September 10th

Electric Potential – Chapter 25

Review

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

$$\Delta U = U_f - U_i = -W$$

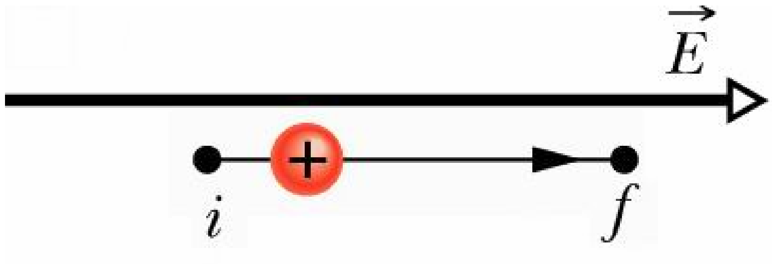
- Electric Potential, *V*

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

- Electrostatic force is conservative - work done by force is path independent

Electric Potential

- Electric potential V for a constant E



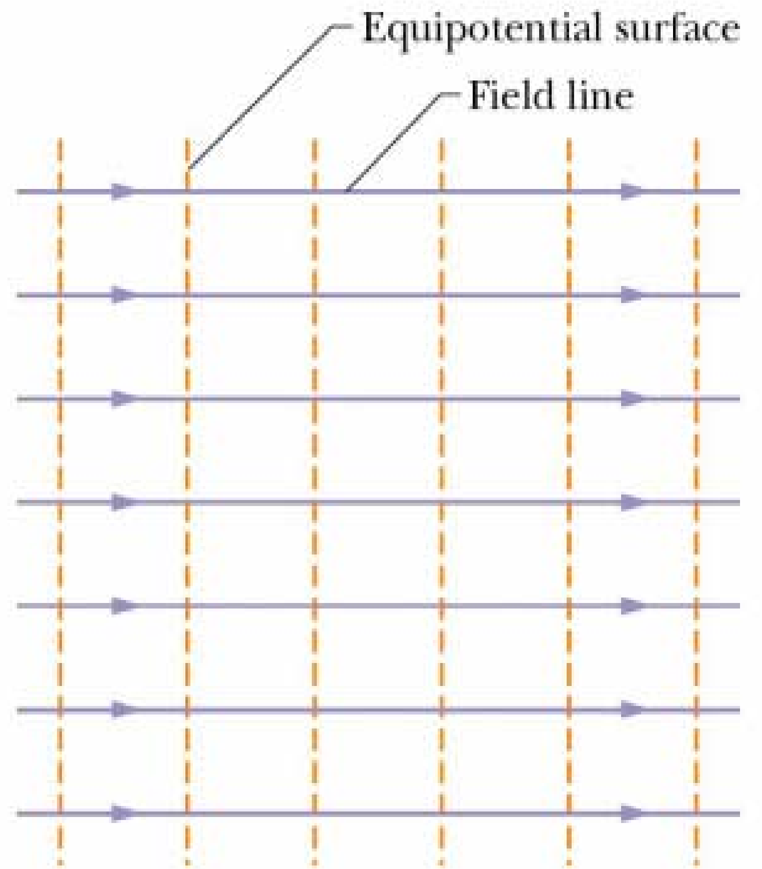
$$\Delta U = U_f - U_i = -W$$

$$\Delta U = -\vec{F} \bullet \vec{d} = -q\vec{E} \bullet \vec{d} = -qEd$$

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

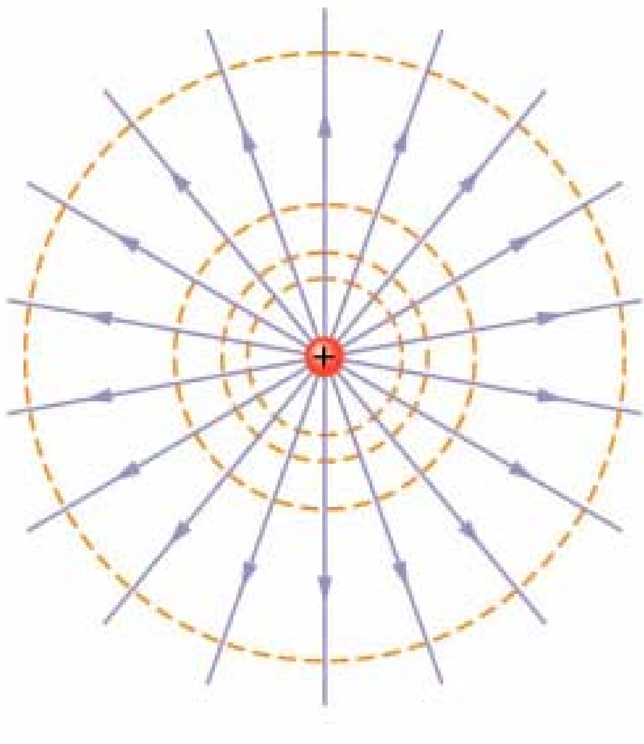
Electric Potential (Fig. 25-3)

- Dashed lines are the edge of equipotential surfaces where all points are at the same potential.
- Equipotential surfaces are always ⊥ to electric field lines and to *E*.
- In this example *V* decreases moving from left to right (moving "downhill" from positive to negative charge).

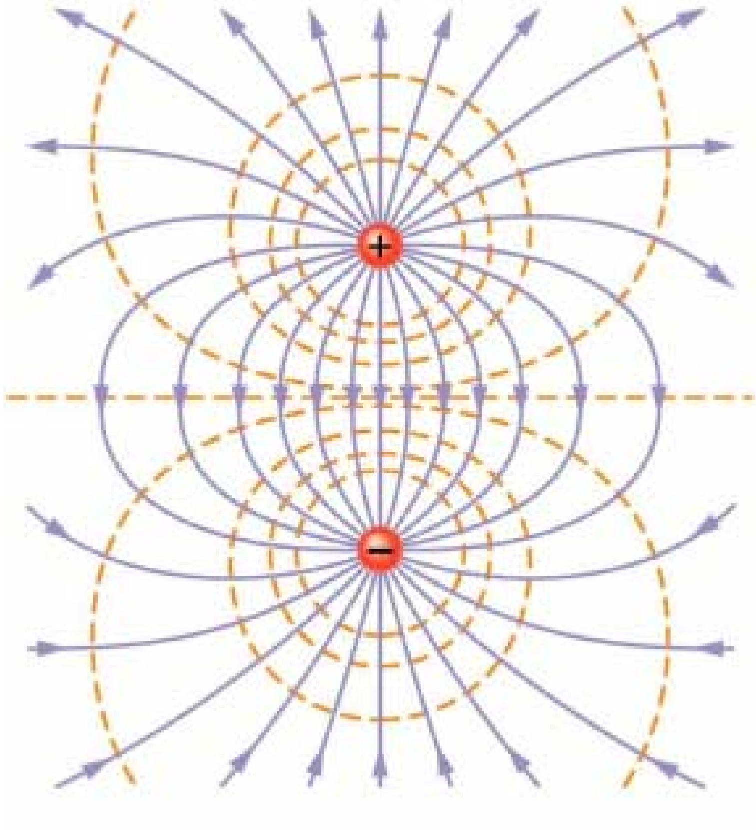


(*a*)

Electric Potential (Fig. 25-3)

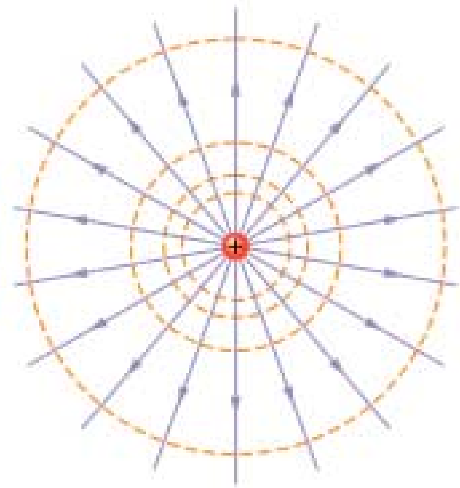


(b)

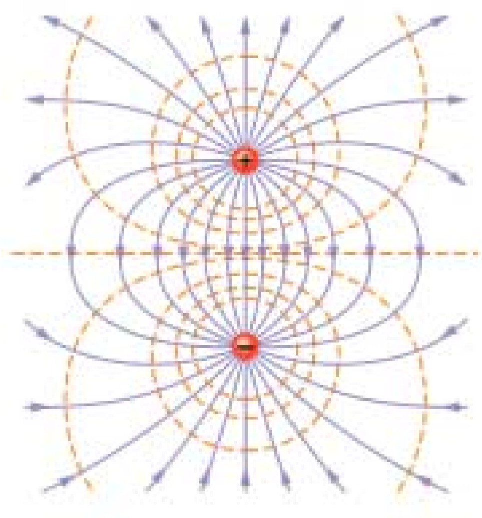


(c)

Electric Potential



(b)



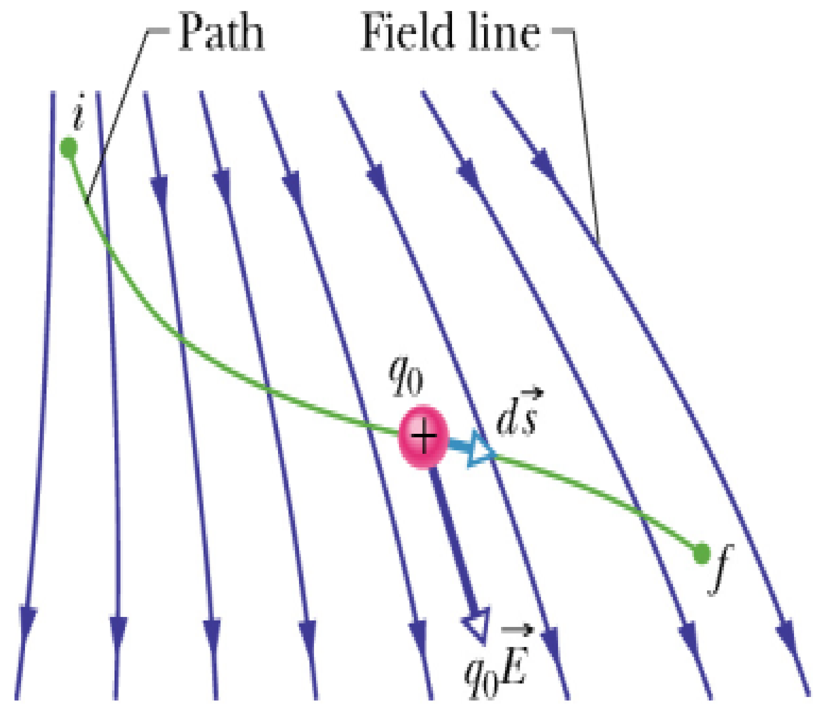
(c)

- *E* field lines are ⊥ to the equipotential surface
- If given equipotential surfaces can draw *E* field lines

Electric Potential (Fig. 25-5)

- Calculate ΔV between points i and f in an electric field E

$$\Delta V = V_f - V_i = -\frac{W}{q_0}$$



- Need to find W when E is not constant.

Electric Potential (Fig. 25-5)

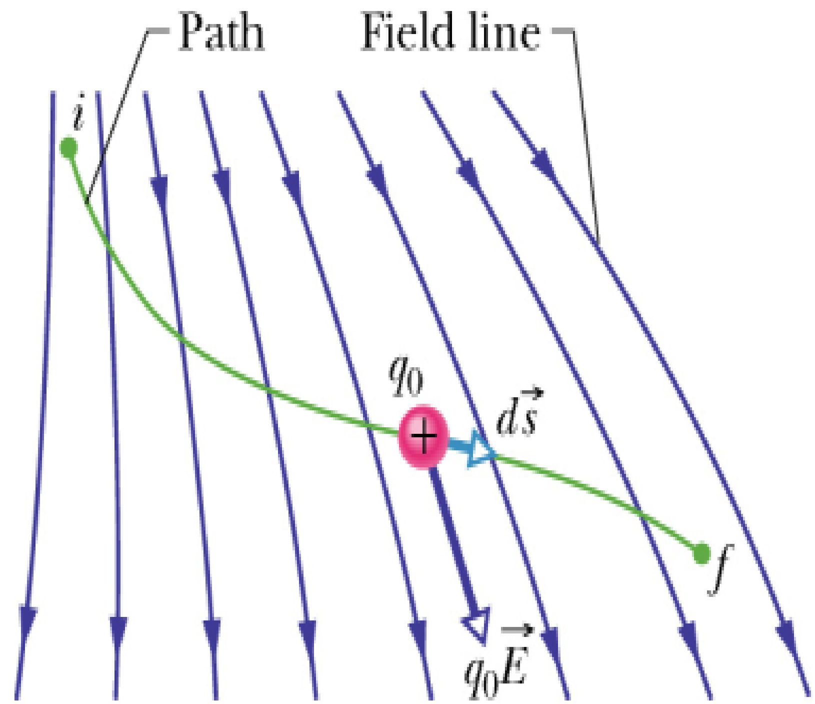
- Calculate differential amount of work

$$dW = \vec{F} \bullet d\vec{s}$$

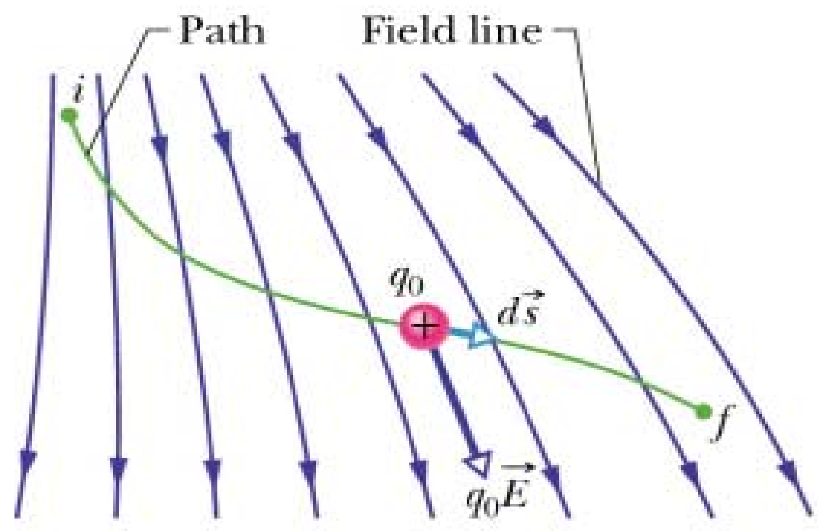
- Remember

$$\vec{F} = q\vec{E}$$

$$dW = q_0 \vec{E} \bullet d\vec{s}$$



Electric Potential (Fig. 25-5)



- Work is

$$W = q_0 \int_i^f \vec{E} \bullet d\vec{s}$$

- Substitute to find ΔV

$$\Delta V = V_f - V_i = -\frac{W}{q_0} = -\int_i^f \vec{E} \bullet d\vec{s}$$

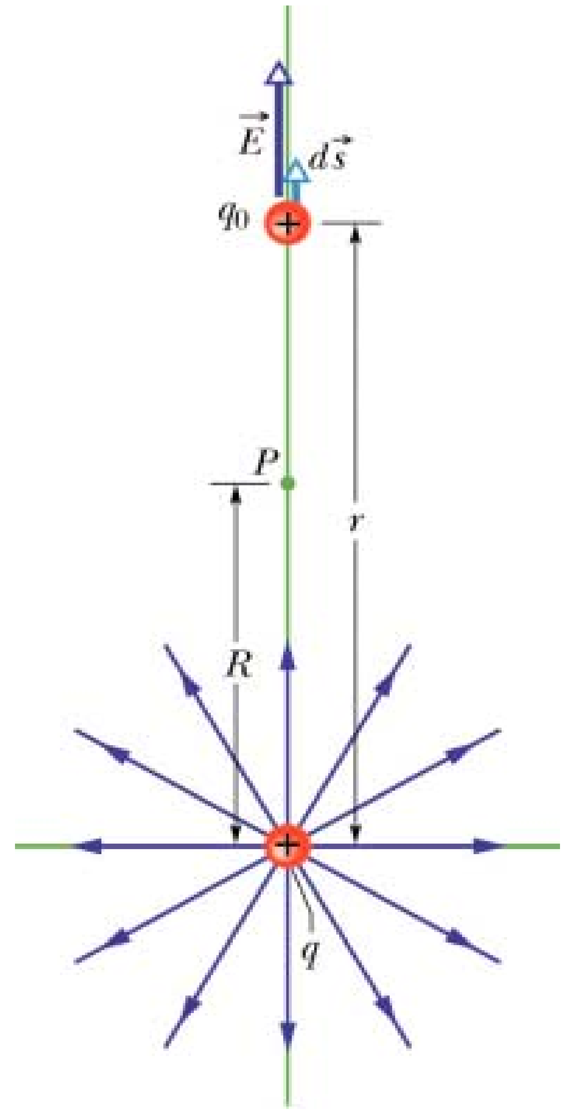
- Potential decreases if path is in the direction of the electric field

Electric Potential (Fig. 25-7)

- Derive potential *V* around a charged particle

$$V_f - V_i = -\int_i^f \vec{E} \bullet d\vec{s}$$

- Imagine moving a + test charge from *P* to ∞
- Path doesn't matter so choose line radially with *E*



Electric Potential

- Choose the path so

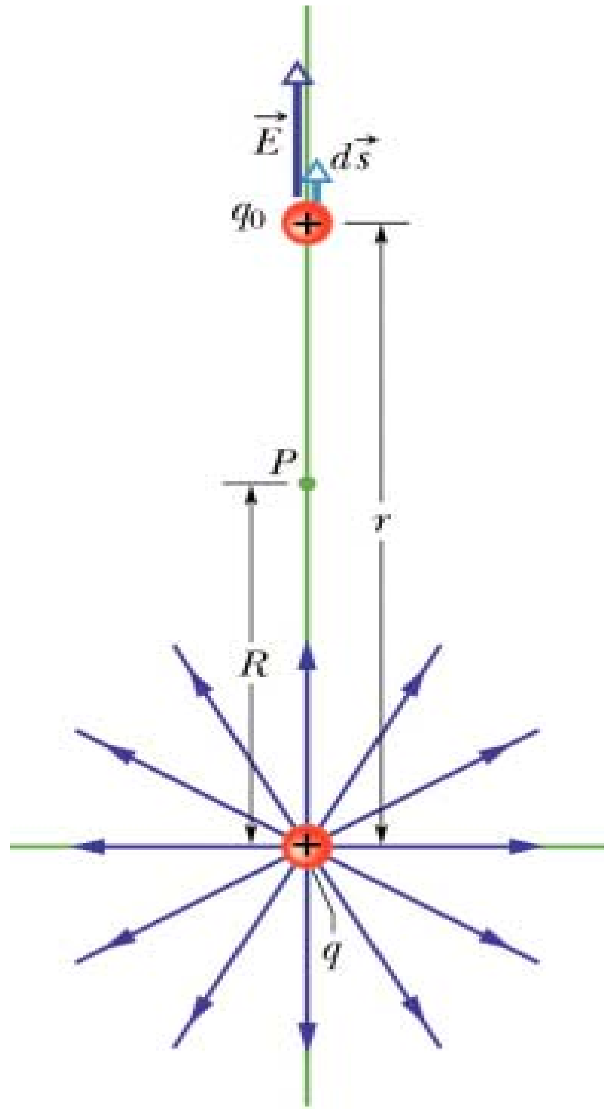
$$\vec{E} \bullet d\vec{s} = E\cos\theta\, ds = E\, ds$$

- Using radial path, rewrite

$$ds = dr$$

- Use limits for *i* = R and *f* = ∞

$$V_\infty - V_R = -\int_R^\infty E\,dr$$



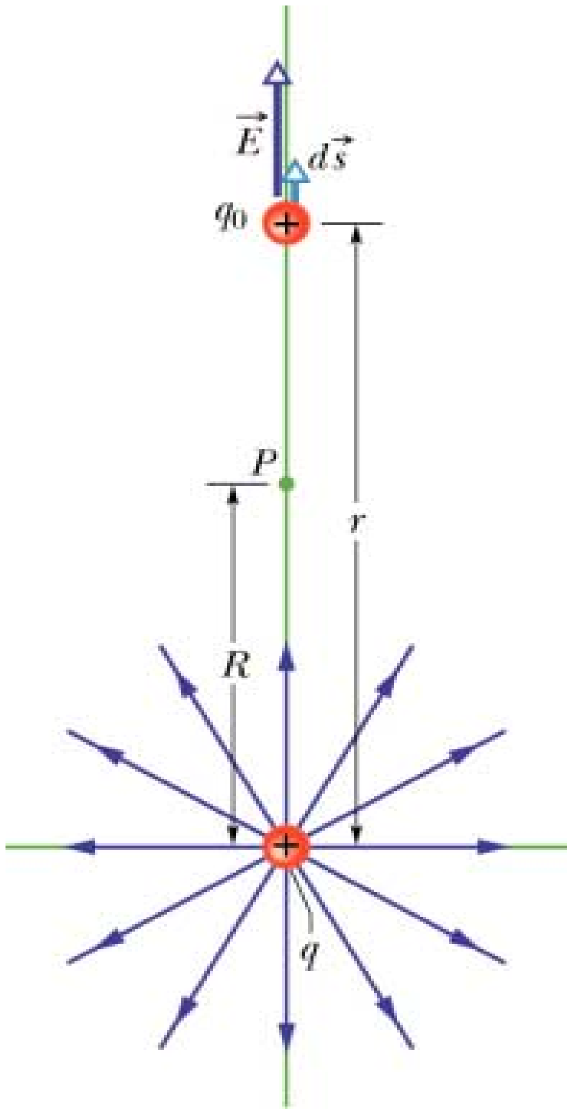
Electric Potential

- Use E for point charge

$$E = k\frac{q}{r^2}$$

- Define $V_\infty = 0$

$$0 - V = -kq\int_R^\infty \frac{1}{r^2}\,dr$$



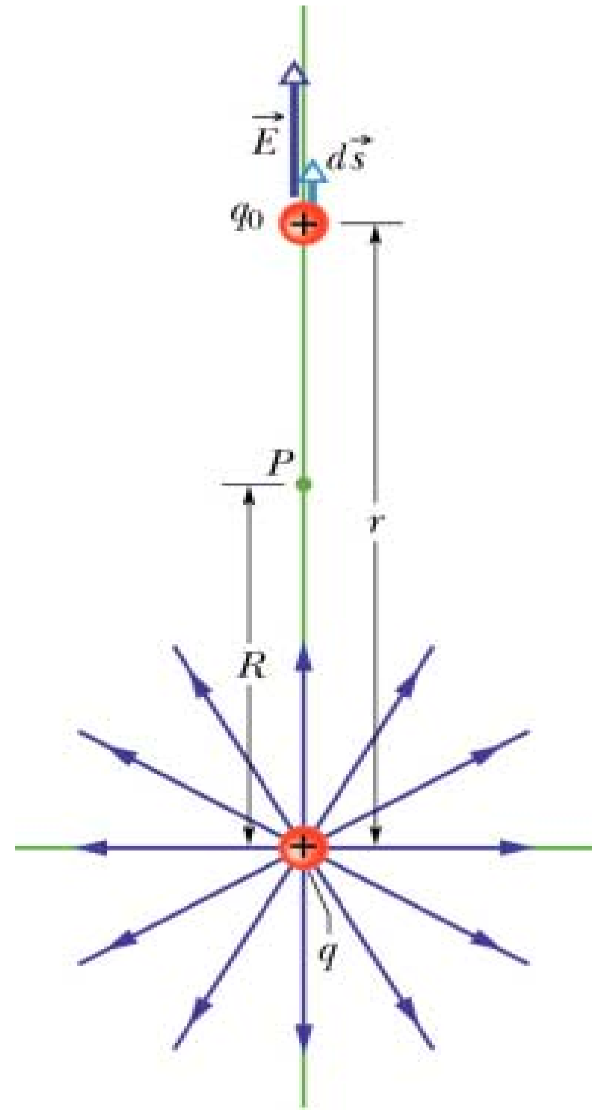
Electric Potential

- Finish integral

$$0 - V = kq\left[\frac{1}{r}\right]_R^{\infty} = -k\frac{q}{R}$$

- Letting *R* become any distance *r* from particle

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



Electric Potential

- Sign of V is same sign as q
  - + charge produces $+V$
  - - charge produces $-V$

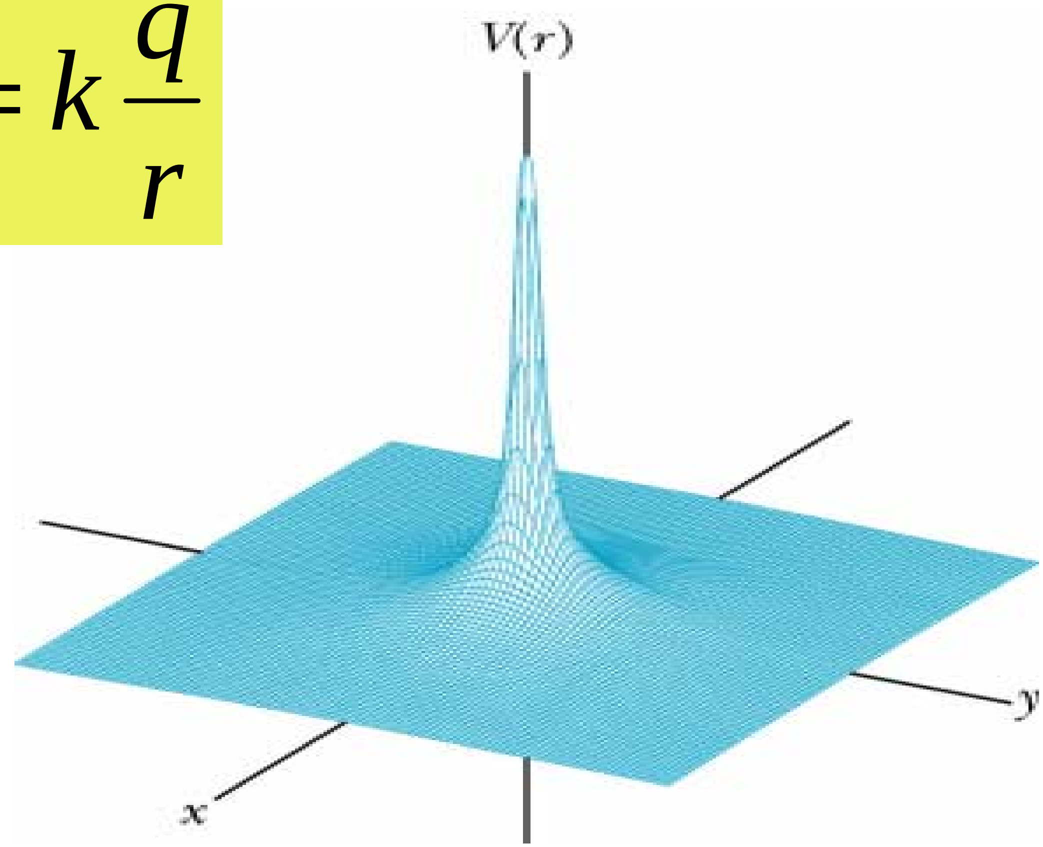
- $|V|$ gets larger as r gets smaller
  - In fact $V = \infty$ when $r = 0$ (on top of charge)

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

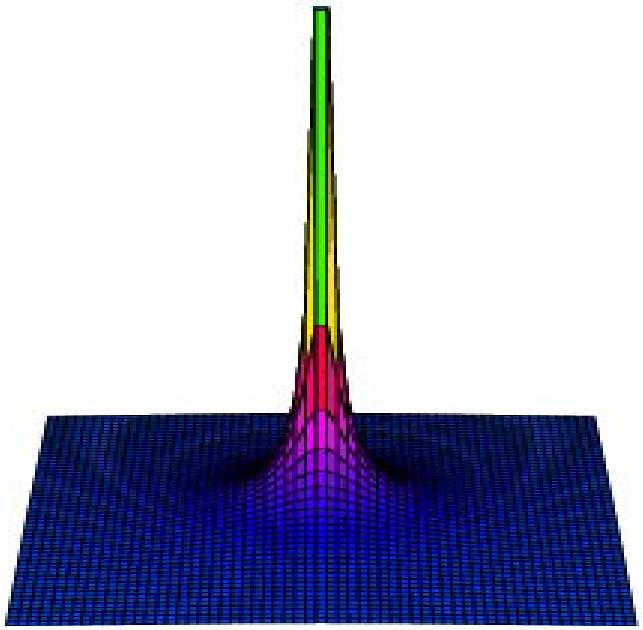
Electric Potential

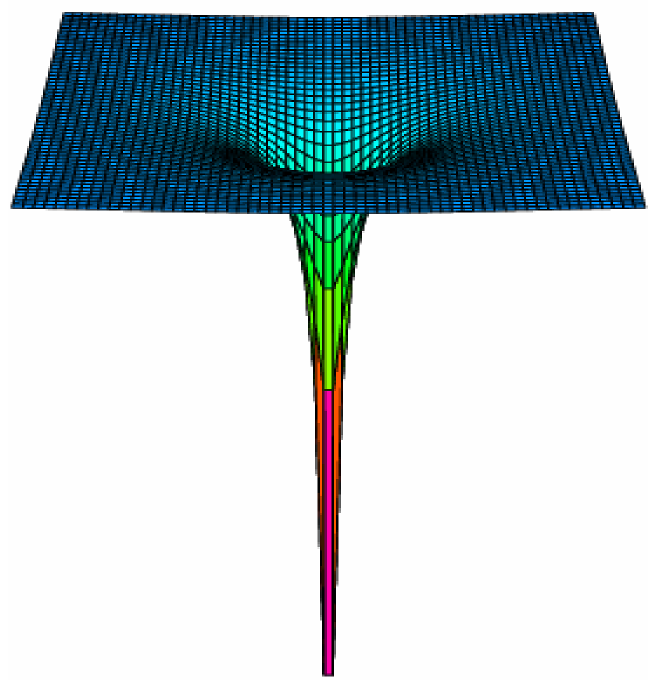
Graphical representation of V for a charge in the x-y plane – plot value of V on the z-axis as a function of x-y position

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



Electric Potential





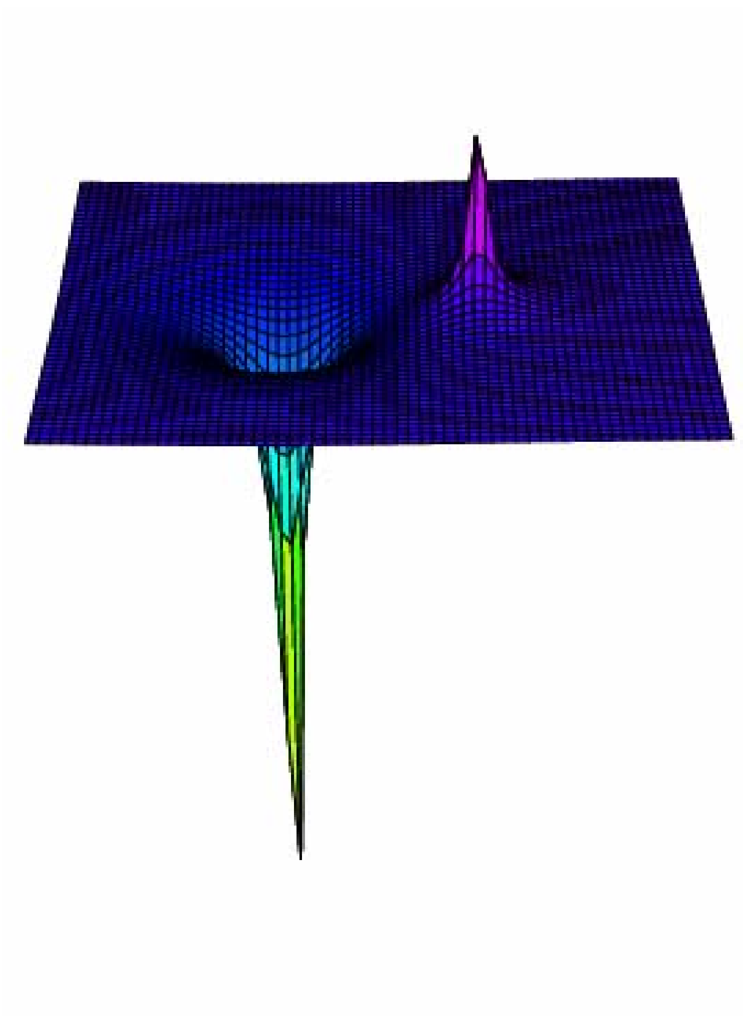
Electric Potential

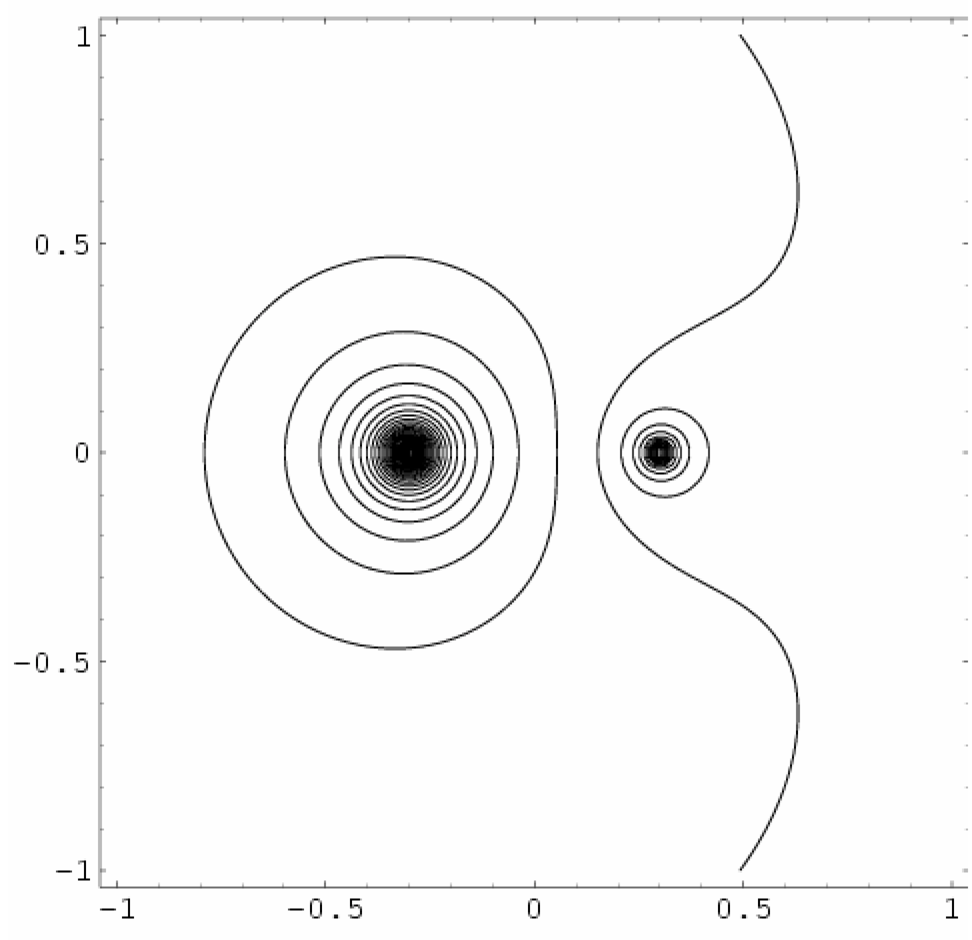
- Use superposition principle to find the potential due to *n* point charges

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

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

Electric Potential (Mathematica)





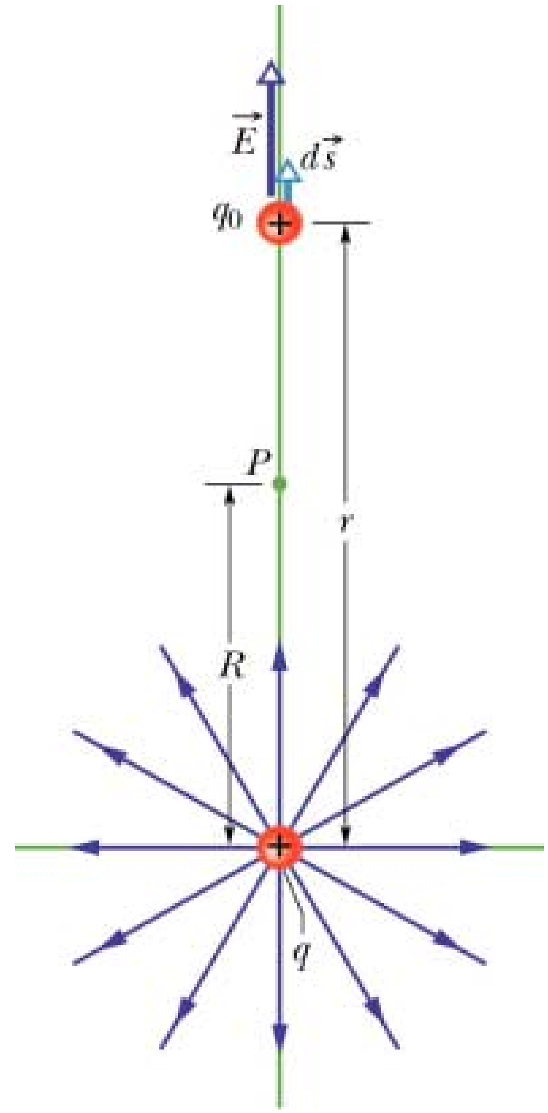
Review

- What is the force *F*, electric field *E*, and potential *V*, at a point *P* a distance *r* away from a point charge?

$$F = k\frac{|q||q_0|}{r^2}$$

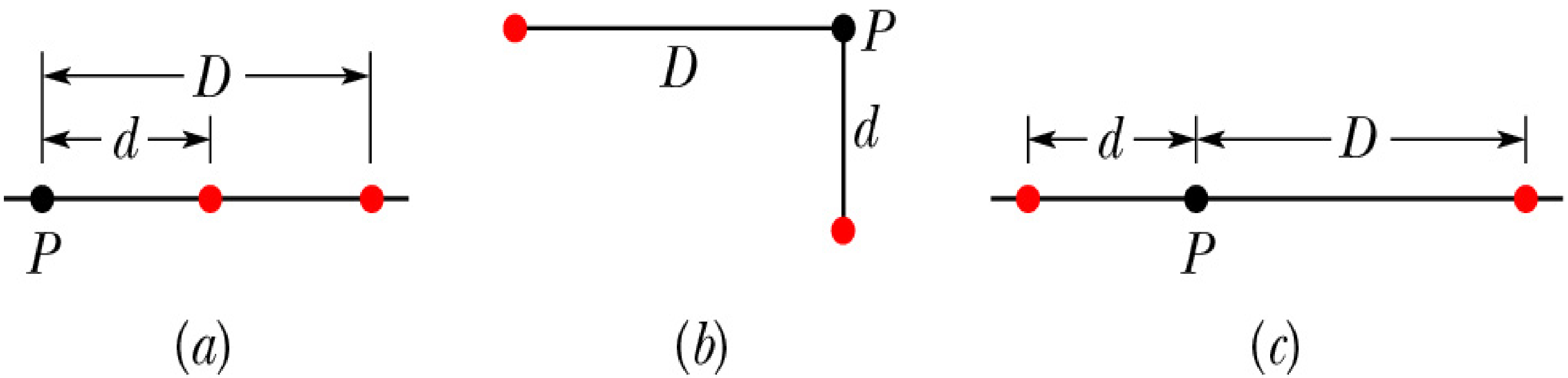
$$E = k\frac{q}{r^2}$$

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



Electric Potential (Checkpoint #4)

- Rank a), b) and c) according to net electric potential V produced at point P by two protons. (Greatest first.)

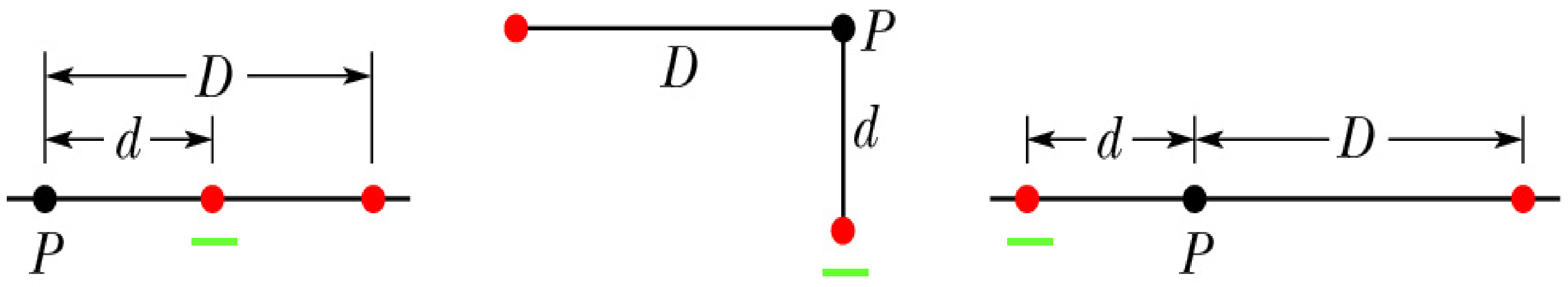


$$V = k\left(\frac{q}{d} + \frac{q}{D}\right)$$

ALL EQUAL

Electric Potential

- Replace one of the protons by an electron. Rank the arrangements now.



(a) (b) (c)

$$V = k\left(-\frac{q}{d} + \frac{q}{D}\right)$$

ALL EQUAL