PHY 2049: Physics II

- Coulomb’s law, electric field, Gauss’ theorem and electric potential.
  \[ F = \frac{\partial U}{\partial x} \quad U = qV \]
- \[-W = q\Delta V\]
- Energy conservation applies.

\[ E = -\frac{\partial V}{\partial x} \]

PHY 2049: Class Quiz

If 500 J of work are required to carry a charged particle between two points with a potential difference of 20 V, the magnitude of the charge on the particle is:

A. 0.040 C
B. 12.5 C
C. 20 C
D. cannot be computed unless the path is given
E. none of these

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Calculate the Electric Field at P
Calculate the el. potential at P

\[ E_x = \frac{2kq}{d^2} \left( 1 - \frac{1}{2\sqrt{2}} \right) \]
\[ E_y = \frac{2kq}{d^2} \left( \frac{3}{2\sqrt{2}} \right) \]
\[ V = -\frac{4kq}{d} \]

What is the potential at the center point (in units of kq/d)?

a) -7 (b) -5 (c) -7 (d) -7

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- Point charge
  \[ V = \frac{kq}{r} \]
- Distribution of charges
  \[ = k \sum \frac{q_i}{r_i} \]
- Line charge at an edge
  \[ = k \lambda \ln \left( \frac{l + \sqrt{l^2 + d^2}}{d} \right) \]
- Disc on an axis through the center
  \[ = \frac{\sigma}{2\varepsilon_0} \left( \sqrt{\xi^2 + R^2} - \xi \right) \]

Some old business:
What is the electric field of a shell of a uniform spherical charge distribution?
What is the potential for each of the above?
Two particles with charges $Q$ and $-Q$ are fixed at the vertices of an equilateral triangle with sides of length $a$. The work required to move a particle with charge $q$ from the other vertex to the center of the line joining the fixed particles is:

- **A.** $0$
- **B.** $kQq/a$
- **C.** $kQq/a^2$
- **D.** $2kQq/a$
- **E.** $1.4kQq/a$

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\[ \Delta V = Ed = \frac{\sigma}{\varepsilon_0} d \]
\[ C = \varepsilon_0 \frac{A}{d} \]

Potential near a sheet charge

\[ V(z) = -\int E \, dz + \text{Const} \]
\[ = V_0 - \frac{\sigma}{\varepsilon_0} z \]
\[ V_a - V_b = \frac{Q}{\varepsilon_0 A} d \]
\[ C = \varepsilon_0 A \frac{d}{d} \]

\[ E(r) = -\frac{\lambda}{2\pi\varepsilon_0 r} \]
\[ V(r) = -\int E \, dr = -\frac{\lambda}{2\pi\varepsilon_0} \ln r \]
\[ V_a - V_b = \frac{Q}{2\pi\varepsilon_0 h} \ln \frac{b}{a} \]
\[ C = 2\pi\varepsilon_0 h \ln \left( \frac{b}{a} \right) \]
HITT

- A uniform electric field, with a magnitude of 600 N/C, is directed parallel to the positive x-axis. If the potential at \( x = 3.0 \) m is 1000 V, what is the potential at \( x = 1.0 \) m?

a. 400 V  
b. 1600 V  
c. 2200 V  
d. 2500 V

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- What is the capacitance of various familiar balls.
  
  \[ C = 4\pi\varepsilon_0 R = 10^{-10} \, \text{R(m)} \, \text{F} \]
  
  - Basketball—it is an insulator
  - Van de Graff top
  - Earth (radius 6.4 X 10^6 m)
    - \( C_E = 0.71 \, \text{mF} \)

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- Energy stored in a capacitor
  
  \[ U = \frac{1}{2} CV^2 = \frac{Q^2}{2C} = \frac{1}{2} QV \]

- Dielectric Strength (oops I burned it/broke it)

- Capacitor Enhancement by inserting a dielectric:
  
  - Replace \( \varepsilon_0 \) by \( \kappa \varepsilon_0 \)

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- \( C_{eq} = C_1 + C_2 + C_3 \)

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- \( \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \)
Charging and discharging of capacitors.

http://edugen.wiley.com/edugen/instructor/main.uni

Switch closed on left, capacitor $C_1$ is being charged:

$$Q = CV = 10 \times 10 \times 10 = 100 \mu C$$

We have $C_2 = C_3 = 20 \mu F$ in parallel.

The equivalent capacitor is then $C_{eq} = 40 \mu F$.

When the switch is thrown to right, the battery is disconnected, the charge is shared between the capacitors $C_1$ and $C_{eq} = 40$. What is the charge on old $C_2$ and $C_3$? Is your answer $40 \mu C$? What is your answer if $C_2 = 10 \mu F$ and $C_3 = 30 \mu F$?

All about capacitors
- Capacitance units Farad
- $C = 4 \pi \varepsilon_0 R$ for a sphere of radius $R$ and dielectric constant $\kappa$.
- Energy stored dielectrics and strength
- Parallel and series elements in a network