September 11/12th

Chapter 25

Electric Potential

Review

- Electric Potential Energy, *U*
  - *W* is the work done by the electic field

$$\Delta U = -W$$

- Electric Potential, *V*

$$\Delta V = \frac{\Delta U}{q} = -\frac{W}{q}$$

Review – Potential

$$\Delta V = -\int_i^f \vec{E} \bullet d\vec{s}$$

- Potential of point charge
- Sign of *V* is same sign as *q*
  - + charge produces + *V*
  - \- charge produces – *V*

$$V = k\frac{q}{r}$$

Electric Potential

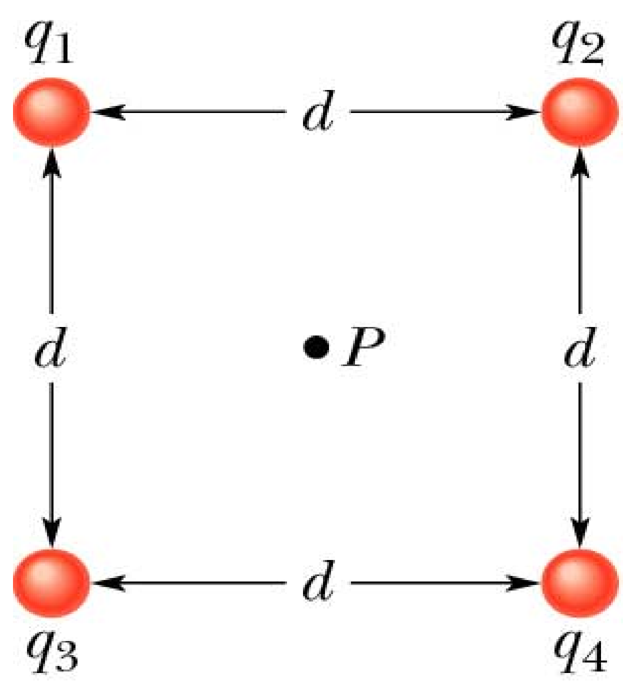
- Use superposition principle to find the potential due to n point charges

$$V = \sum_{i=1}^{n} V_i = k \sum_{i=1}^{n} \frac{q_i}{r_i}$$

- This is an algebraic sum, not a vector sum
- Include the sign of the charge

Potential Due to Group of Point Charges

- What is *V* at point P if distance *d* is 1m and the charges are:
  - Q1=+10 C
  - Q2=-20 C
  - Q3=+5 C
  - Q4=+10 C



Work

- Work done by electric field, *W*

$$\Delta U = -W = -\Delta V q$$

- Work done by you, W_{app}

$$W_{app} = -W = \Delta V q$$

Potential Energy

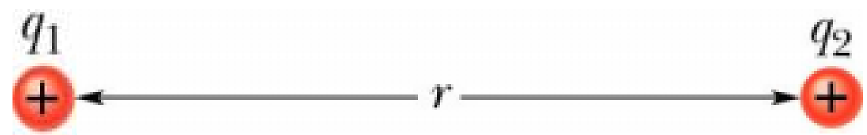
- Total electric potential energy, U, of a system of charges is obtained from the work done by an external F, (W_{app}) to assemble the system, bringing each charge in from ∞. In terms of work done by the field, $W_{app} = -W$.

- Bring q_1 from ∞, $W_{app} = 0$ since no electric F yet

Potential Energy (Fig. 25-16)

- Potential due to q_1 is

$$V = k\frac{q_1}{r}$$



- Bring q_2 in from infinity. From definition of potential energy

$$U = W_{app} = q_2 V = k\frac{q_1 q_2}{r}$$

or

$$U = k\frac{q_1 q_2}{r}$$

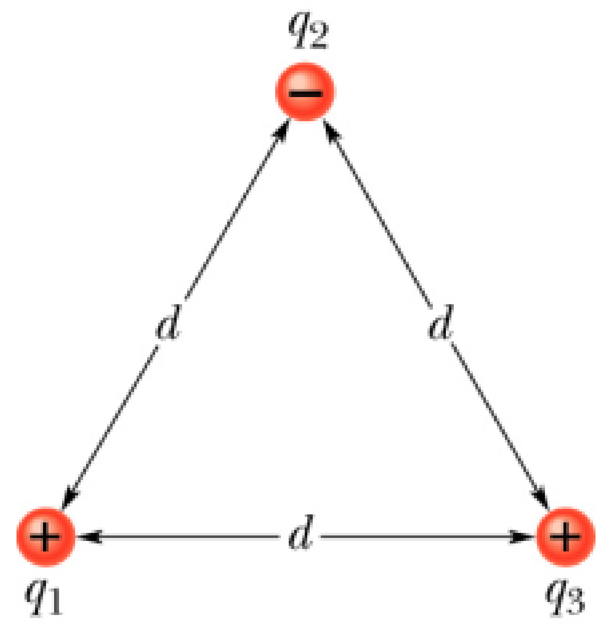
- Charges of like sign, W_{app} and U are +
- Charges of opposite sign, W_{app} and U are -

Potential Energy

- What is the potential energy when add an additional charge to system?

- Move q_1 from ∞, $W_{app} = U = 0$
- Move q_2 from ∞

$$W_{12} = U_{12} = k\frac{q_1 q_2}{d}$$



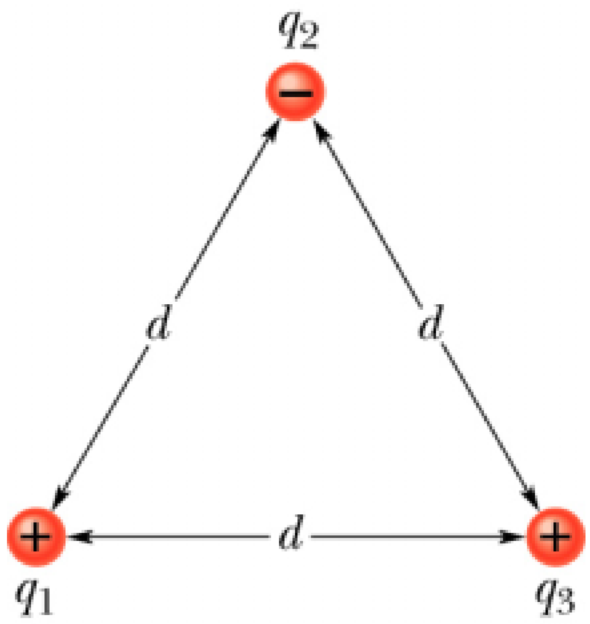
Potential Energy (Fig. 25-17)

- Now bring in q_3

$$W_{13} = U_{13} = k\frac{q_1 q_3}{d}$$

- Must also remember q_2

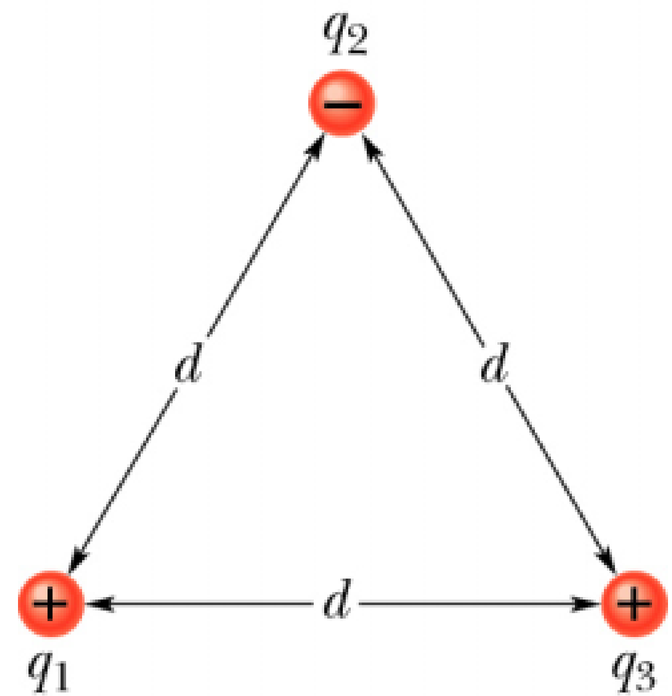
$$W_{23} = U_{23} = k\frac{q_2 q_3}{d}$$



Potential Energy

- Total potential energy is the scalar sum

$$U = U_{12} + U_{13} + U_{23}$$



$$q_1 = +q, \quad q_2 = -4q, \quad q_3 = +2q$$

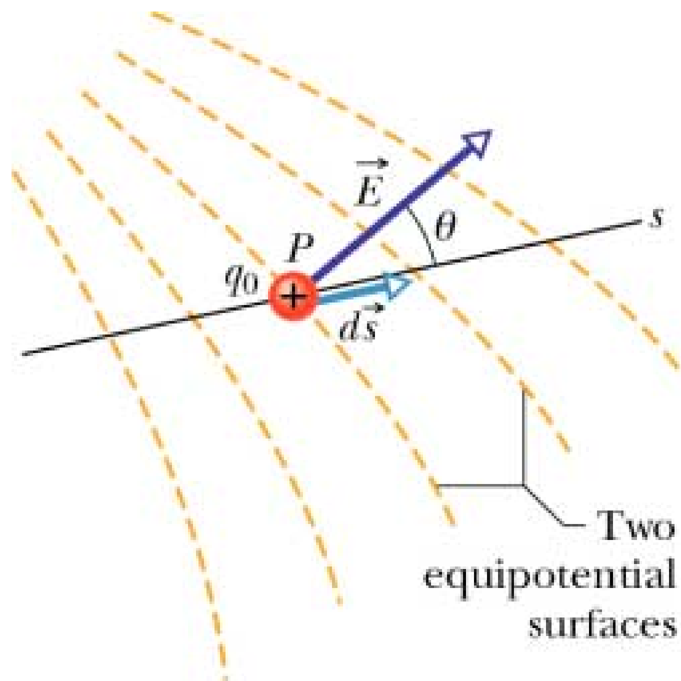
$$U = k\left(\frac{(+q)(-4q)}{d} + \frac{(+q)(+2q)}{d} + \frac{(-4q)(+2q)}{d}\right) = -k\frac{10q^2}{d}$$

Electric Field (Fig. 25-15)

- How do we calculate *E* from *V*?
- Component of *E* in direction of *ds*

$$E_s = -\frac{\partial V}{\partial s}$$

- Component of *E* in any direction is negative rate of change of *V* with distance in that direction



Electric Field

- Take *s* axis to be *x*, *y*, or *z* axes

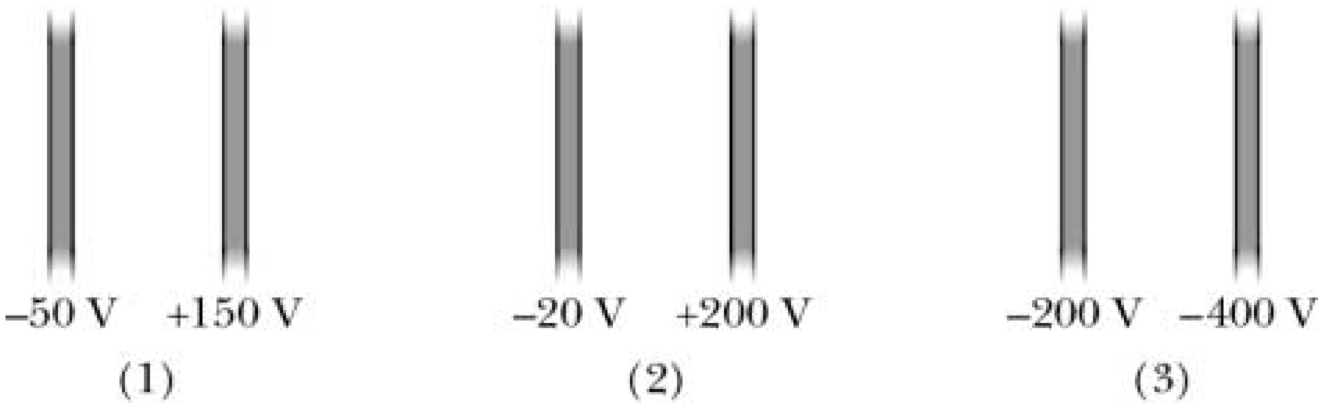
$$E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$$

- If *E* is uniform and *s* is ⊥ to equipotential surface

$$E = -\frac{\Delta V}{\Delta s}$$

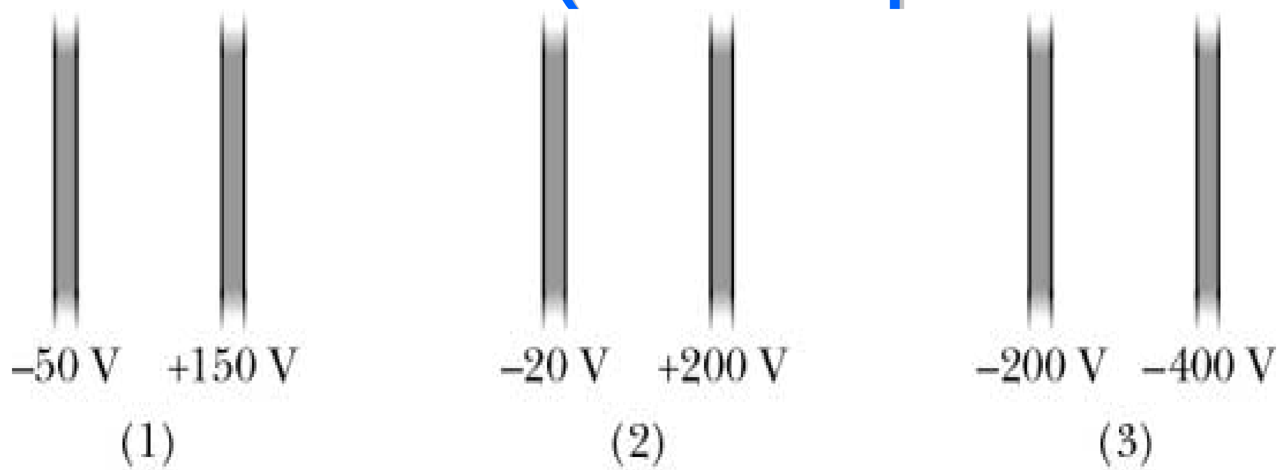
Electric Field (Checkpoint #6)

- 3 pairs of parallel plates with same separation and V of each plate. *E* field is uniform between plates and ⊥ to the plates.



- A) Rank (greatest first) magnitude of *E* between the plates

Electric Field (Checkpoint #6)



$$E = -\frac{\Delta V}{\Delta s}$$

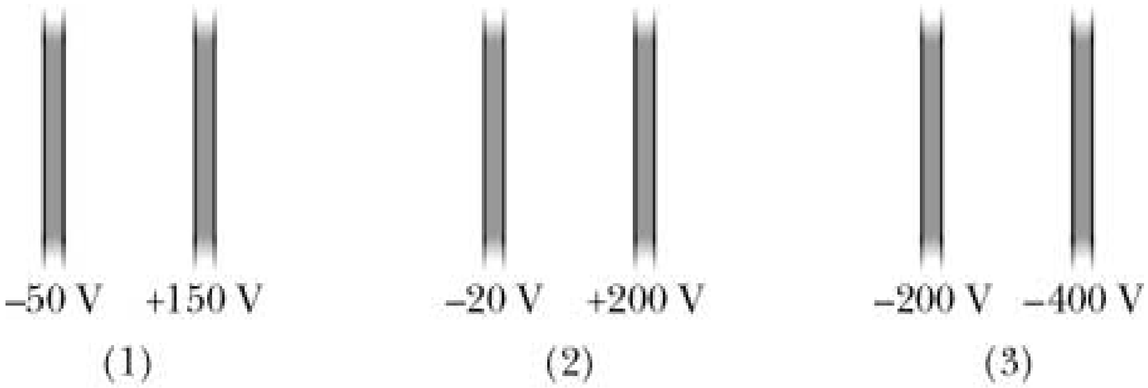
but asked for magnitude of *E*

$$E_1 = \frac{200}{d} \qquad E_2 = \frac{220}{d} \qquad E_3 = \frac{200}{d}$$

2, then 1 & 3

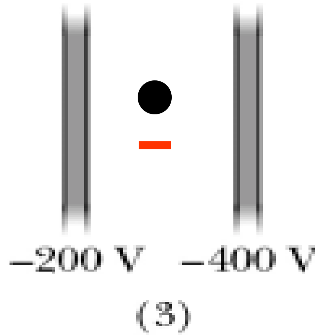
Electric Field (Checkpoint #6)

- B) For which pair does E point to the right



#3

- C) If an electron is released midway between plates in (3) what does it do?



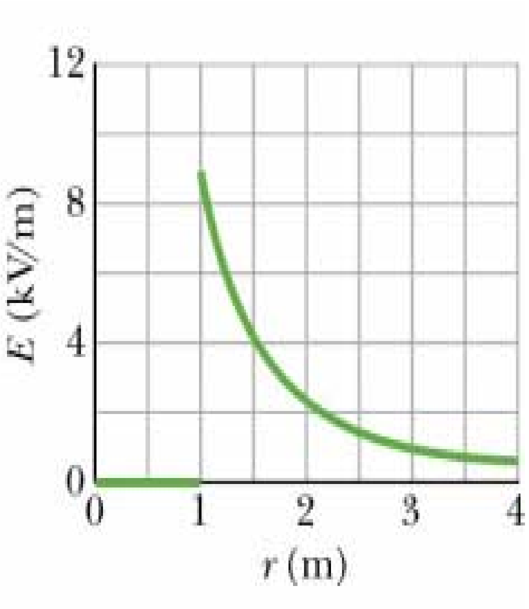
Accelerate to the left

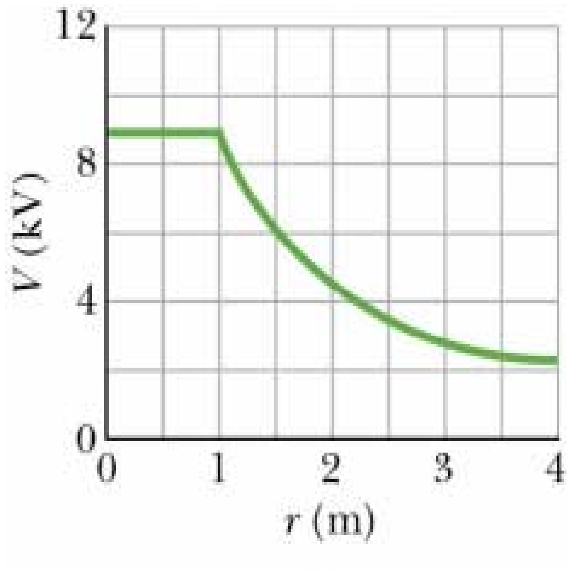
Electric Potential for Conductors

- Using what we know about conductors
  - *E* = 0 inside
  - All excess charge is on surface

- All points of a conductor – whether inside or on the surface – are at the same potential
  - A conductor is an equipotential

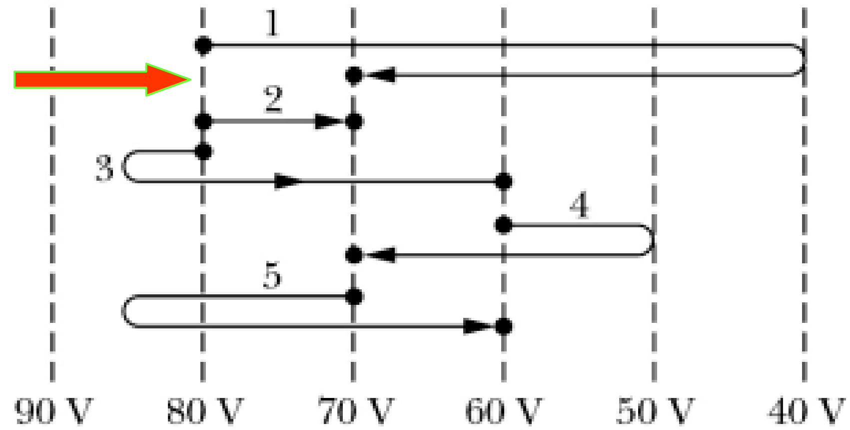
Electric Potential for Conductors (Fig. 25-18)





Electric Potential (Checkpoint #3)

- An electron moves along 5 different paths between parallel equipotential surfaces
- a) What is the direction of the *E* associated with the surfaces?



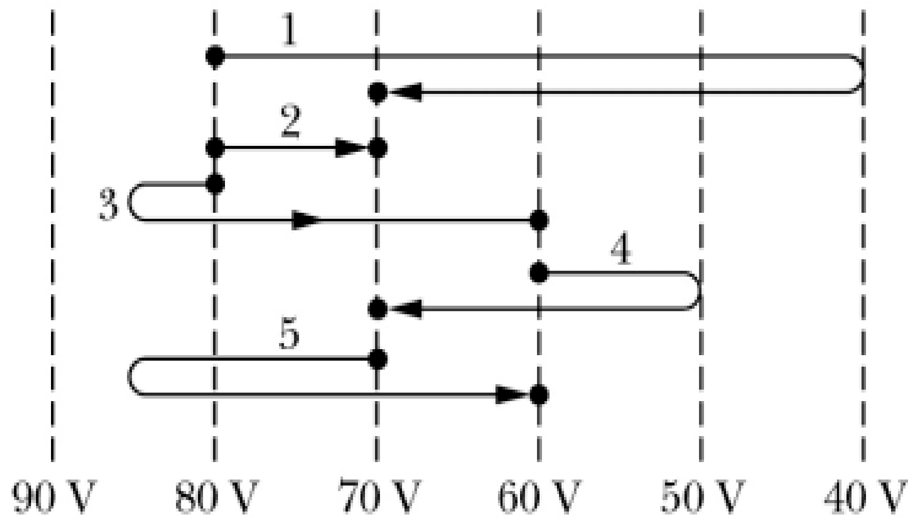
- Positive potentials which decrease going to the right.

Electric Potential (Checkpoint #3)

- c) Rank the paths by amount of work we do (greatest first).

$$W^* = -W = q\Delta V$$

$$W^* = q\left(V_f - V_i\right)$$



- Electron gives $W^*_{Path-1} = -q\left(70 - 80\right) = +10q$

3, then 1 & 2 & 5, last 4