The electric field: Introduction

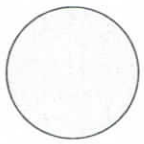
Parallel concept: The gravitational field at the Earth's surface.

Mass	force of gravity	(force of gravity)/mass
.5 kg		
1 kg		
2 kg		

As the mass increases, so does the force of gravity. However, what remains constant?

The magnitude of the Earth's gravitational field at the Earth's surface is 10 N/kg.

The Earth's gravitational field decreases as one moves further from the earth. The Earth's gravitational field decreases as $1/r^2$.
Sketch the Earth's gravitational field.



At a distance of 4000 miles from the Earth's center g = 10 N/kg.

What is g at 8000 miles from the Earth's center?

What is the force on a 5-kg object at a distance of 4000 miles from the Earth's center?

What is the force on a 5-kg object at a distance of 8000 miles from the Earth's center?

gravitational field =

$$\frac{\text{Force on test object}}{\text{Mass of test object}} = \text{N/kg}$$ symbol: g

electric field =

$$\frac{\text{Force on test object}}{\text{Charge of test object}} = \text{? (units)}$$ symbol: E

What is the force on a 2-coulomb charge where E = 100 N/C?

What is the force on a 5-μC charge where E = 3000 N/C?

Electric Field vs. Electric Force

Point A and Point B are separated by a distance of 100 meters.

Electric Field

There is a +5 C charge located at point A. There is no charge located at point B.

* If a charge were placed at point B, would there be a force on that charge? Answer: _____

* Is there an electric field at point B? Answer: _____

Let's check the strength of the electric field at point B

Electric Force

a) What would be the *electric force* of the +5 C charge on a +1 C test charge located at point B? Give magnitude and direction. (Use $\pm \mathbf{i}$.)

b) What would be the *electric force* of the +5 C charge on a +2 C test charge located at point B? Give magnitude and direction. (Use $\pm \mathbf{i}$.)

c) What would be the *electric force* of the +5 C charge on a –3 C test charge located at point B? Give magnitude and direction. (Use $\pm \mathbf{i}$.)

The Electrostatic Force: The predominant force on the atomic/molecular level

The gravitational force between two objects is given by

$$F_{grav} = G\frac{m_1 m_2}{r^2}$$

The electrostatic force between two objects is given by

$$F_{es} = k\left|\frac{q_1 q_2}{r^2}\right|$$

- Find the following:

  Mass of the electron:

  Mass of the proton:

  Charge of the electron:

  Charge of the proton:

The average distance between the electron and the proton in the hydrogen atom is known as the Bohr radius.

- Using this distance find, the gravitational force between the proton and electron.

- Using this distance find, the electrostatic force between the proton and electron.

- What force holds a solar system together?

- What force holds an atom together?

Coulomb's Law: more problems

1. Three charges are placed in a row: a –3 C charge on the left, a +2 C charge in the middle and a +6 C charge on the right. The distance separating the charges is 1×10^4 m. Calculate the net electrical force (magnitude and direction) on (a) the +6 C charge and (b) the +2 C charge.

[Label the charges **A** (left), **B** (middle) and **C** (right). Question a): To find the net force on C, find the sum of force "A on C" and force "B on C". Do we have to calculate force "A on B"?]

a)

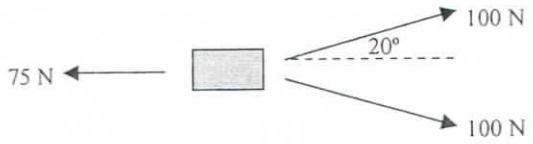
b)

6

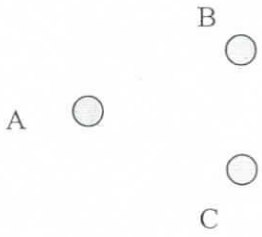
2. Four ions (Na^{+1} ,Cl^{-1} , Na^{+1} ,Cl^{-1})are in a row each separated from its neighbors by 3×10^{-10} m. Calculate the net force on the chlorine ion at the end due to the other three ions.

Forces at angles

1. Three forces are pulling on a 5-kg object as shown. a) What is the net force on the object and b) what is its acceleration?



2. Charge A (+10 μC) is located at the origin. Charges B and C (+25 μC) are located at the positions (40 cm, 30 cm) and (40 cm, –30 cm) respectively. What is the net force of charges B and C on A?



3. The same as problem **2** except that Charge B is –25 μC.