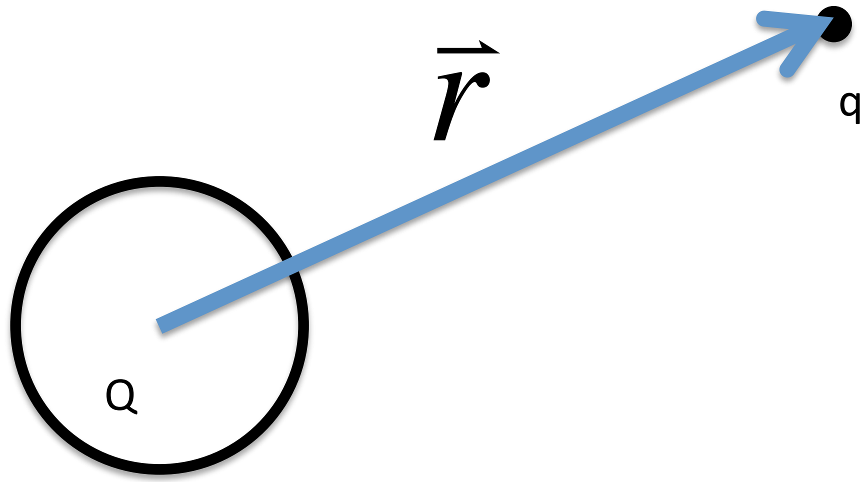
Announcement:

Clickers:

75% of questions answered per session: 3 points
Each question answered correctly: 1 more point

In-class Quiz: Tuesday, 30 minutes, 3 questions Start 9 am Sharp

Handing it in worth 2 clicker points
Each question worth 2 clicker points



Coulomb's Law

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}\hat{r}$$

Electric Field

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

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$$

Gauss's Law $$\Phi_{total} = \frac{Q_{enclosed}}{\varepsilon_0}$$

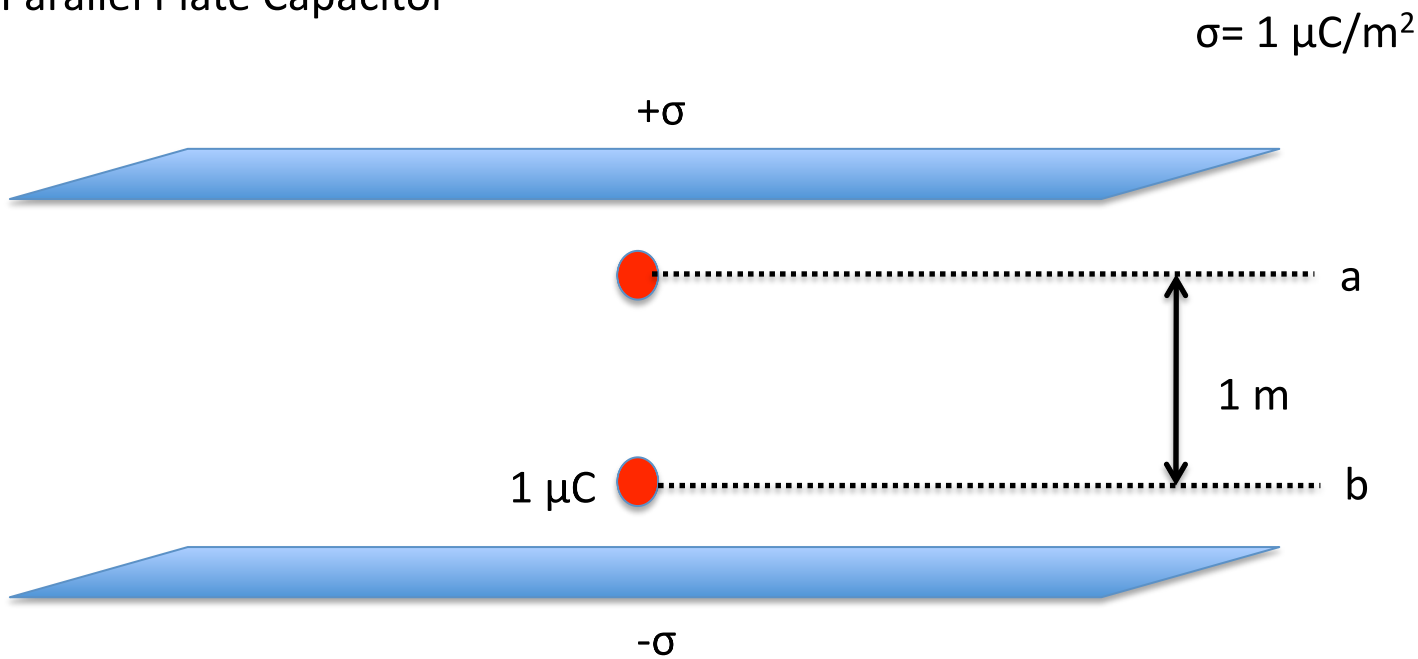
Flux over a closed surface $$\Phi_{total} = \int \vec{E} \cdot \hat{n} dS$$

Electric Potential Energy on charge q: U(q) (J)

Work done by electric field is independent of path,
but dependent on charge

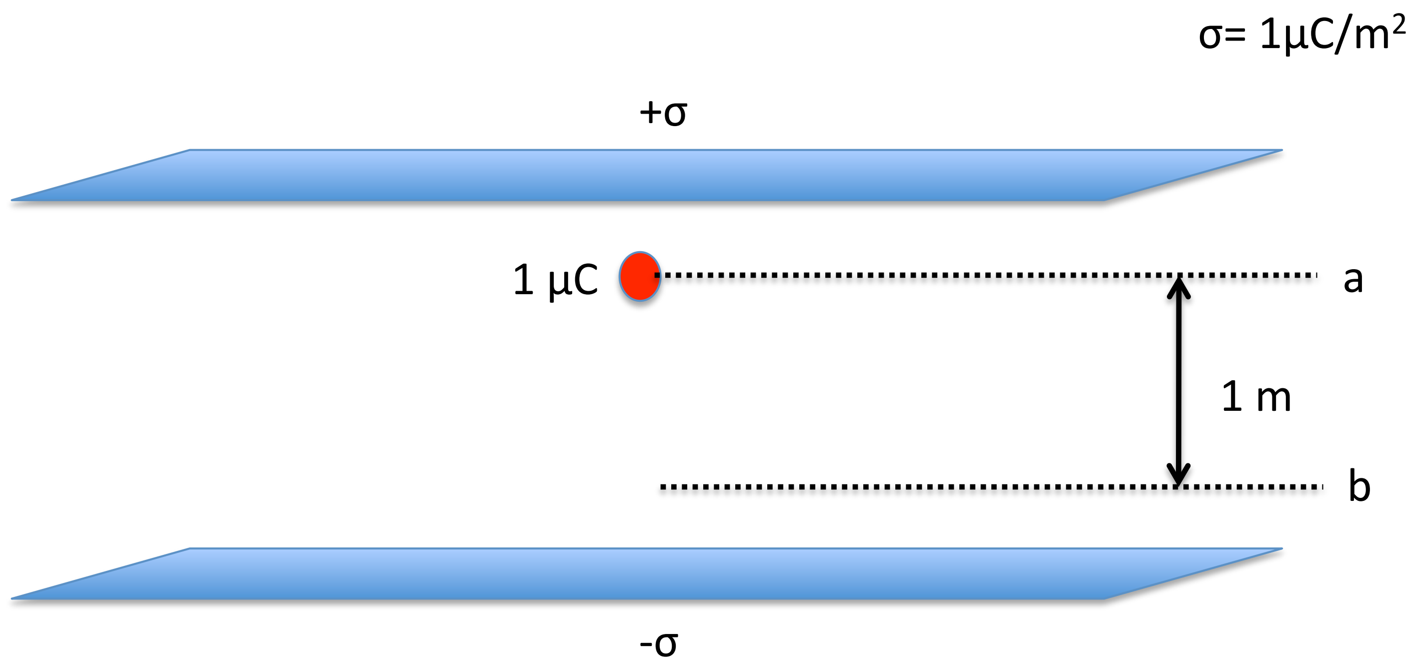
Electric Potential: V = U/q (V)

Example : Parallel Plate Capacitor



Electric field between parallel plates = $\sigma/\varepsilon_0 = \dfrac{1\times10^{-6} C/m}{8.85\times10^{-12}\cdot C^2/Nm} = 1.1\times10^{5} N/C$

Work done by my hand = qEd = $(1\times10^{-6} C)\times(1.1\times10^{5}\dfrac{N}{C})\times(1m) = 0.11Nm = 0.11J$



Potential Energy at position a

$$U(a)-U(b) = 0.11\ J$$

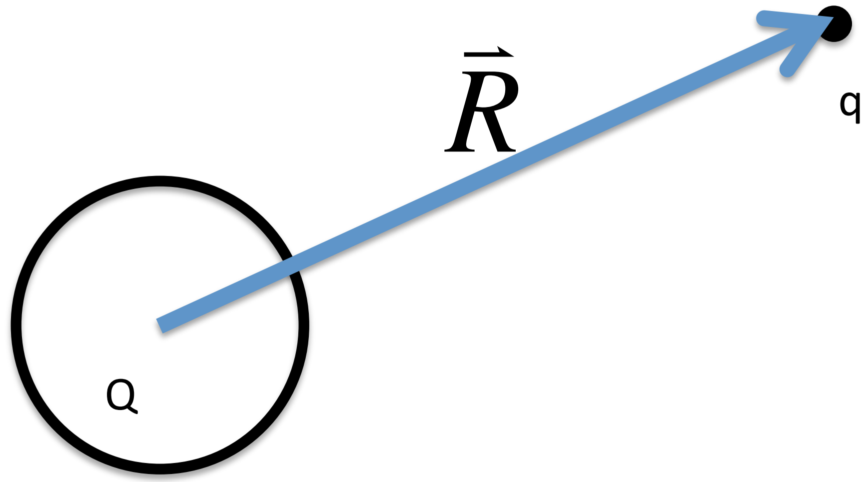
Potential

$$(U(a)-U(b))/q = V(a)-V(b) = 0.11\ J/1\mu C = 1.1\times10^{5}\ V$$

Problem 1: When a negative charge is released and moves along an electric field line, it moves to a position of

a. lower potential and lower potential energy.
b. lower potential and higher potential energy.
c. higher potential and lower potential energy.
d. higher potential and higher potential energy.
e. decreasing magnitude of the electric field.

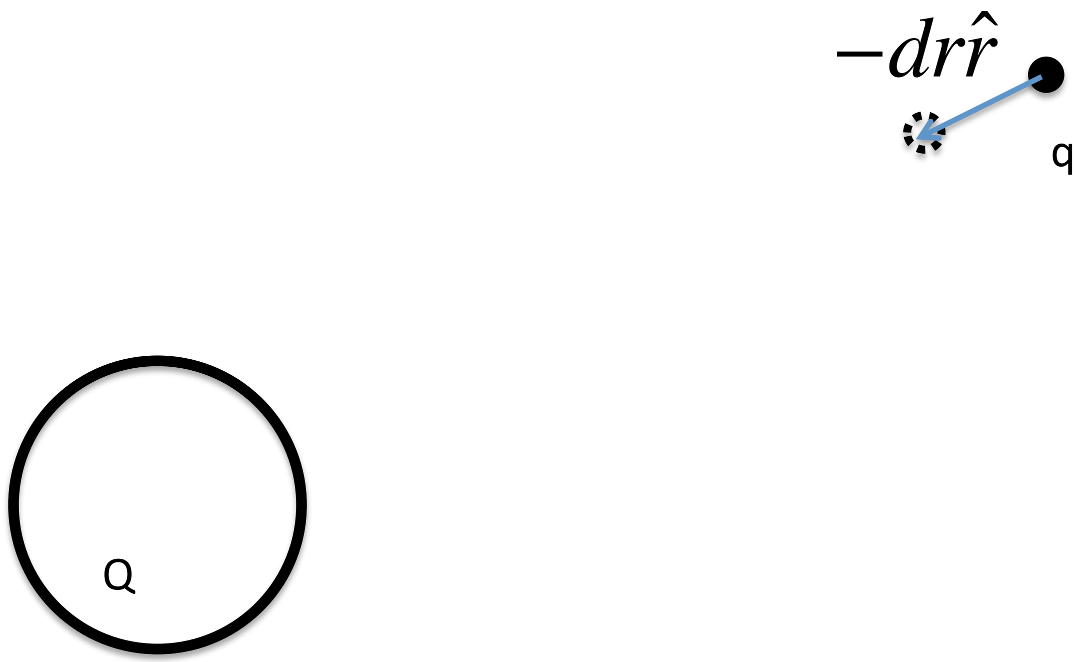
Example: Q stationary: how much energy does it take to bring q to the below position?



$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}\hat{r}$$ At distance r

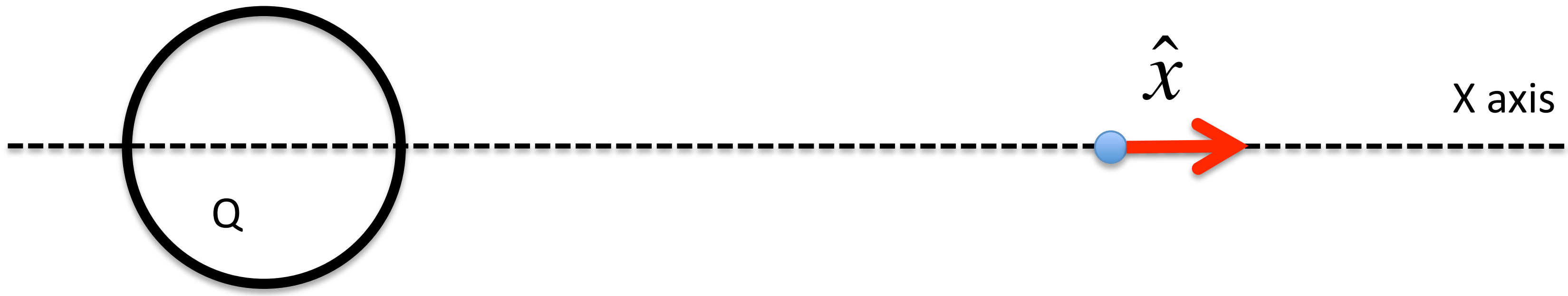
Work done by hand = Required Energy

How much energy does it take to move it an infinitesimal distance in at distance r?



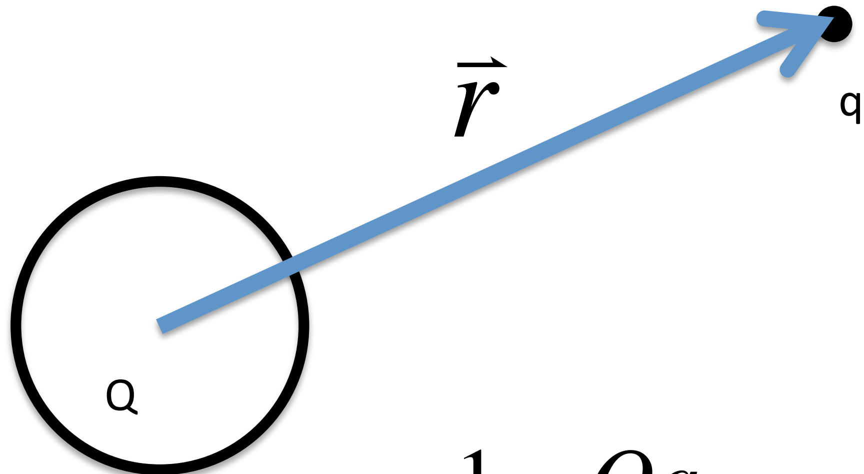
$$Work = Force \times Distance = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}\hat{r} \cdot -dr\hat{r} = -\frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}dr$$

$$Work_{total} = \int_{\infty}^{R} -\frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}dr = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{R}$$



$$V(x) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{x}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{x^2}\hat{x} = -\frac{dV}{dx}\hat{x}$$



Potential Energy at R : $$\frac{1}{4\pi\varepsilon_0}\frac{Qq}{r}$$

Potential at R: $$V(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}\hat{r} = -\frac{dV}{dr}\hat{r}$$

In general,

Gradient Discussion: Board

Problem 2: The electric field in a region of space is given by $E_x = (3.0x)$ N/C, $E_y = E_z = 0$, where x is in m. Points A and B are on the x axis at $x_A = 3.0$ m and $x_B = 5.0$ m. Determine the potential difference $V_B - V_A$.

a. –24 V

b. +24 V

e. –18 V

d. +30 V

e. –6.0 V

Problem 3: Points A [at (3, 6) m] and B [at (8, –3) m] are in a region where the electric field is uniform and given by **E** = 12**i** N/C. What is the electric potential difference $V_A - V_B$?

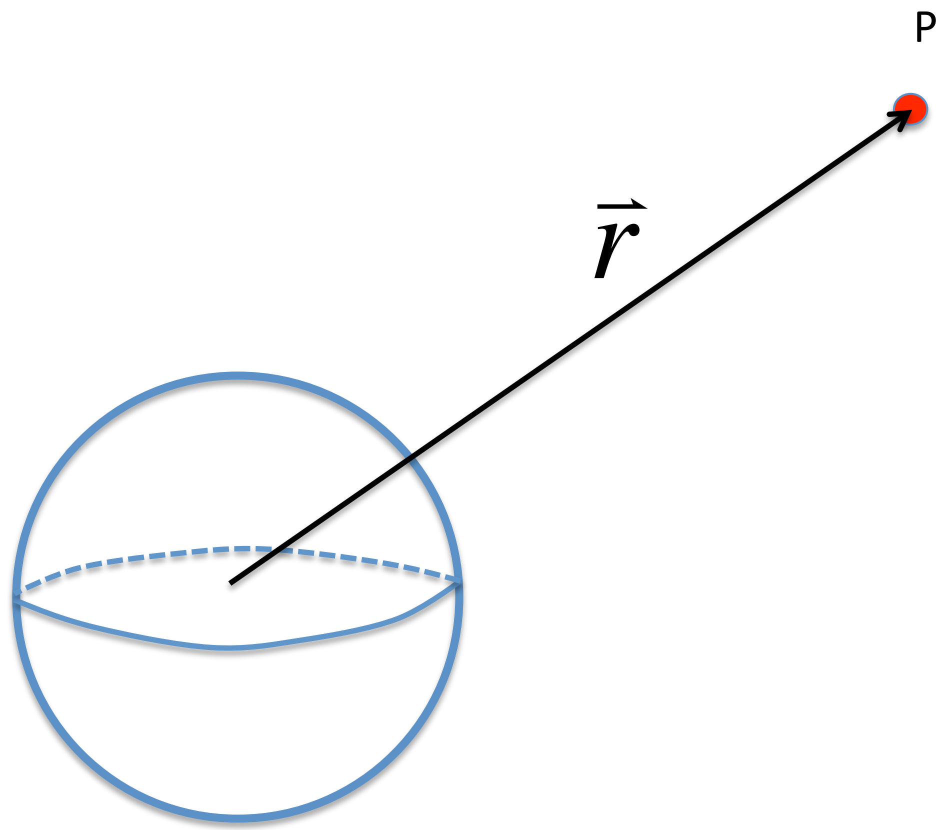
a. +60 V
b. –60 V
c. +80 V
d. –80 V
e. +50 V

Problem 4: Points A [at (2, 3) m] and B [at (5, 7) m] are in a region where the electric field is uniform and given by **E** = (4**i** + 3**j**) N/C. What is the potential difference $V_A - V_B$?

a. 33 V
b. 27 V
c. 30 V
d. 24 V
e. 11 V

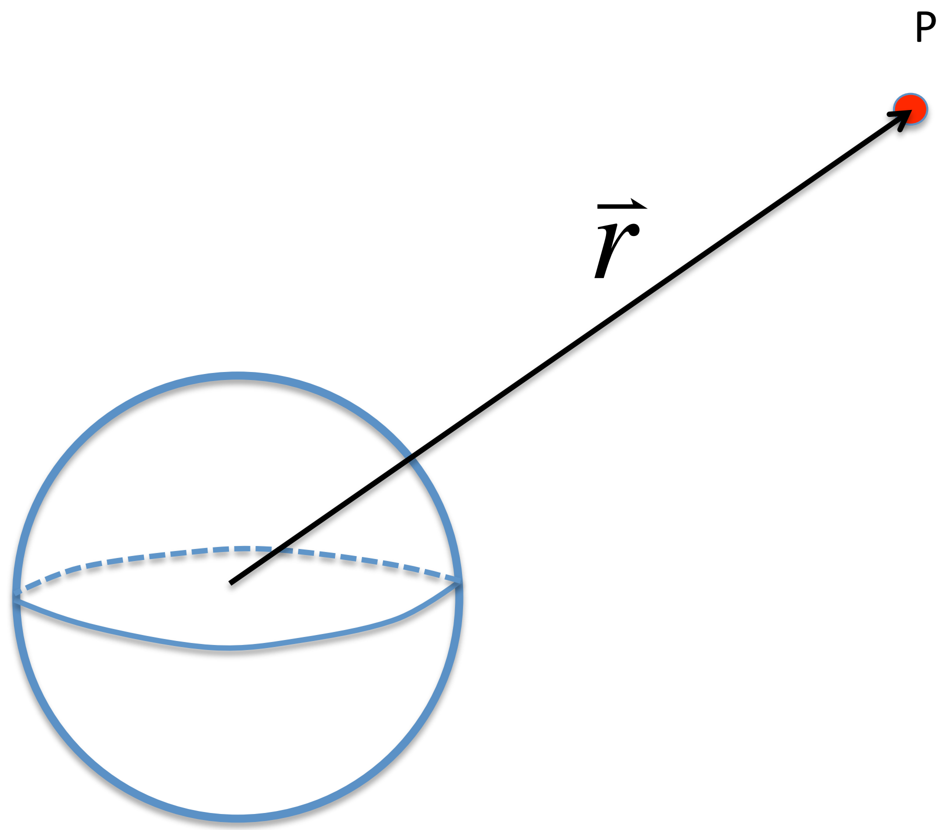
Example: Conducting Sphere with total charge Q

Radius : R



Example: Uniformly Charged Sphere with total charge Q

Radius : R



What about a non-traditional objects?

Conducting irregular shaped object