HW Set #4

23-27 Choose $V=0$ at $r=\infty$

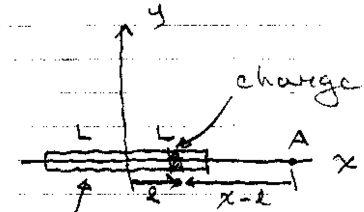
All potential energy $\rightarrow$ kinetic energy when charge moves far away.

Start $(K=0)$ $\quad E = U = k\dfrac{(-0.125C)(1.6\times10^{-19}C)}{(0.75m)}$

finish $(V=0)$ $\quad E = K = \frac{1}{2}m_e v^2$

$$v = \sqrt{\frac{2U}{m_e}} = 2.33\times10^{7}\ \frac{m}{s}$$

23-33



total charge Q $\quad dq = \lambda\, d\ell$

length $= 2L$

charge density $\lambda = \frac{Q}{2L}$

$$V(x) = \frac{1}{4\pi\epsilon_0}\int \frac{dq}{r} = \frac{1}{4\pi\epsilon_0}\lambda\int\frac{d\ell}{r}$$

$dq = \lambda\, d\ell$

$r = x-\ell, \quad -L \le \ell \le L$

$$V(x) = \frac{\lambda}{4\pi\epsilon_0}\int_{-L}^{L}\frac{d\ell}{x-\ell}$$

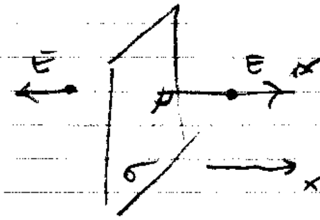
$$= \frac{\lambda(-1)}{4\pi\epsilon_0}\ln(x-\ell)\Big|_{-L}^{L}$$

$$= \frac{\lambda(-1)}{4\pi\epsilon_0}\left[\ln(x-L)-\ln(x+L)\right]$$

$$= \frac{\lambda(-1)}{4\pi\epsilon_0}\ln\left(\frac{x-L}{x+L}\right)$$

$$= \frac{Q}{8\pi\epsilon_0}\ln\frac{x+L}{x-L}$$

23 - 37



constant E field at every point

magnitude:

$$\bar{E} = \frac{\sigma}{2\epsilon_0}$$

direction:

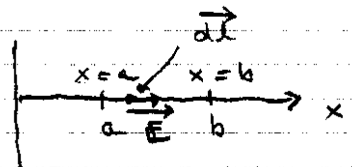
away from plane

(see page 583)

Potential difference from E-field

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

pick $\cancel{l}$ in x-direction: $\vec{dl} = dx\,\hat{i}$ ← unit vector in x-direc.



$$V_b - V_a = -\int_a^b \bar{E}\, dx \underbrace{\cos 0^\circ}_{=1}$$

voltage decreases as x increases

$$-100\,V = -\frac{\sigma}{2\epsilon_0}(b-a) = -\frac{\sigma}{2\epsilon_0} d$$ ← distance

distance: $d = \dfrac{100\,V \times (2\epsilon_0)}{(0.55\times10^{-6}\,C/m^2)}$

$$= 3.2 \times 10^{-3}\,m$$

24 - 9 Want $C = 0.40\,\mu F$

If $d = 4.0\,mm$

What A is necessary?

$$C = \epsilon_0 \frac{A}{d} \qquad p.615$$

$$A = \frac{dC}{\epsilon_0}$$

$$= \frac{(4.0\times10^{-3}\,m)(0.40\,\mu F)}{8.85\times10^{-12}\,C^2/Nm^2}$$

$$= 1.8\times10^{2}\,m^2$$

check units

$$\frac{m \cdot F}{C^2/Nm^2} = \frac{\cancel{m}\left(\frac{C}{\cancel{N}m/C}\right)}{C^2/\cancel{N}m^2}$$

$$= m^2$$

24-11

For a spherical conductor of radius R

$$V = \frac{kQ}{R} \quad \text{at the surface}$$

(choose $V=0$ at infinity)

capacitance:

$$C = \frac{Q}{V} = \frac{R}{k} = 4\pi\epsilon_0 R$$

with $R = 6.38 \times 10^{6}\ m$

$$C = (4\pi)(8.85\times 10^{-12}\ \tfrac{F}{m})(6.38\times 10^{6}\ m)$$

$$= 7.1 \times 10^{-4}\ F$$

about units: notice

$$1\,F = 1\ \frac{C^2}{Nm}$$

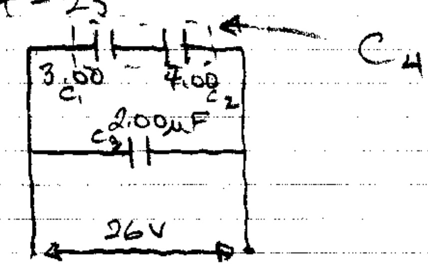
and

$$\epsilon_0 = 8.85\times 10^{-12}\ \frac{C^2}{Nm^2}$$

the way it's given on inside book cover

$$= 8.85\times 10^{-12}\ \frac{F}{m}$$

24-25



a) Equivalent C:

C_1 and C_2 in series

$$C = C_3 + C_4$$

$$= C_3 + \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$

$$= C_3 + \frac{C_1 C_2}{C_1 + C_2}$$

$C_4 = 1.71\mu F$

$$= 2.00\mu F + \frac{12.00}{7.00}\mu F = 3.71\mu F$$

b) Across C_3 and C_4:

$$V_3 = V_4 = 26\,V$$

Now

$$Q_1 = Q_2 = Q_4 = Q$$

So

$$Q = C_4 V_4 = (1.71\mu F)(26V) = 44.6\mu C$$

So

$$V_1 = \frac{Q}{C_1} = 11.1\,V, \quad V_2 = \frac{Q}{C_2} = 14.9\,V$$