PHY132 Introduction to Physics II
Class 12 – **Outline:**

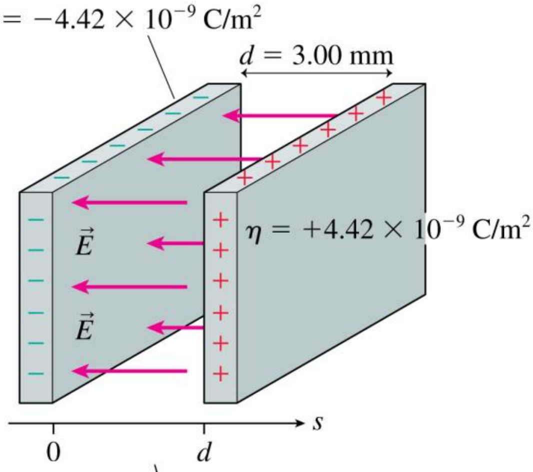
- Electric Potential of:
  - Parallel Plate Capacitor
  - Point Charge
  - Many Charges

Last time I asked you to consider…

- A battery is designed to supply a steady amount of which of the following quantities?
  - Energy
  - Power
  - Electric potential difference
  - Electric current

The Electric Field Inside a Parallel-Plate Capacitor

This is a review of Chapter 26.



$$\vec{E} = \left(\frac{\eta}{\epsilon_0}, \text{ from positive toward negative}\right)$$

$$= (500 \text{ N/C, from right to left})$$

The Electric Potential Inside a Parallel-Plate Capacitor

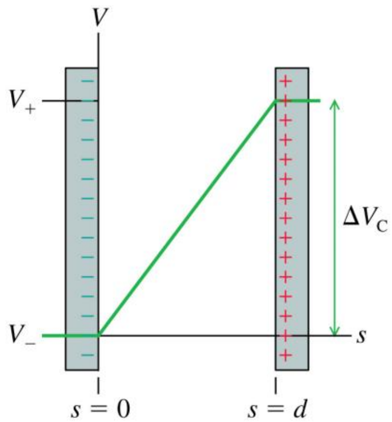
- The electric potential inside a parallel-plate capacitor is

$V = Es$ (electric potential inside a parallel-plate capacitor)

where s **is the distance from the *negative* electrode.**

- The *potential difference* ΔV_C, or "voltage" between the two capacitor plates is

$$\Delta V_C = V_+ - V_- = Ed$$



Units of Electric Field

- If we know a capacitor's voltage ΔV and the distance between the plates d, then the electric field strength within the capacitor is:

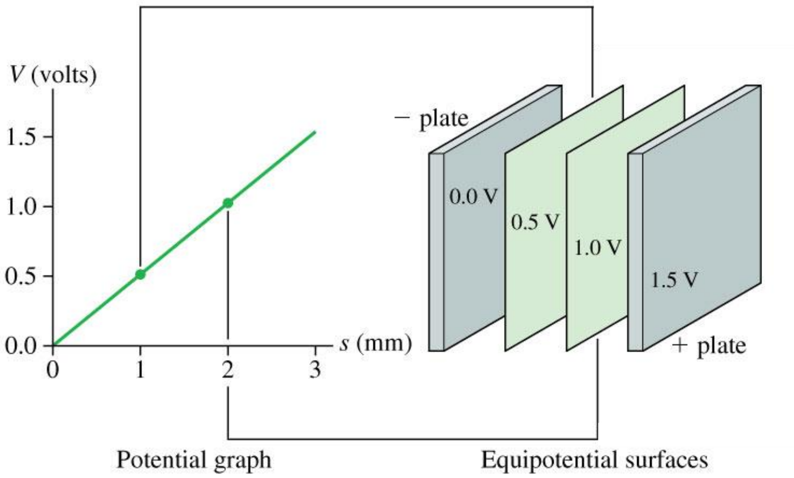
$$E = \frac{\Delta V_{\mathrm{C}}}{d}$$

- This implies that the units of electric field are volts per meter, or $\mathrm{V/m}$.
- Previously, we have been using electric field units of newtons per coulomb.
- In fact, as you can show as a homework problem, these units are equivalent to each other:

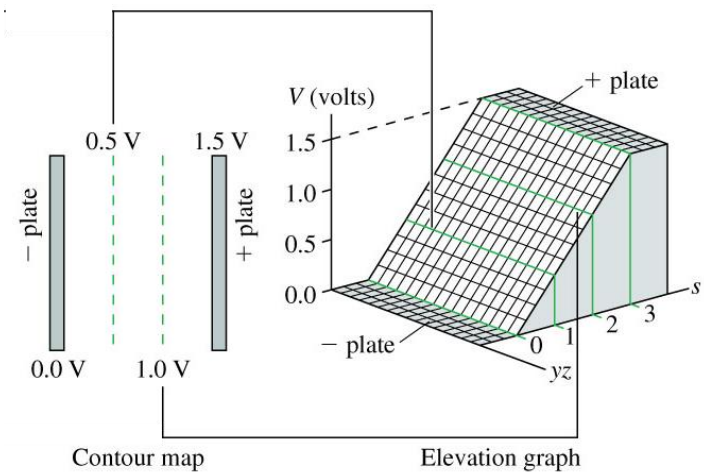
$$1\ \mathrm{N/C} = 1\ \mathrm{V/m}$$

Electric Potential = Electric Potential Energy per charge

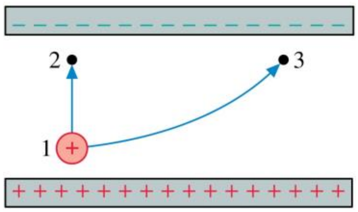
The Electric Potential Inside a Parallel-Plate Capacitor



The Electric Potential Inside a Parallel-Plate Capacitor



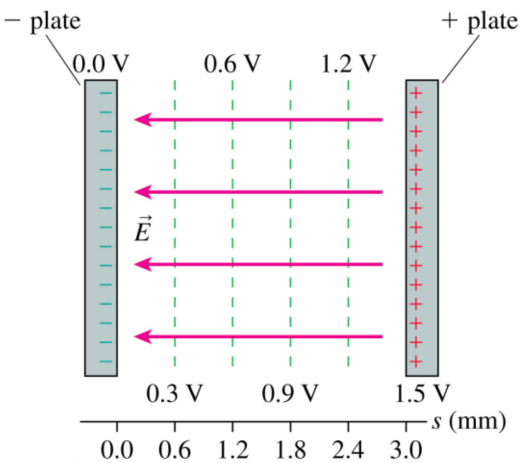
Two protons, one after the other, are launched from point 1 with the same speed. They follow the two trajectories shown. The protons' speeds at points 2 and 3 are related by



A. $v_2 > v_3$.
B. $v_2 = v_3$.
C. $v_2 < v_3$.
D. Not enough information to compare their speeds.

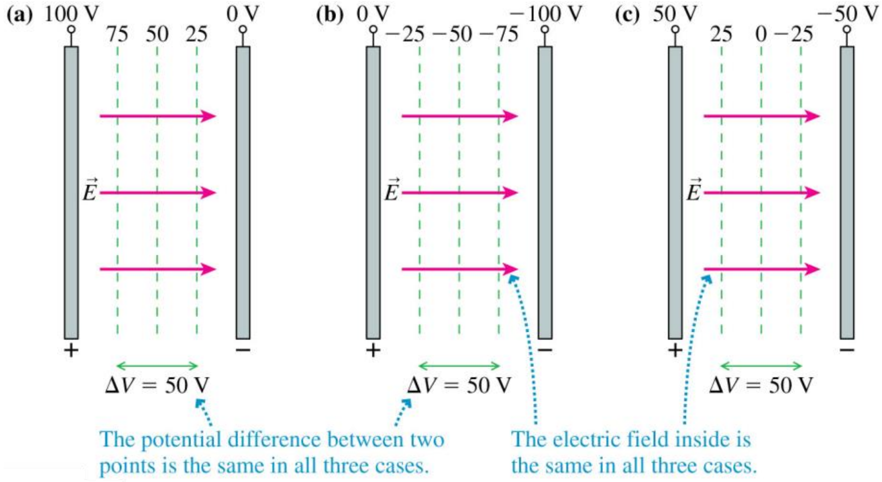
The Parallel-Plate Capacitor

- The figure shows the contour lines of the electric potential and the electric field vectors inside a parallel-plate capacitor.
- The electric field vectors are *perpendicular* to the equipotential surfaces.
- The electric field points in the direction of *decreasing* potential.



The Zero Point of Electric Potential

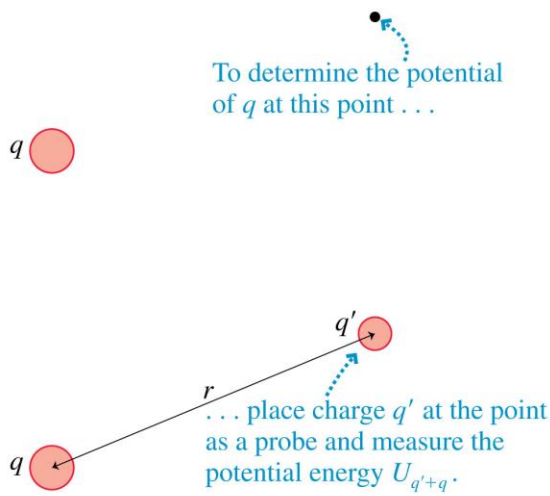
Where you choose $V = 0$ is arbitrary. The three contour maps below represent the *same physical situation*.



The Electric Potential of a Point Charge

- Let q in the figure be the source charge, and let a second charge q', a distance r away, probe the electric potential of q.
- The potential energy of the two point charges is

$$U_{q'+q} = \frac{1}{4\pi\epsilon_0}\frac{qq'}{r}$$



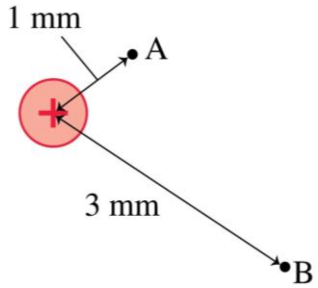
The Electric Potential of a Point Charge

- The electric potential due to a point charge q is

$$V = \frac{U_{q'+q}}{q'} = \frac{1}{4\pi\epsilon_0}\frac{q}{r} \qquad \text{(electric potential of a point charge)}$$

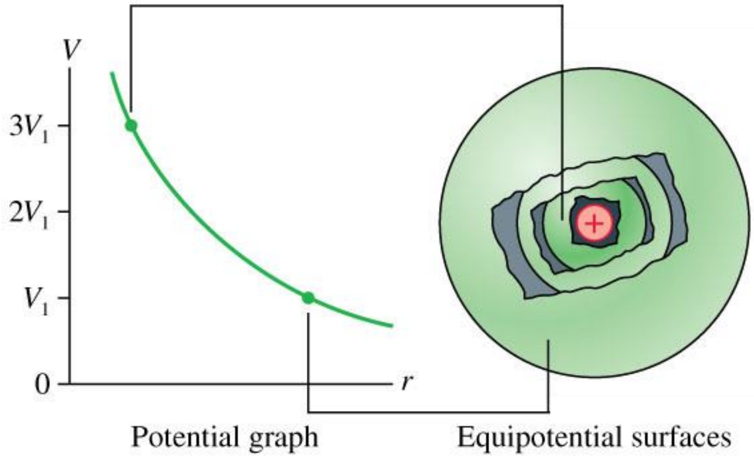
- The potential extends through all of space, showing the influence of charge q, but it weakens with distance as $1/r$.
- This expression for V assumes that we have chosen $V = 0$ to be at $r = \infty$.

What is the ratio V_B/V_A of the electric potentials at the two points?



A. 9.
B. 3.
C. 1/3.
D. 1/9.
E. Undefined without knowing the charge.

The Electric Potential of a Point Charge



Quick Equations Quiz.. [1/4]
Which is which?

The magnitude of the **force**, in Newtons, on a point charge that is near another point charge is:

A. $K\dfrac{q}{r}$

C. $K\dfrac{q_1 q_2}{r}$

B. $K\dfrac{q}{r^2}$

D. $K\dfrac{q_1 q_2}{r^2}$

$$K = \frac{1}{4\pi\varepsilon_0}$$

Quick Equations Quiz.. [2/4]
Which is which?

The magnitude of the **Electric Field**, in Newtons per Coulomb, near a point charge is:

A. $K\dfrac{q}{r}$

C. $K\dfrac{q_1 q_2}{r}$

B. $K\dfrac{q}{r^2}$

D. $K\dfrac{q_1 q_2}{r^2}$

$$\boxed{K = \frac{1}{4\pi\varepsilon_0}}$$

Quick Equations Quiz.. [3/4]
Which is which?

The **electric potential energy**, in Joules, of two point charges is:

A. $K\dfrac{q}{r}$

C. $K\dfrac{q_1 q_2}{r}$

B. $K\dfrac{q}{r^2}$

D. $K\dfrac{q_1 q_2}{r^2}$

$$\boxed{K = \frac{1}{4\pi\varepsilon_0}}$$

Quick Equations Quiz.. [4/4]
Which is which?

The **electric potential**, in Volts, near a point charge is:

A. $K\dfrac{q}{r}$

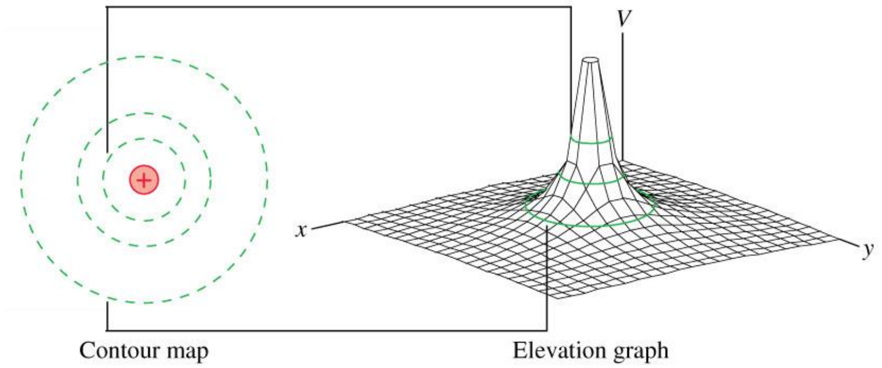
C. $K\dfrac{q_1 q_2}{r}$

B. $K\dfrac{q}{r^2}$

D. $K\dfrac{q_1 q_2}{r^2}$

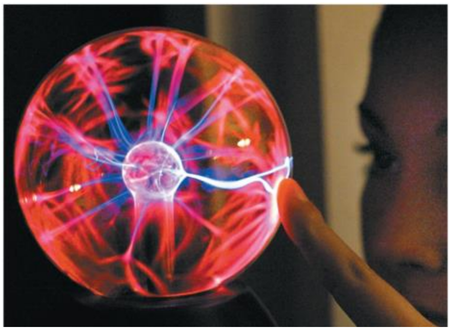
$$K = \frac{1}{4\pi\varepsilon_0}$$

The Electric Potential of a Point Charge



The Electric Potential of a Charged Sphere

Outside a uniformly charged sphere of radius R, the electric potential is identical to that of a point charge Q at the center.

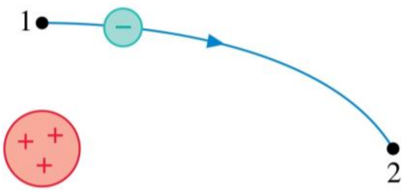


$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$

where $r > R$.
If the potential at the surface V_0 is known, then the potential at $r > R$ is:

$$V = \frac{R}{r}V_0$$

An electron follows the trajectory shown from point 1 to point 2. At point 2,



A. $v_2 > v_1$.

B. $v_2 = v_1$.

C. $v_2 < v_1$.

D. Not enough information to compare the speeds at these points.

The Electric Potential of Many Charges

- The electric potential V at a point in space is the sum of the potentials due to each charge:

$$V = \sum_i \frac{1}{4\pi\epsilon_0} \frac{q_i}{r_i}$$

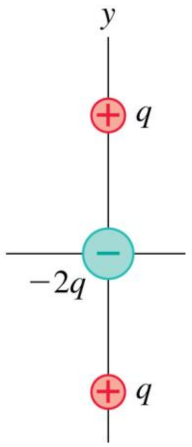
  where r_i is the distance from charge q_i to the point in space where the potential is being calculated.

- **The electric potential, like the electric field, obeys the principle of superposition.**

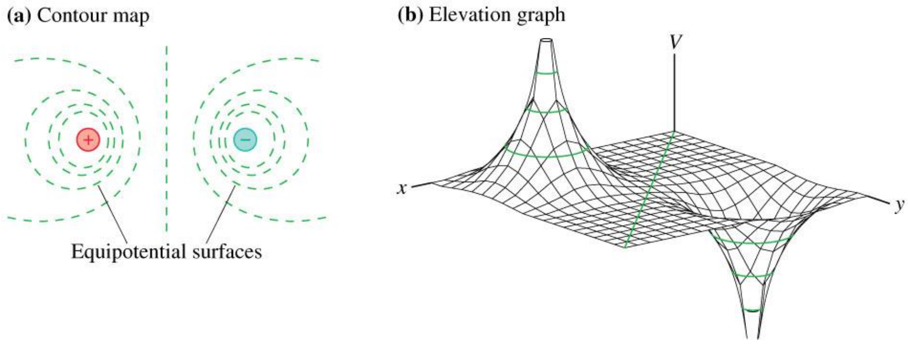
Problem 28.66

The arrangement of charges shown is called a linear electric quadrupole. The positive charges are located at $y = \pm s$.

Find an expression for the electric potential on the y-axis at a distance $y >> s$.

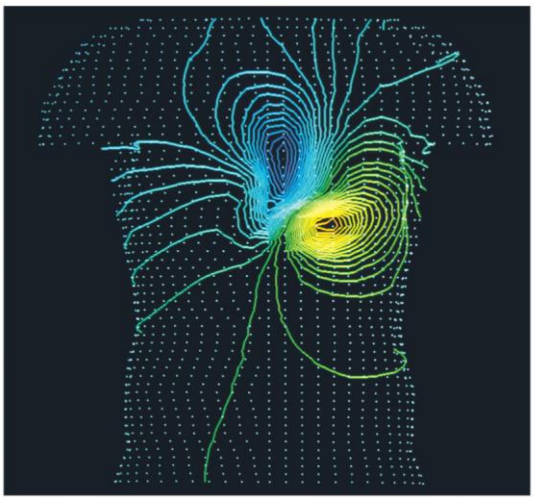


The Electric Potential of an Electric Dipole



The Electric Potential of a Human Heart

- Electrical activity within the body can be monitored by measuring equipotential lines on the skin.
- The equipotentials near the heart are a slightly distorted but recognizable *electric dipole.*



At the midpoint between these two equal but opposite charges,

A. $\vec{E} = \vec{0}$; $V = 0$.

B. $\vec{E} = \vec{0}$; $V > 0$.

C. $\vec{E} = \vec{0}$; $V < 0$.

D. $\vec{E}$ points right; $V = 0$.

E. $\vec{E}$ points left; $V = 0$.

At which point or points is the electric potential zero?

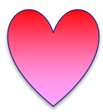
A. B. C. D.

E. More than one of these.

The next test…

- Term Test 2 is in 4 weeks:
- Tuesday, Mar. 10 6:10pm in room TBA
- This will cover Chapters 25, 26, 28, 29 and conceptual questions (clicker-style questions) from Chapter 30
- Remember the second half of chapter 23 on lenses will not be tested on the midterm or final exam.

Have a great Reading Week!!



- Happy Valentine’s Day tomorrow!
- Sorry, no office hours for me next week.
- When you get back on Feb. 23, Professor Meyertholen will start where I am leaving off: Chapter 29, connecting Electric Potential with Electric Field.
- I hope you enjoy the rest of your semester, and please keep coming to see me in office hours; you are my students until the final exam is done!
- And even after you are no longer my students, please stay in touch and drop by whenever you like!
- Best wishes and see you around!