Lec 7

Chap 24

13. $U = \frac{Kq}{r}$, $r = 0.15m$

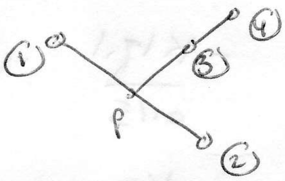
a) $q = 3.3\,nC$

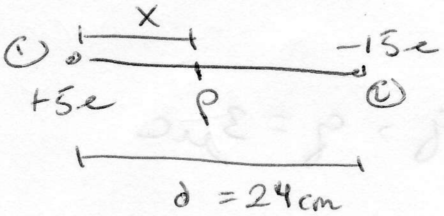
b) charge density → divide by surface area:

$= \frac{q}{4\pi r^2} \cong 12\ nC/m^2$

17. $U_1 = \frac{Kq}{d}$ $U_2 = \frac{Kq}{d}$ $U_3 = -\frac{Kq}{d}$ $U_4 = -\frac{Kq}{2d}$

$U_T = \frac{Kq}{2d}$



19 

$U_1 = \frac{K(5e)}{x}$ $U_2 = \frac{\cancel{K}-K(15e)}{(d \pm x)}$ since x could be positive or negative

and want $U_T = 0$

$\therefore U_1 + U_2 = 0$

$\frac{5Ke}{x} = \frac{+15Ke}{d \pm x}$

$d \pm x = 3x$

$d = +6\ cm, -12\ cm$

43. (d)

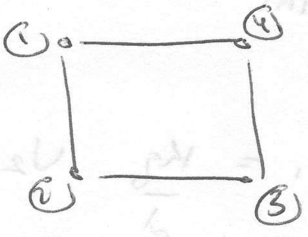
eqn 24-43: $W = U = \frac{kq_1q_2}{r}$ for any pair of charges

take U at ∞ to be zero.

so find U between all pairs of charges in system:

$$U = k\left[\underset{U_{14}}{\frac{-q^2}{a}} \underset{U_{12}}{- \frac{q^2}{a}} + \underset{U_{13}}{\frac{q^2}{\sqrt{2}a}} \underset{U_{23}}{- \frac{q^2}{a}} + \underset{U_{24}}{\frac{q^2}{\sqrt{2}a}} \underset{U_{34}}{- \frac{q^2}{a}}\right]$$

$$= 2kq^2\left(-\frac{2}{a} + \frac{1}{\sqrt{2}a}\right)$$



51. at A: $V_1 = \frac{-k|q_1|}{0.15}$ $V_2 = \frac{kq_2}{0.05}$ $V_T = 6\times10^4$ V

at B: $V_1 = \frac{kq_1}{0.05}$ $V_2 = \frac{kq_2}{0.15}$ $V_T = -7.8\times10^5$ V

c) $\Delta U = U_f - U_i = -W$ and $U = Vq$, $q = 3\mu C$

$= U_A - U_B$

$= q(V_A - V_B)$

$W = 2.52$ J

d) Since bringing the charge closer to another +ve charge, potential energy has increased.

(e) (f) only need U_f and U_i so path is not important

$\therefore$ same work is required.

63. a) $U = Vq$

$= \frac{Kq_1q_2}{r}$, $r = 1m$

$= 0.225$ J

b) $F = \frac{Kq_1q_2}{r^2}$

$= 0.225$ N $= ma$

acceleration on A:

$F = m_a a$, $m_a = 5g$

$a = 45$ m/s^2

on B:

$0.225 = m_B a$

$a = 22.5$ m/s^2

c) Energy and momentum are conserved:

1) $\frac{1}{2}m_a v_a^2 + \frac{1}{2}m_b v_b^2 = 0.225$ J ← kinetic energy

2) $m_a v_a = m_b v_b$ → sub into ①

$v_a = 7.75$ m/s, $v_b = 3.8$ m/s

Chp 25

1. $C = \frac{q}{V}$ ——— $+q$ ——— $-q$

a) $= 3.5$ pF, $q = 70$ pC, $V = 20$ V

b) $C = \frac{200 pC}{20V} = 10$ pF

c) $3.5 \times 10^{-12} = \frac{200 nC}{V}$

$V = 57.1$ V

3. $C = \frac{\epsilon A}{d}$, $A = \pi r^2$

a) ≈ 144 pF

b) $q = CV$, $V = 120$ V

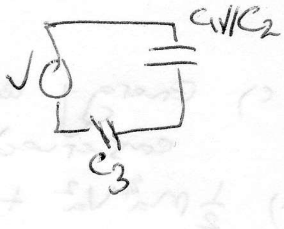
$= 1.7 \times 10^{-8}$ C

(18)

10. $C_T = C_3 + \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1}$

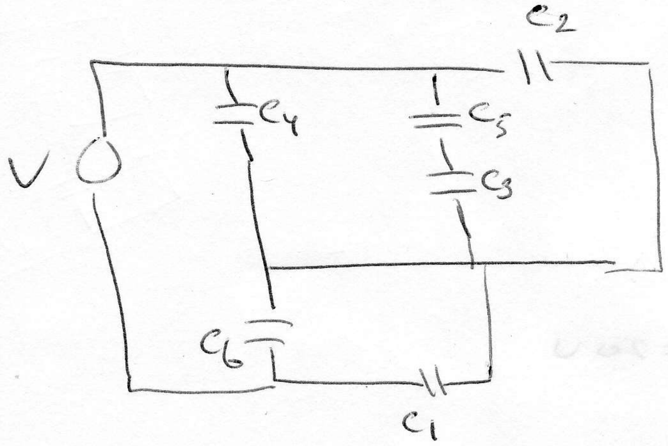
$= 7.3\,\mu F$

11. $C_T = \left[(C_2 + C_1)^{-1} + \frac{1}{C_3}\right]^{-1} = 3.1\,\mu F$

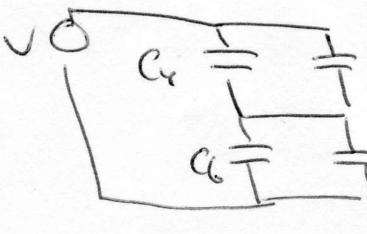


since $C_1 // C_2$ and in series with C_3

15.

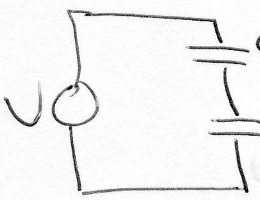


1)



$C_A = \left(\frac{1}{C_5} + \frac{1}{C_3}\right)^{-1} + C_2$

2)



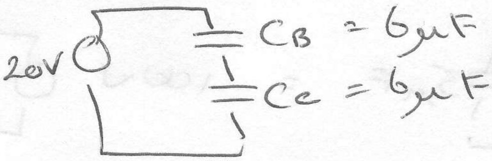
$C_B = C_A + C_4 = 6\,\cancel{pF}\,\mu F$

$C_C = C_1 + C_6 = 6\,\cancel{pF}\,\mu F$

a) so $C_{eq} = \left(\frac{1}{C_B} + \frac{1}{C_C}\right)^{-1} = 3\,\cancel{pF}\,\mu F$

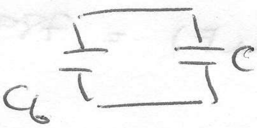
b) $q = C_{eq} V = 60\,\mu C$

15. c) from step 2:



- Since $C_B = C_c$, voltage across each divides evenly and so $V_c = 10\,V$

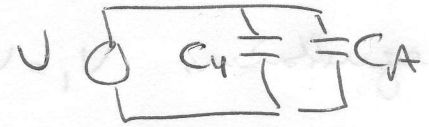
- the C_c element is



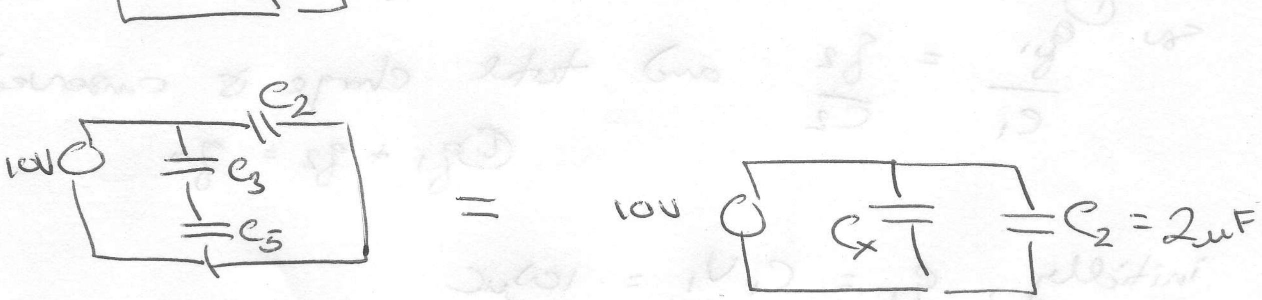
and have same voltage across shunt elements, so $V_{C_1} = 10V$, too

d) $q = C_1 V = 30\,\mu C \quad (V = 10\,V)$

e) volt. across C_B is $10\,V$:



so volt across C_A is $10\,V$.



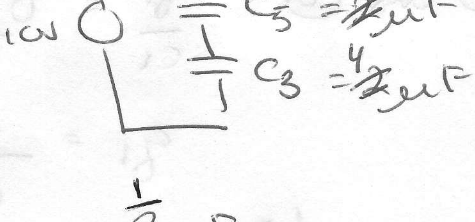
and volt across C_2 is $\underline{\underline{10V}}$

$C_x = \left(\frac{1}{C_3} + \frac{1}{C_5}\right)^{-1}$

$= 2\,\mu F$

f) $q_2 = C_2 V_2 = 20\,\mu C$

g) have 10V across C_x:

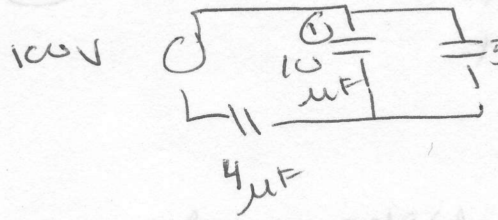


again volt divides evenly

so $V_3 = 5V$ $\quad \left(\text{i.e. } V_3 = \dfrac{\frac{1}{2\mu F}}{\frac{1}{2\mu F} + \frac{1}{2\mu F}} \cdot 10V\right)$

h) $q_3 = C_3 V_3 = 20\,\mu C$

17.



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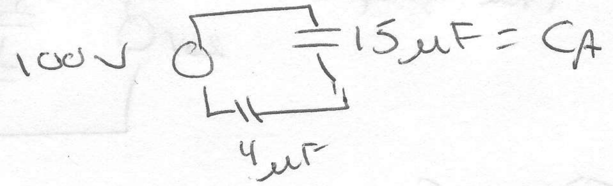


$V_A = V_1 = \left(\frac{15}{15+4}\right)\frac{\mu F}{\mu F}(100V) = 79\ V$

$q_1 = (79V)(10\mu F) = 789\mu C$

c) if no C_3, $V_1 = 100V$ and $q_1 = 1000\mu C$

so increase is $211\mu C$

b) was 79 V up to 100 V so $\Delta V = 21 V$

21. electric potential must reach equilibrium: $V_1 = V_2$

so (1) $\frac{q_1}{C_1} = \frac{q_2}{C_2}$ and total charge is conserved

(2) $q_1 + q_2 = q_0$

initially, $q_1 = C_1 V_1 = 100\mu C$

$q_2 = 300\mu C$

$q_0 = \underline{\underline{200}}\ \mu C$ (since polarities are opposite, must subtract)

new values of q_1

So from (1) and (2) $\frac{q_1}{C_1} = \frac{q_0 - q_1}{C_2}$

$q_1 = \frac{q_0 C_1}{C_1 + C_2} = 5\times 10^{-5} C$

b) and $q_2 = 150\mu C$ to make $q_1 + q_2 = 200\mu C$

a) $V = q_1/C_1 = \frac{q_2}{C_2} = \underline{\underline{50V}}$

29. $U = \frac{1}{2} C V^2$, $U = 10 \text{ kW-h} = (10)(1000)(3600) \text{ W}\cdot\text{s}$

$V = 1000 \text{ V}$

$C = 72 \text{ F}$

31.

$C_{eq} = 6 \mu F$

$U = \frac{1}{2} C_{eq} V^2$

$= 0.27 \text{ J}$

37.

$d = 3\text{mm}$ $V_{initial} = 6V$

$C = \frac{\epsilon A}{d} = \frac{q}{V_{initial}}$

$q = 1.5 \text{ nC}$

(this stays constant)

after 8 mm apart, find new C and V

a) $C = \frac{\epsilon A}{8\text{mm}} = \frac{1.5 \text{ nC}}{V_{new}}$

$V_{new} = 16 \text{ V}$

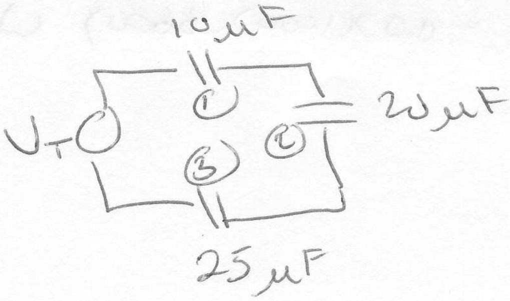
b) $U_i = \frac{1}{2} C_i V_i^2 = 4.5 \times 10^{-9} \text{ J}$

c) $U_f = \frac{1}{2} C_f V_f^2 = 1.2 \times 10^{-8} \text{ J}$

d) $W = \Delta U = U_f - U_i = 7.5 \times 10^{-9} \text{ J}$

(3)

39.



do voltage divider on each cap:

$$V_1 = \left[\frac{\frac{1}{C_1}}{\left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)}\right](V_T) = 100\,V \text{ (max)}$$

$$V_2 = \left[\frac{\frac{1}{C_2}}{\left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)}\right]V_T = 100$$

$$V_3 = \left[\frac{\frac{1}{C_3}}{\left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)}\right]V_T = 100$$

V_1 is limiting factor since C_1 is smallest

so solve for $V_T \rightarrow V_T = \underline{\underline{190\,V}}$

b) $U = \frac{1}{2}C_{eq}V^2$, $V = 190\,V$, $C_{eq} = \left(\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}\right)^{-1}$

$= 0.095\,J$

41. $C = \dfrac{2\pi\epsilon_0\epsilon_r L}{\ln(b/a)}$ no L for per-unit length

$\epsilon_r = 2.6$ (page 669)

$b = 0.6\,mm$ $a = 0.1\,mm$

$= 87\,pF/m$

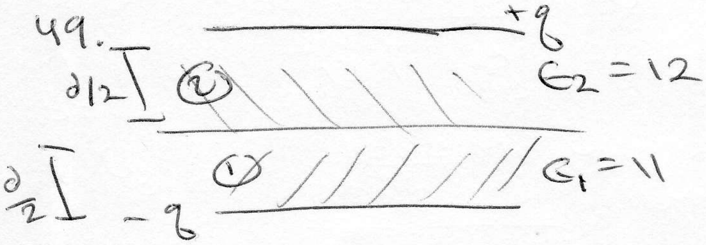
45. $V = \int \bar{E}\cdot d\bar{l} = E\cdot d$

$$= (200\times10^{3})(2\times10^{-3}) = 400\text{ V}$$

$$C = \frac{\epsilon_0\epsilon_r A}{d} = 8.2\times10^{-10}\text{ F}$$

$$U = \frac{1}{2}CV^2 = 66\,\mu\text{J}$$

49.



Gauss' Law in two regions:

① $\int \epsilon_0\epsilon_1 \bar{E}_1\cdot d\bar{S} = q_{encl} = q$

② $\int \epsilon_0\epsilon_2 \bar{E}_2\cdot d\bar{S} = q$

$\therefore |E_1| = \dfrac{q}{\epsilon_0\epsilon_1 A}$ | $|E_2| = \dfrac{q}{\epsilon_0\epsilon_2 A}$

$V_1 = \displaystyle\int_0^{d/2} \bar{E}_1\cdot d\bar{l}$ | $V_2 = \displaystyle\int_{d/2}^{d} \bar{E}_2\cdot d\bar{l}$

$= \dfrac{q\left(\frac{d}{2}\right)}{\epsilon_0\epsilon_1 A}$ | $= \dfrac{q\left(\frac{d}{2}\right)}{\epsilon_0\epsilon_2 A}$

and $C = \dfrac{q}{V_T}$, $V_T = V_1 + V_2 = \dfrac{q\left(\frac{d}{2}\right)}{\epsilon_0 A}\left(\dfrac{1}{\epsilon_1} + \dfrac{1}{\epsilon_2}\right)$

$= 17.3\text{ pF}$