Ch 25 Questions

1. Electric potential energy is how much work it takes to assemble a system of charges by moving them to or from a reference point (usually infinity). The work is due to the coulomb force exerted on a charged particle in an electric field and the distance it has to be moved (work = force x distance). The electric field is a result of the electric potential created by the charges of the system.

2. If a negative charge is moving in the same direction as an electric field, then it is moving in the opposite direction of the force it is experiencing. Thus its potential energy is increasing. Electric fields 'point downhill' ie from high to low potential, thus the charge is moving to lower potential.

5. Electric field always points in the direction of the greatest change in potential. Potential does not change along equipotential lines.

The equation E = - del V shows that the magnitude of the components of the electric field are proportional to the rate of change in the direction of each component.

6. The equipotential surfaces for an infinite line are concentric cylinders centered around the line. The equipotential surfaces for a sphere are concentric spheres centered around the sphere.

7. Charges are free to move within a conductor. If the potential varied throughout the conductor there would be an electric field, and hence a force acting on the charges, causing them to move. Remember that static means nothing is moving.

8. No, it just implies that the potential is constant. Remember that the electric field is the rate of change of the potential.

25.2 $\Delta K = q\,|\Delta V|$ $\qquad \dfrac{7.37\times10^{-17}\,J}{115\,V} = q = 6.41\times10^{-19}\,C$

25.4 $\qquad K = \frac{1}{2} m_e v^2 = \frac{1}{2}(9.1\times10^{-31}\,kg)(4.2\times10^{5}\,m/s)^2$

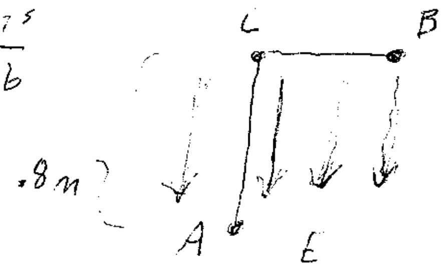
$\Delta K = -q\,\Delta V \qquad q = -1.6\times10^{-19}\,C$

$\Delta V = -.502\,V$

25.6 Remember Lab 2.

$|E| = \dfrac{dV}{dx} = \dfrac{25000\,V}{.015\,m} = 1.67\times10^{6}\,\dfrac{N}{C}$

25.9 Note: $\dfrac{\text{Volts}}{\text{meter}} = \dfrac{\text{Newtons}}{\text{coulomb}}$



$E = -325\,\frac{V}{m}\,\hat{j}$

$\Delta V = -\int_A^B \vec{E}\cdot d\vec{s}$

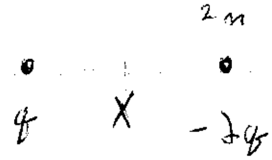
$= -\int_A^C \vec{E}\cdot d\vec{s} - \int_C^B \vec{E}\cdot d\vec{s}$

along $\overline{AC}$ $\quad \vec{E}\cdot d\vec{s} = 325\,\frac{V}{m}\,dy$

$\overline{CB}$ $\quad \hat{j}\cdot d\vec{x} = 0$ (dot product of perp. vectors = 0)

$\Delta V = -\int_A^C E\,dy = -(.8\,m)(-325\,V/m) = 260\,V$

25.18



$$\vec{E} = 0 = \frac{k_e q}{x^2} + \frac{k_e(-2q)}{(x-2m)^2}$$

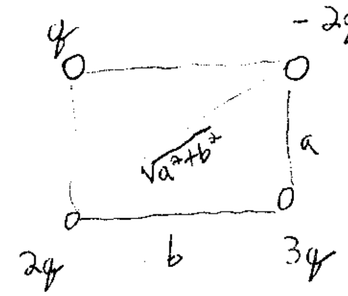
$$(x-2)^2 - 2x^2 = 0 \rightarrow \quad x = -4.83\ m$$

$$V = \frac{k_e q}{x} + \frac{-k_e 2q}{2-x} = 0 \qquad 2-x-2x=0$$

$$x = \frac{2}{3}\ m$$

25.34

$$U = \sum_{ij} \frac{k_e q_i q_j}{r_{ij}} \quad \text{for all } i \neq j$$



$$= k_e q^2 \left[-\frac{2}{.4} - \frac{6}{.2} + \frac{6}{.4} + \frac{2}{.2} + \frac{3}{.447} - \frac{4}{.447} \right]$$

$$= -3.69\ J$$

25.37

$$V(x) = a + bx \qquad a = 10.0\ V \quad b = -7\ V/m$$

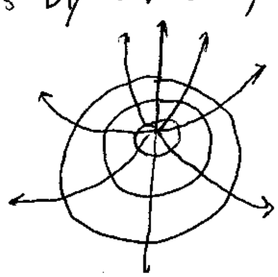
$$V(3.0m) = (10 - 7(3))\ V = -11\ V \qquad V(0.0m) = 10\ V$$

$$V(6.0m) = (10 - 7(6))\ V = -32\ V$$

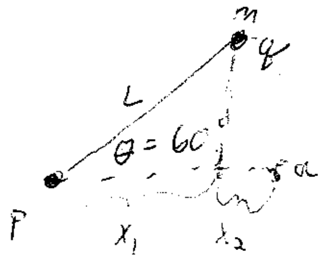
$$E = -\frac{dV}{dx} = -0 - b = 7 \frac{V}{m}$$ positive x direction

25.40 a) the field is larger at point A

b) the potential drops by 2V every 1cm $\frac{\Delta V}{\Delta x} = \frac{2V}{.01m} = 200 \frac{V}{m}$ down



25.14 This is just like a pendulum.



$\longrightarrow \vec{E} = 300\ V/m\ \hat{x}$

see previous problem

$\cos 60° = \frac{x_1}{L}$

$x_1 = \frac{L}{2}$

$x_2 = \frac{L}{2}$

$\Delta V = -\int \vec{E} \cdot d\vec{s} = -\frac{L}{2}\ 300\ V/m$

$\Delta U = q\,\Delta V = -\frac{qL}{2}|E|$

Since electrostatic forces are conservative, the lost potential energy is converted to kinetic energy

$L = 1.5\ m$

$q = 2.0 \times 10^{-6}\ C$

$\Delta K = -\Delta U$

$\frac{1}{2}mv^2 = -\Delta U \qquad v = \sqrt{\frac{qL|E|}{m}} = .3\ m/s$

25.16

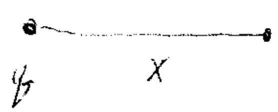
Forces are equal and opposite $\vec{F} = 0 \quad \vec{F} = q\vec{E}$

$\Rightarrow \vec{E} = 0$

$V = \frac{k_e q}{r} \times 2 = 2\left(\frac{2\mu C}{.8m}\right)\left(8.99 \times 10^9 \frac{Nm^2}{C^2}\right)$

$= 4.5 \times 10^4\ V$

25.17



$|E| = 500 \frac{V}{m} = \frac{k_e q}{r^2}$

$k_e q = |E| r^2 = Vr$

$V = -3.00\ kV = \frac{k_e q}{r}$

$r = \frac{V}{|E|} = 6.00\ m$

$q = \frac{r}{k_e}V = -2\mu C$

25.43 a) $\lambda = \alpha x$

$\left[\frac{C}{m}\right] = \alpha [m]$ α has units of $\frac{C}{m^2}$

b) $V = \int_0^L \frac{k_e \lambda}{x+d}\,dx = \int_0^L \frac{k_e \alpha x}{x+d}\,dx$

$w = x+d$
$x = w-d$
$dx = dw$

$$= k_e \alpha \int_d^{L+d} \left(\frac{w}{w} - \frac{d}{w}\right) dw$$

$$= k_e \alpha \quad w\Big|_d^{L+d} - d \ln w \Big|_d^{L+d}$$

$$= k_e \alpha \left(L - d \ln\left(\frac{L+d}{d}\right)\right)$$

25.48

$V = \frac{k_e q}{r}$ $q = \frac{7.5 \times 10^3 V \; (.3 m)}{8.99 \times 10^9 \frac{N \cdot m^2}{C^2}} = 2.5 \times 10^{-7} C$

$N = \frac{q}{e} = \frac{2.5 \times 10^{-7} C}{1.602 \times 10^{-19} C} = 1.56 \times 10^{12}$ electrons

25.52 breakdown occurs when $|E| = 3.0 \times 10^6 \; V/m$ (problem 51)

$V = 600 \; kV$

$r = \frac{V}{|E|} = .200 \, m$

$q = \frac{Vr}{k_e} = 13.3 \; \mu C$