Sign up with MasteringPhysics.com using the code in the syllabus.

Two preliminary assignments are due soon.

The first graded assignment (Homework #1) due next week.
Example

If $q_3 = q_2$, what is the Net Force on $q_1$?
(direction & magnitude)

Coulomb's Law

\[ F = k \frac{|q_1||q_2|}{r^2} \]

just gives magnitudes...
What’s Inside a Proton?

Every proton and neutron is made of three charged particles called “quarks” ...which can come in two types.

Two “Up” quarks have positive charge \((q = +2/3 \, e)\)
One “Down” quarks have negative charge \((q = -1/3 \, e)\)

They repel (and attract) each other with tremendous force!
Quark Model of a Proton

\[ d = 1.0 \times 10^{-15} \text{ m} \]

\[ q_1 = -5.3 \times 10^{-20} \text{ C} \]
\[ q_2 = 1.1 \times 10^{-19} \text{ C} \]
\[ q_3 = q_2 \]
Should Protons Explode?
The electric force inside a proton is huge: 50 Newtons!

The (+) quarks would accelerate out of the nucleus in an instant! So, are protons exploding?

No. There is another, stronger, **FORCE** binding them together.

This **Strong Nuclear Force** also keeps protons inside the nucleus.

......stay tuned......
Do Force Fields Really Exist?
Do **Force Fields** Really Exist?

Yes!
A Fixed Charge

Force on the test charge will point away from $+q$...

...and get stronger the closer it is to $+q$

Now, bring in a small charge ($+q_0$), to test the force.
An Electric **Force Field** Due to a Charge

Arrows show the force a positive charge would feel there.
We define **Electric Field** \( \vec{E} \) as the Force a charge \( q_0 \) would feel, divided by \( q_0 \).

\[
\vec{E} = \frac{\vec{F}}{q_0}
\]

SI unit: N/C

\[
F = q \cdot \vec{E}
\]

So the main charge (+q) “produces an Electric field” all around it. The strength of this field a distance \( r \) from +q is:

\[
E = \frac{k \cdot q}{r^2}
\]
Electric Field ($\mathbf{E}$) is a vector that points the same direction as the force on a positive charge at that point. The $\mathbf{E}$ field varies from point to point.

$\vec{E}$ field due to a positive charge

$\vec{E}$ field due to a negative charge
The Electric **Field** can be measured at any **location**. Every charge produces an $E$ field throughout the *entire space* around it.

What if there are two or more charges?

The $E$ field is the vector sum of the $E$ fields made by each.
Electric Field Lines

Electric field lines are a convenient way of visualizing the electric field.

Electric field lines:
1. Point along the E field vector at every point
2. Tell us which way a (+) particle would move
3. Start at positive charges*
4. End at negative charges*
5. Are more dense where the field is stronger

*which may be far away
(a) $E$ field lines point away from positive charges
Figure 19-14B

(b) $E$ field lines point toward negative charges
Electric Field Lines: Two Positive Charges

Question:
If you dropped a Proton at point “X” how would it move?
One Positive Charge
One Negative Charge
(equal but opposite)

**Question:**

If you dropped an **electron** at point “X” how would it move?
Opposite but unequal charges

Charged particles move along Electric Field lines.

More charge = more field lines.
We can measure an Electric Field (E) by the force it exerts on a positive test charge (q₀): \( E = \frac{F}{q_0} \)

That field will exert a force on all charges (q):
\[
F = q \cdot E
\]
(...causing them to accelerate: \( F = ma \))

The direction of the force is along the direction of the field, but....q can be negative. Negative charges feel a force in the opposite direction as the field.

Example: The electric field in one location is: \( E = 6 \text{ N/C} \) in the positive x direction. What is the force on an electron there?
The Electric Field

**Electric Field** may be a new concept for you. Is it even *real*?

It imparts a **force** on a **charge**, so it must be real.

It can be measured at any point in space. (Units: N/C)

Everything you know about **force** can be used to understand **E** fields. (eg. forces add as vectors)
Charged Plates

Electric charge can accumulate on plates.
(e.g. pie plates)

A positively charged plate will produce an electric field like this:
Capacitor

Two charged plates, one positive and one negative, will produce a uniform electric field.

This is called a parallel plate capacitor.