Course Updates

http://www.phys.hawaii.edu/~varner/PHYS272-Spr10/physics272.html

Notes for today:

1) Review of Quiz 2
2) Assignment 5 (Mastering Physics) online and separate, written problems due Wednesday
3) Review all of Chap 21-24 for Midterm
4) Schedule for next week:
   1) Monday: holiday
   2) Wednesday: review
   3) Friday: Midterm #1

Problem 1

Roster ID: ______________________

Physics 272. Practice Midterm I
There are 4 problems. Each is assigned 25 points.
Show your work.

Problem 1: 25 points

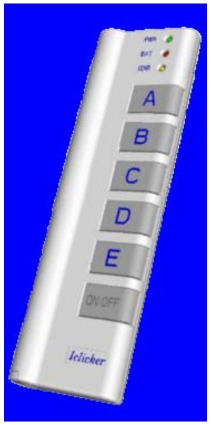
Two equal charges of 3.0 μC are on the y-axis. One is at the origin and the other is at $y = 6$ m. A third charge $q_3 = 2.0\mu$C is on the x-axis at $x = 8$ m.

Find the electric field at the location of q_3. (Hint: first draw a diagram)

Checking in?

For a point charge, if r→ 0 E= ?

A) 0
B) 49
C) Infinity
D) Sqrt(-1)
E) None of the above



Checking in?

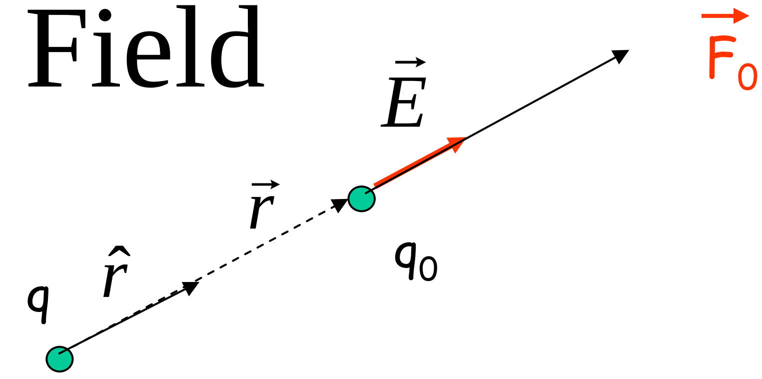
For a point charge, if $r \rightarrow 0$ E= ?

A) 0
B) 49
C) Infinity
D) Sqrt(-1)
E) None of the above

However, if try to draw the vector, it doesn't point anywhere.

This is an example of a singularity. You can think of the electric field for q_3 only being valid for locations not exactly at its location (finite for finite distance from the charge).

Electric Field



$\vec{E}$ for point charge q?

Can calculate:

$$E = \frac{F_{q_0}}{q_0} = \frac{\dfrac{|qq_0|}{4\pi\varepsilon_0 r^2}}{q_0} = \frac{|q|}{4\pi\varepsilon_0 r^2}$$

magnitude

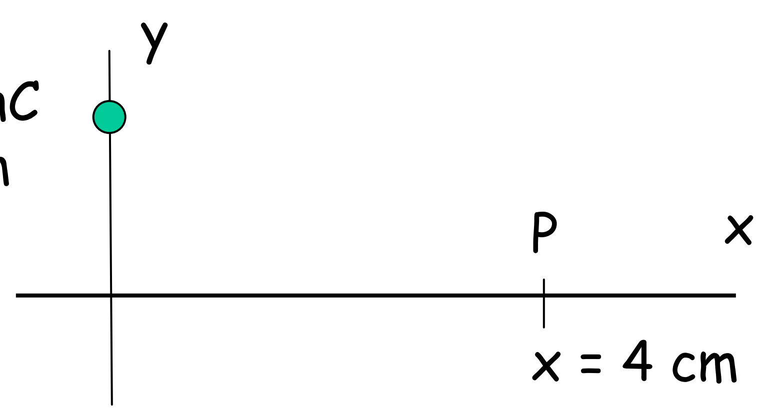
$$\vec{E} = \frac{q}{4\pi\varepsilon_0\, r^2}\hat{r}$$

magnitude and direction.

r defined from q!

Example: a.) E at P?

q_1 = 60 nC
y_1 = 3 cm



Problem 2

Problem 2: 25 points

Suppose a non-conducting sphere of radius R has a *non-uniform* charge density $\rho(r) = B/r$ inside.

(a) Draw a sketch of this sphere.

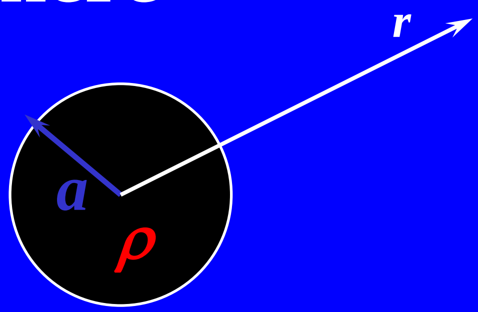
(b) Find the electric field inside the sphere. (show the Gaussian surface used on your sketch).

(c) Find the electric field outside of the sphere. (show the Gaussian surface used on your sketch).

Uniform charged sphere

- **Outside sphere: (*r* > *a*)**

$$E = \frac{\rho a^3}{3\varepsilon_0 r^2}$$



- **Inside sphere: (*r* < *a*)**
  - **We still have spherical symmetry centered on the center of the sphere of charge.**
  - **Therefore, choose Gaussian surface = sphere of radius *r***

Gauss' Law

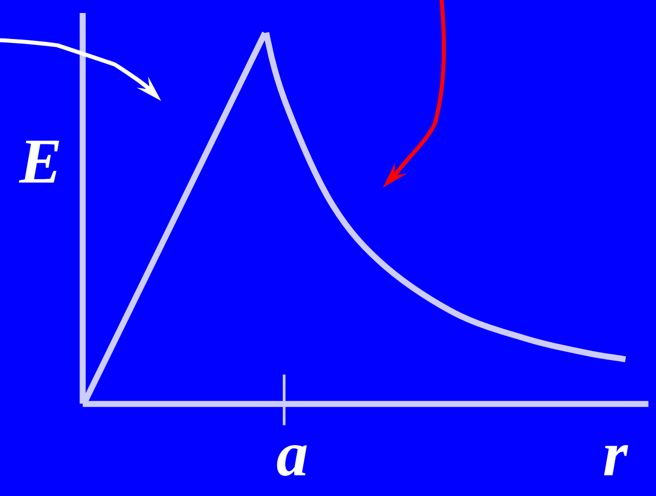
$$\oint \vec{E} \bullet d\vec{A} = 4\pi r^2 E = \frac{q}{\varepsilon_0}$$

But,

$$q = \frac{4}{3}\pi \mathrm{r}^3 \rho$$

Thus:

$$E = \frac{\rho}{3\varepsilon_0} r$$



Problem 3

Problem 3: 25 points

A ring of radius 5 cm is in the y-z plane with its center at the origin. The ring carries a uniform charge of 10 nC. A small particle of mass $m = 10$ mg and charge $q_0 = 5$ nC is placed at $x = 12$ cm and released.

(a) What is the initial potential energy of the particle ?

(b) What is the speed of the particle when it is a great distance away from the ring ?

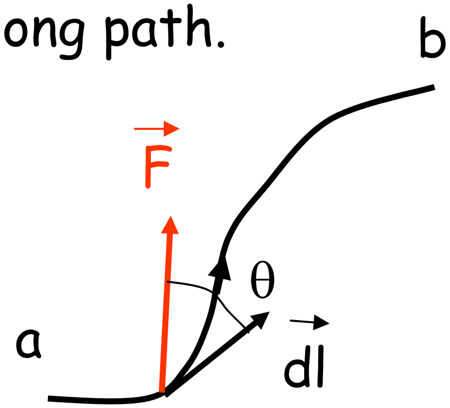
Electrical Potential

Review:

$W_{a \to b}$ = work done by force in going from a to b along path.

$$W_{a\to b} = \int_a^b \vec{F} \bullet d\vec{l} = \int_a^b q\vec{E} \bullet d\vec{l}$$

$$\Delta U = U_b - U_a = -W_{a\to b} = -\int_a^b q\vec{E} \bullet d\vec{l}$$



U = potential energy

$$\Delta V = V_b - V_a = \frac{\Delta U}{q} = \frac{U_b - U_a}{q} = -\frac{W_{a\to b}}{q} = -\int_a^b \vec{E} \bullet d\vec{l}$$

- Potential difference is the negative of the work done per unit charge by the electric field as the charge moves from a to b.
- Only changes in V are important; can choose zero at any point.

  Let $V_a = 0$ at a = infinity and $V_b \to V$, then:

$$V = -\int_\infty^r \vec{E} \bullet d\vec{l}$$

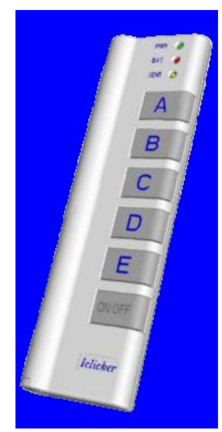
V = electric potential

Problem 4a

Problem 4: 25 points

(a) [**5 pts**] If the charge on an isolated spherical conductor is doubled, its capacitance *quadrupules, doubles, drops by half, remains the same.* ? Explain.

A) quadruples
B) doubles
C) Drops by half
D) Remains the same



Problem 4a

Problem 4: 25 points

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B) doubles
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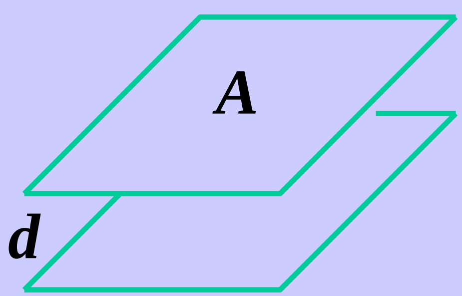
None of the expressions for capacitance depends on charge. Capacitance only depends upon geometry (and possibly a dielectric)

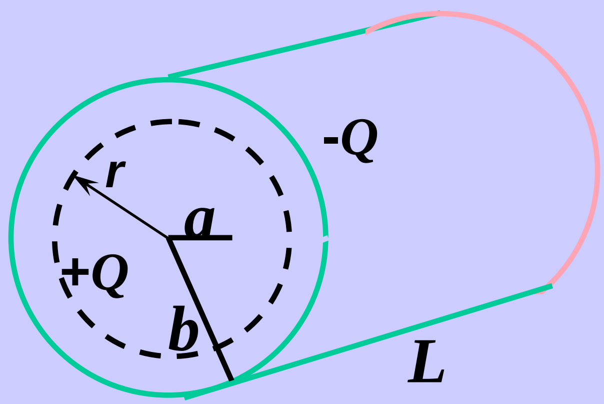
Capacitor Summary

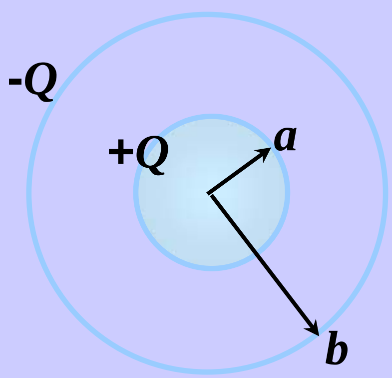
- A Capacitor is an object with two spatially separated conducting surfaces.
- The definition of the capacitance of such an object is:

$$\boxed{C \equiv \frac{Q}{V}}$$

- The capacitance depends on the geometry :







Parallel Plates

$$C = \frac{A\varepsilon_0}{d}$$

Cylindrical

$$C = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{b}{a}\right)}$$

Spherical

$$C = \frac{4\pi\varepsilon_0 ab}{b-a}$$

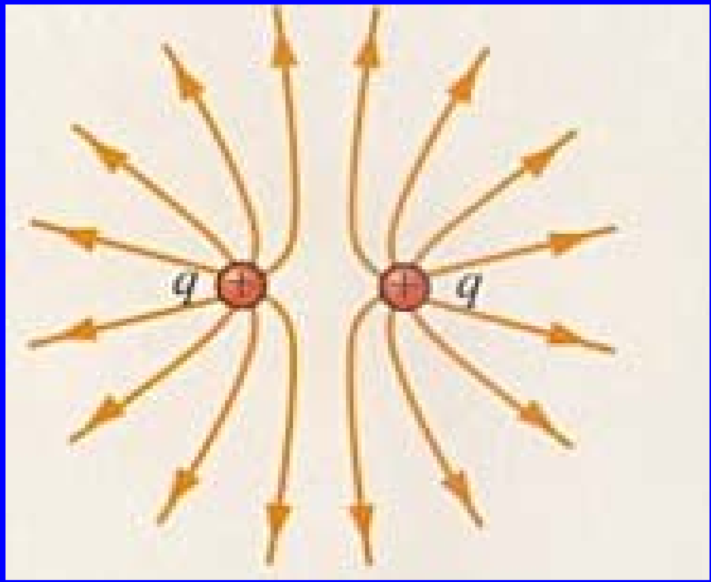
Problem 4b

(b) [**5 pts**] Two charges of the same magnitude and sign are placed a certain distance apart. At what points in space is the electric field zero (draw a sketch) ?

Field Lines From Two Like Charges

- There is a zero halfway between the two charges

- $r >> a$: looks like the field of point charge ($+2q$) at origin



Problem 4c

(c) [**10 pts**] One electron is accelerated through a potential difference of 10 kV. Another electron is accelerated through a potential difference of 40 kV. What is the ratio of the final velocities of the two electrons ?

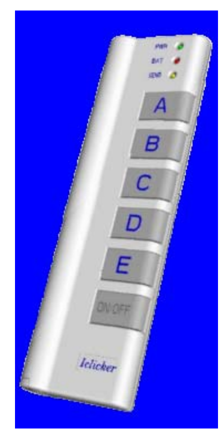
Conservation of Energy of a particle from Phys 170

- Kinetic Energy (K) $K = \frac{1}{2} m v^2$
  - non-relativistic
- Potential Energy (U) $U(x, y, z)$
  - determined by force law
- for Conservative Forces: K+U is constant
  - total energy is always constant
- examples of conservative forces
  - gravity; gravitational potential energy
  - springs; coiled spring energy (Hooke's Law): $U(x) = \frac{1}{2} k x^2$
  - electric; electric potential energy (today!)
- examples of non-conservative forces (heat)
  - friction
  - viscous damping (terminal velocity)

Problem 4d

(d) [**5 pts**] The electrostatic potential is measured to be $V(x, y, z) = 4|x| + V_0$. The charge distribution responsible for this potential is a *a point charge at the origin, a uniformly charged thread in the x-y plane, a uniformly charged sheet in the y-z plane, a uniformly charged sphere of radius* $1/\pi$ *at the origin* (pick one).

A) A point charge at Origin
B) Uniformly charged thread in x-y plane
C) Uniformly charged sheet in y-z plane
D) Uniformly charged sphere of rad 1/pi at Origin



Problem 4d

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A) A point charge at Origin
B) Uniformly charged thread in x-y plane
C) Uniformly charged sheet in y-z plane
D) Uniformly charged sphere of rad 1/pi at Origin

Take the gradient of the potential to get the expression for the Electric Field in this case. In this case it is a constant, which is as seen in the next slide. (point charge/sphere for points outside ~ $1/r^2$, line charge ~ $1/r$)

Gauss' Law: Help for the Homework Problems

Midterm

- Gauss' Law is ALWAYS VALID!

$$\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = q_{enclosed}$$

- What Can You Do With This?

  If you have (a) spherical, (b) cylindrical, or (c) planar symmetry AND:

  - If you know the charge (RHS), you can calculate the electric field (LHS)
  - If you know the field (LHS, usually because E=0 inside conductor), you can calculate the charge (RHS).

- Spherical Symmetry: Gaussian surface = sphere of radius r

  LHS: $\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = 4\pi\varepsilon_0 r^2 E$

  RHS: q = ALL charge inside radius r

  $$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$$

- Cylindrical symmetry: Gaussian surface = cylinder of radius r

  LHS: $\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = \varepsilon_0 2\pi r L E$

  RHS: q = ALL charge inside radius r, length L

  $$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

- Planar Symmetry: Gaussian surface = cylinder of area A

  LHS: $\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = \varepsilon_0 2AE$

  RHS: q = ALL charge inside cylinder $=\sigma A$

  $$E = \frac{\sigma}{2\varepsilon_0}$$

Reminder for Midterm

- Closed book, closed notes
- One 3” x 5” note card, calculator
- Office Hours usually after this class (9:30 – 10:00) in WAT214 – today (1-1:30pm)
- Will start <= 8:30am – find a seat, be ready