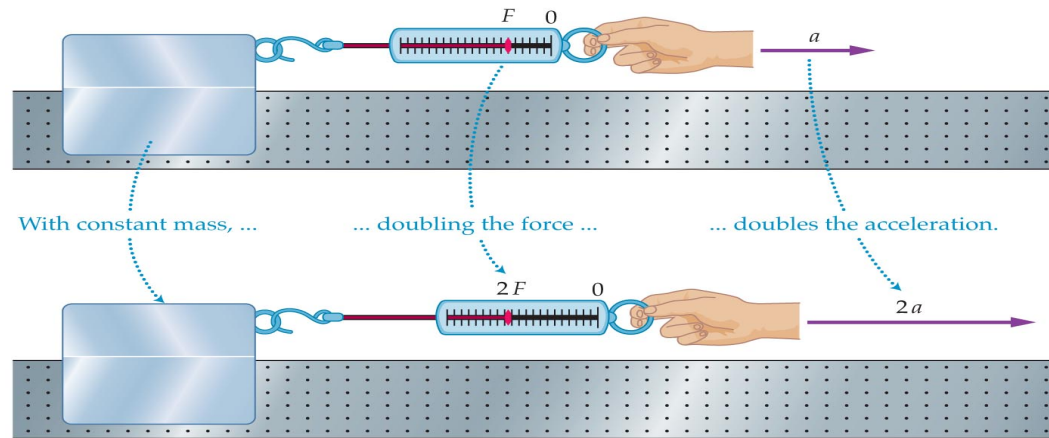
What is the effect of friction on a moving object?

The speed of a ball increases as it rolls down an incline and it decreases as it rolls up an incline. What happens to the speed if it rolls on a horizontal surface?

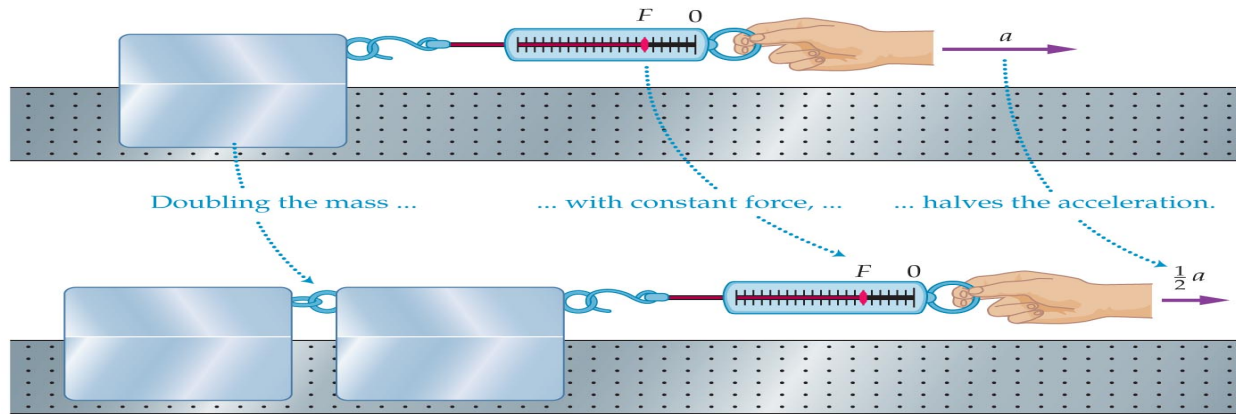
Inertia says that no force is required to maintain motion. Why, then, do you have to keep pedaling your bicycle to maintain motion?

A space probe was launched toward Jupiter. How much force is necessary to keep it moving?

A force is a push or a pull.  
Forces produce accelerations.



Mass is a measure of the inertia of an object.  
(Therefore more mass, less acceleration).



Newton's Second Law:

Net Force = mass \* acceleration

(Net force means the vector sum of all the forces)

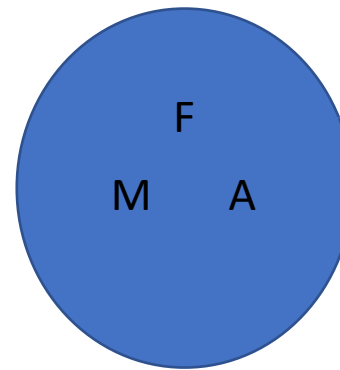
$$\Sigma F = ma$$

How much force is needed to cause a 2 kilogram mass to accelerate at 3 m/s<sup>2</sup> ?

$$\Sigma F = ma = 2 \text{ kg} * 3 \text{ m/s}^2 = 6 \text{ kg m/s}^2$$

1 kg m/s<sup>2</sup> is defined as a Newton (abbreviated N)

Therefore the answer is 6 N





A football lineman often attempts to get his body under that of his opponent and push upward. Why?

What effect does this have on the friction force between the opposing lineman's feet on the ground?

## Newton's Third Law of Motion:

For every force or action, there is an equal but opposite force or reaction.

The action and reaction act on different objects.

-----  
**Action = Reaction**  
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I stand on the ground.

The force which I exert on the ground is equal and opposite in direction to the force which the ground exerts on me.



The cannon just fired a ball.

Which of the following is true?

- a) The force the cannon exerted on the ball was larger than the force the ball exerted on the cannon.
- b) The force the ball exerted on the cannon was larger than the force the cannon exerted on the ball.
- c) The force the cannon exerted on the ball was the same size as the force the ball exerted on the cannon.



WEIGHT = force of gravity

Force = mass \* acceleration

Force of gravity = mass \* acceleration of gravity (g)

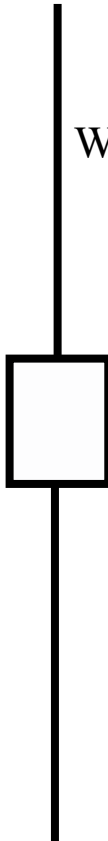
Weight = mg

What is the weight of 2 kilograms of iron?

Forces of 10 N and 4 N act in opposite directions. What is the magnitude of the resultant force?

What is the weight of a 2.5 kilogram object (in Newtons)?

In the cabin of a jetliner that cruises at 600 km/hr, a pillow drops from an overhead rack into your lap below. Since the jetliner is moving so fast, why doesn't the pillow slam into the rear of the compartment when it drops?



What is the tension here?

2 kilogram mass

2 N downward force applied here

## Summary Rules for Newtons Laws

### Rule 0:

If there is no mention of friction it is usually safe to assume that there is no friction acting in the problem. If the question mentions friction, or asks about it, you need to be more careful.

### Rule 1:

If an object is moving at constant velocity, or constant speed in a straight line, that means that the acceleration is zero and the sum of the forces acting is zero. If you know that some force is acting, then there must be another force (usually friction) which is acting in the opposite direction to make the sum of the forces equal to zero.

### Rule 2:

If an unbalanced force is acting, then it must cause an acceleration which is given by  $a=F/m$ .