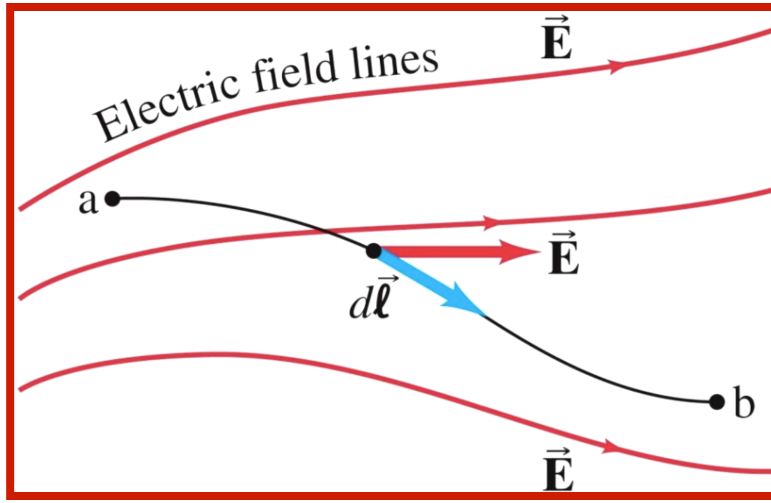
- The ***General Relationship*** between a **Conservative Force** & its **Potential Energy** has the form:

$$U_b - U_a = -\int_a^b \vec{\mathbf{F}} \cdot d\vec{\ell}.$$



- For the **Electric Force:**

$$\mathbf{F = qE} \;\&\; \mathbf{U = qV}$$

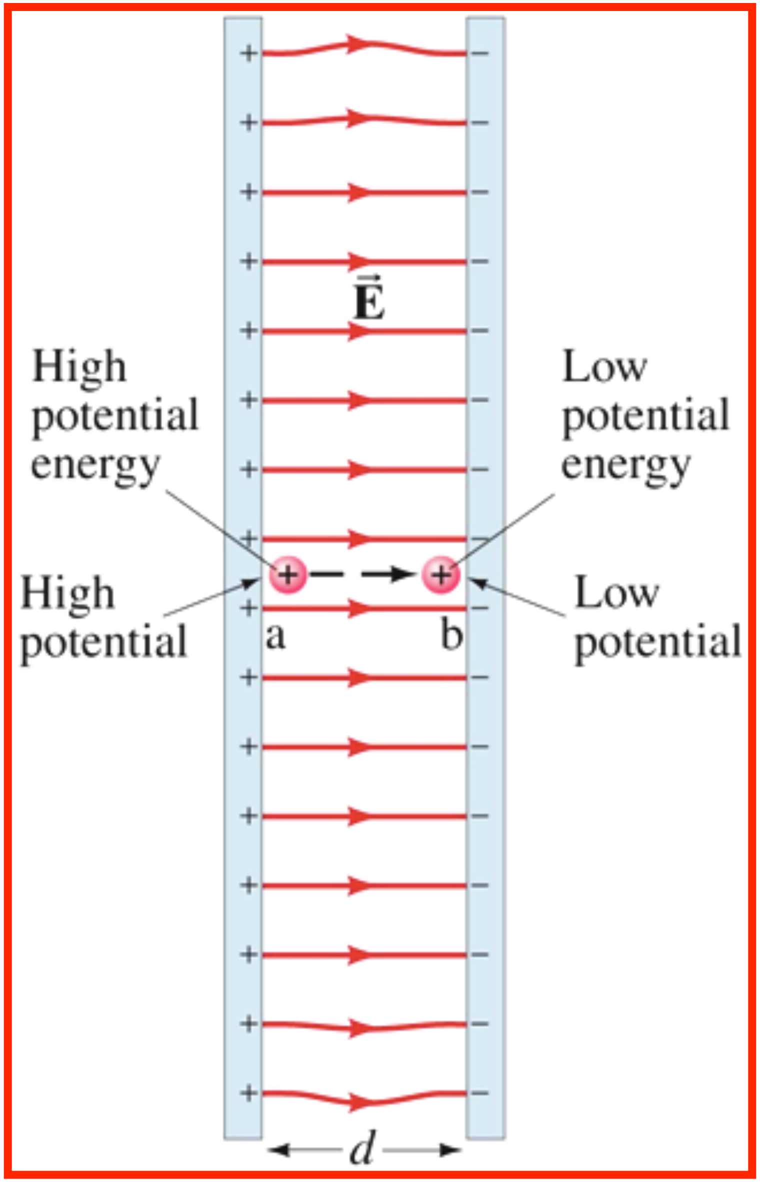
- So, the relationship is:

$$V_{ba} = V_b - V_a = -\int_a^b \vec{\mathbf{E}} \cdot d\vec{\ell}.$$

The simplest case is a

Uniform* E *Field

$$V_{\mathrm{ba}} = -Ed$$



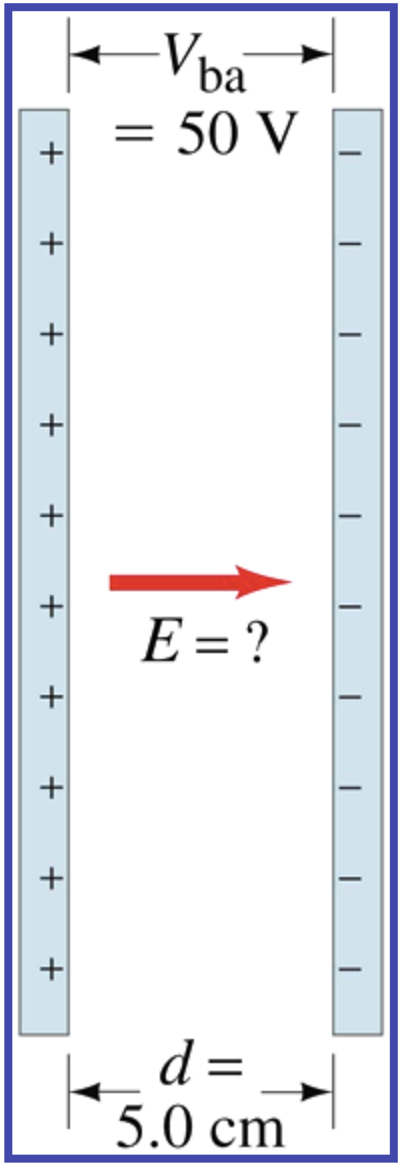
Example

E field obtained from voltage

- Two parallel plates are charged to produce a potential difference of **50 V**. The plate separation is

  d = 0.050 m.

- Calculate the magnitude of the electric field **E** in the space between the plates.



Example

E field obtained from voltage

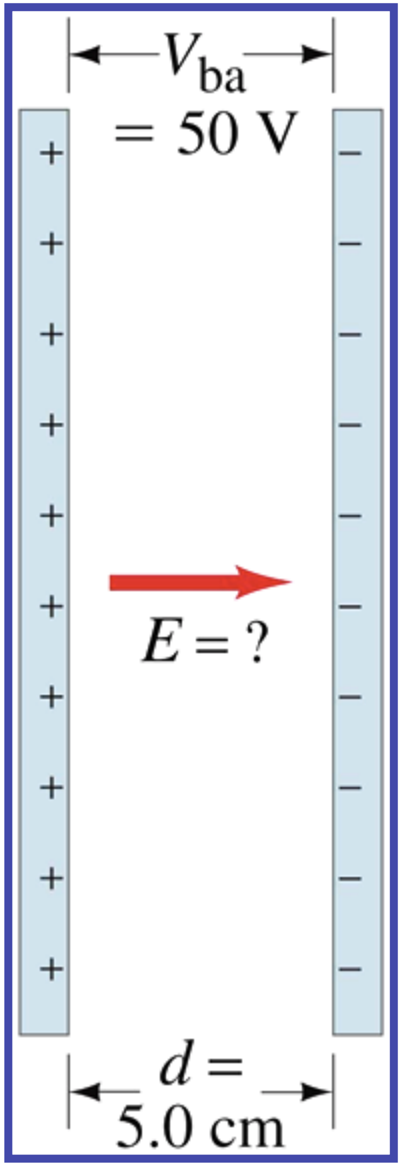
- Two parallel plates are charged to produce a potential difference of **50 V**. The plate separation is

$$\mathbf{d = 0.050\ m.}$$

- Calculate the magnitude of the electric field **E** in the space between the plates.

$$E = (V_{ba})/d = (50)/(0.05)$$

$$E = 1{,}000\ V/m$$



Example

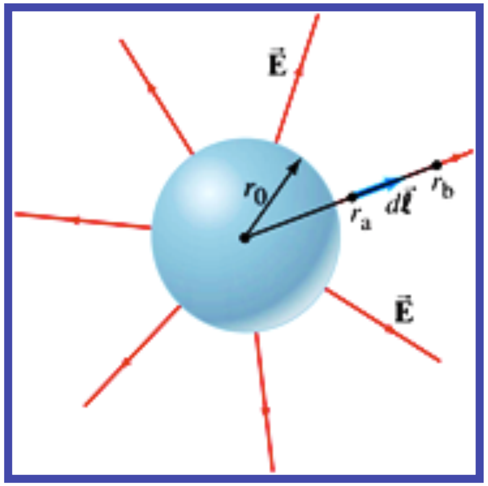
Charged Conducting Sphere

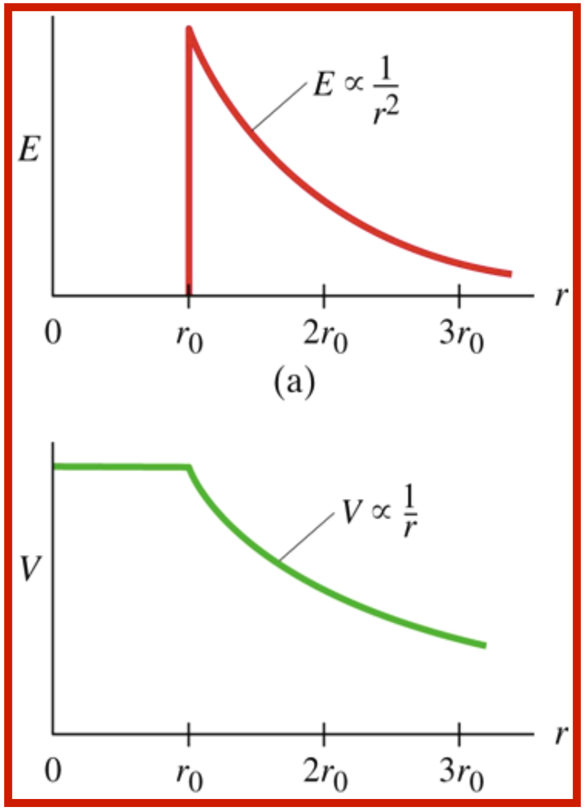
A conducting sphere is uniformly charged with total charge **Q**. Calculate the potential at a distance **r** from the sphere's center for

(a) $r > r_0$, (b) $r = r_0$, (c) $r < r_0$

V is plotted here, and compared with the electric field **E**. Use the relation:

$$V_{ba} = V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{\ell}.$$





Example

Charged Conducting Sphere

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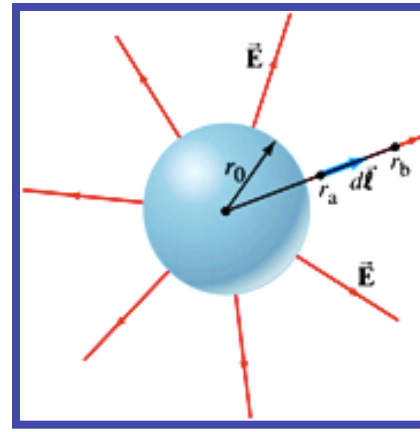
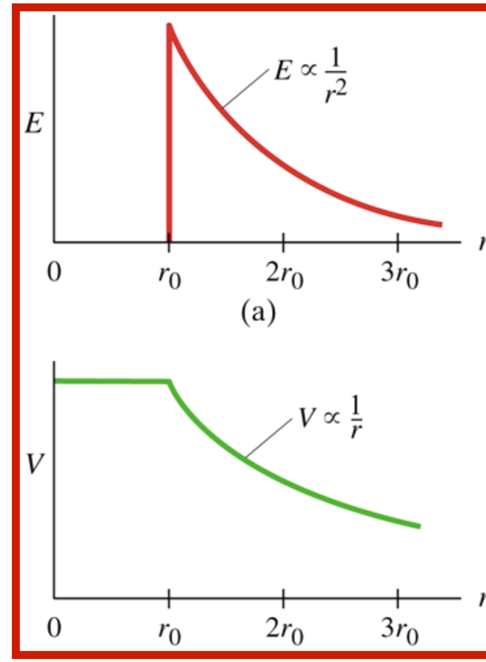




Use the relation:

$$V_{ba} = V_b - V_a = -\int_a^b \vec{E} \cdot d\vec{\ell}.$$

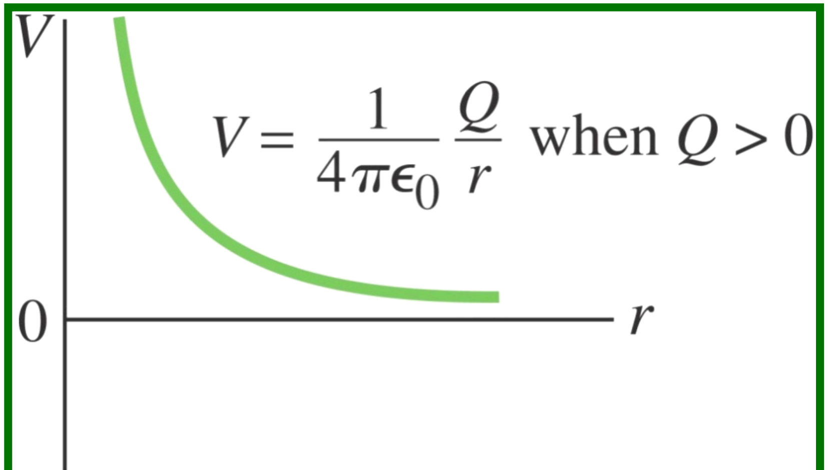
$$V_{ba} = -\,[Q/(4\pi\varepsilon_0)] \int [dr/(r^2)]$$

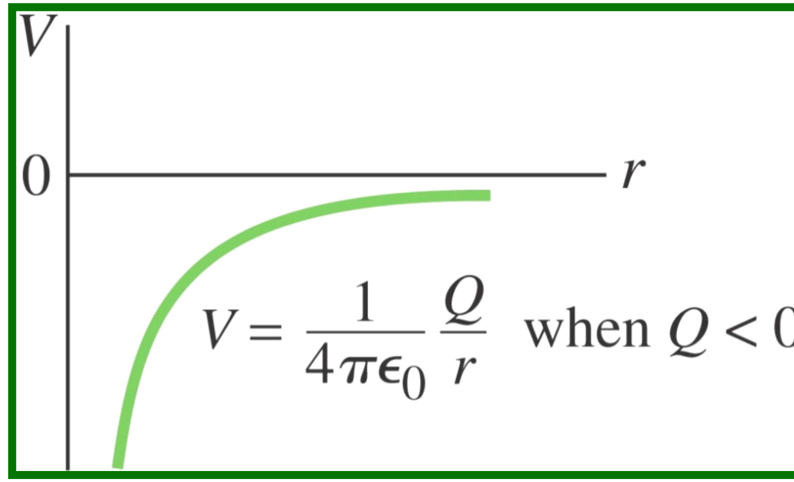
Limits r_a = to r_b

$$V_b - V_a = -\int_{r_a}^{r_b} \vec{E} \cdot d\vec{\ell} = -\frac{Q}{4\pi\epsilon_0} \int_{r_a}^{r_b} \frac{1}{r^2}\, dr = \frac{1}{4\pi\epsilon_0}\left(\frac{Q}{r_b} - \frac{Q}{r_a}\right)$$

Setting the potential **V** to zero at **r = ∞** gives the **General Form of *the Potential Due to a Point Charge***:

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





Example: Work required to bring two positive charges close together:

- Calculate the minimum work that must be done by an external force to bring a charge **q = 3 μC** from a great distance away (take **r = ∞**) to a point **0.500 m** from a charge **Q = 20 μC**.

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•Calculate the minimum work that must be done by an external force to bring a charge **$q = 3\ \mu C$** from a great distance away (take **$r = \infty$**) to a point **0.500 m** from a charge **$Q = 20\ \mu C$**.

$$W = q.V = q(V_b - V_a)$$

$$= qk_e[(Q/r_b) - k_eQ(Q/r_a)]$$

1.08 J

Example: Potential above two charges

(a) Calculate the electric potential at point **A** in the figure due to the two charges shown. **(b)** Repeat the calculation for point **B**. (Solution on white board).