

Preview of Period 5: Forces and Newton's Laws

5.1 The Fundamental Forces of Nature

What are the four fundamental forces of nature?

How do we see their effects?

5.2 Forces and Newton's Laws

What causes an object to move?

How are force, acceleration, and the mass of objects related?

What happens when one object exerts a force on another object?

5.3 The Frictional Force

What are the two types of friction?

What determines the amount of friction between objects?

When is friction useful?

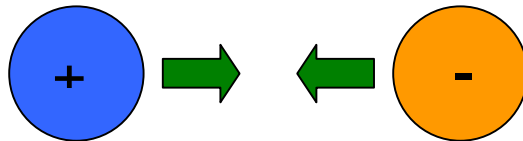
Act. 5.1: Fundamental Forces

Gravitational force - an attractive force that exists between all objects.

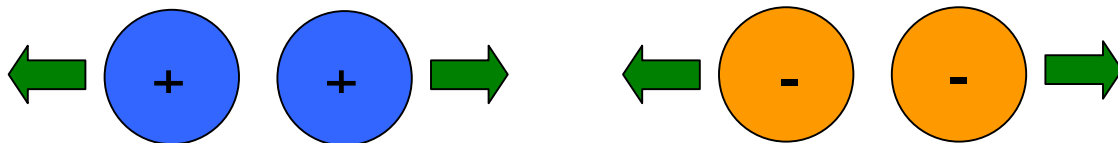
The gravitational force between the center of the Earth and objects near it causes objects to fall toward the surface of the Earth.

Electromagnetic force - holds matter together by providing the force that binds atoms into molecules.

The force between particles of opposite charge is attractive.



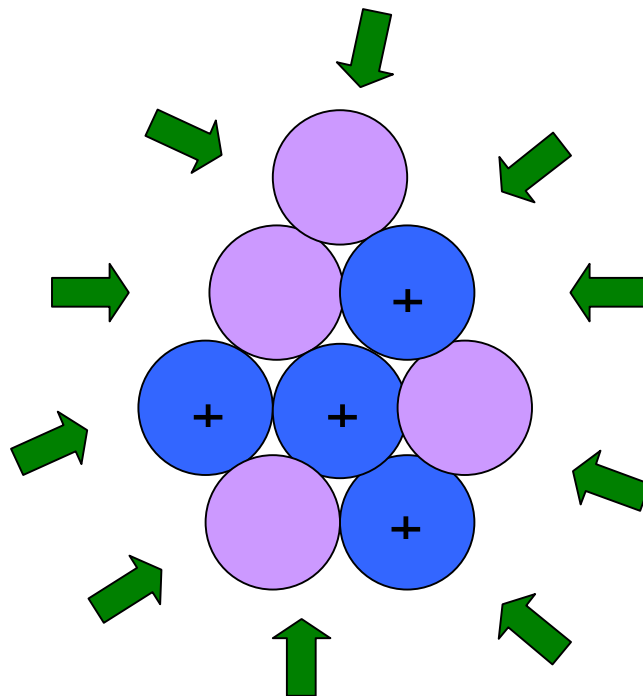
The force between particles of the same charge is repulsive.



Since like charges repel one another, how can positively charged protons exist closely packed in an atomic nucleus?

Strong nuclear force - holds protons and neutrons together in atomic nuclei.

It is the strongest force, but it acts over only very short distances inside a nucleus.



Weak nuclear force - responsible for some kinds of radioactive decay, such as the decay that creates radon gas.

It is the next to the weakest force, and acts only when particles are close together.

Act. 5.2: Forces and Newton's Laws

Newton's First Law

An object remains at rest or moves at constant speed in a straight line unless a net force acts on it.

- ◆ To make an object at rest move, a force must act on it.
- ◆ To make a moving object change speed or direction (accelerate), a force must act on it.

Newton's Second Law

If forces act on an object, and if the forces do not balance one another, the object experiences a net force and accelerates.

Force = Mass x acceleration

$$F = M a$$

F = force (in newtons)

M = mass (in kilograms)

a = acceleration (in meters/second²)

(Example)

What acceleration occurs when a net force of 10 N is applied to a 20 kg box?

$$a = \frac{F}{M} = \frac{10 \text{ kg m/s}^2}{20 \text{ kg}} = 0.5 \text{ m/s}^2$$

Newton's Third Law

If one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.

Will the cart move when the fan is turned on?

Will the cart move if the fan blows onto a sail?

Act. 5.4.: The Frictional Force

Which force is greater - **static** or **sliding** friction?

What does the amount of friction between objects depend upon?

Activity 5.4.c

1. Measure the cart's weight in newtons using the spring scale.
2. Measure the force needed to pull the wooden cart across the smooth board **at a constant velocity**.
3. The **coefficient of friction** between the cart and the smooth board

$$= \frac{\text{Force to pull cart}}{\text{Weight of cart}}$$

Friction Summary

What does the amount of friction between objects depend upon?

- The type of materials in contact
- The smoothness of their surfaces
- The amount of force that presses their surfaces together.

When is friction useful?

Why do you sprinkle sand on icy surfaces?

Period 5 Summary

5.1: All forces currently known can be classified into four fundamental forces:

The **gravitational force**, an attractive force between all objects.

The **electromagnetic force**, electric and magnetic forces that arise from charged particles.

The **strong nuclear force** that holds atomic nuclei together.

The **weak nuclear force**, responsible for some nuclear decay.

4.2: Newton's three laws describe the motion of objects.

First Law: An object remains at rest or moves at a constant speed in a straight line unless forces make it do otherwise.

Second Law: If forces act upon an object, and if they do not balance one another, the object experiences a net force and accelerates.

$$F = M a$$

Period 5 Summary, continued

Third Law: If one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.

4.3:The **frictional force** results from the electromagnetic interactions between atoms on surfaces when they rub together.

The amount of friction depends on

- ◆ the type of materials in contact,
- ◆ the smoothness of their surfaces, and
- ◆ the amount of force pressing the surfaces together.

Stationary objects experience **static friction**

Moving objects experience **sliding friction**

Static friction is greater than sliding friction.

Period 5 Review Questions

- R.1** Define the four fundamental forces. Where can we see these forces in action?
- R.2** According to Newton's first law of motion, what is the motion of an object that experiences no net force?
- R.3** What is required to make an object accelerate? What determines the amount of the acceleration?
- R.4** According to Newton's third law, if you exert a force on a table by pressing down on it with your hand, does your hand feel a force? If so, how large is the force and where does it come from?
- R.5** Although the frictional force is important, it is not one of the four fundamental forces. How does the frictional force relate to the fundamental forces?
- R.6** What determines the amount of the frictional force between two objects? What is the coefficient of friction?
- R.7** In class, you measured the force required to drag a wooden cart at constant velocity. What was the cart's acceleration? If the cart did not accelerate, why did the scale measure a force, given that $F = M a$?