20.1) In Book

20.2) $W = \Delta U = nq\Delta V = (6.02\times10^{23})(-1.6\times10^{-19})(-5-9)$

$= 1.348\times10^{6}$ J

20.4) $\Delta V = E\cdot\Delta r$

$\frac{25{,}000}{.015} = E = 1.6\times10^{6}$ N/c

20.5) In Book

20.7) a) $V_1 = \frac{kq}{r} = \frac{(8.99\times10^{9})(1.6\times10^{-19})}{.01} = 1.44\times10^{-7}$ V

b) $V_2 = \frac{kq}{r} = \frac{(8.99\times10^{9})(1.6\times10^{-19})}{.02} = 7.19\times10^{-8}$

$\Delta V = V_2 - V_1 = -7.21\times10^{-8}$ V

c) same as a+b except $q = -1.6\times10^{-19}$

so $V_{1e} = -1.44\times10^{-7}$

$V_{2e} = -7.19\times10^{-8}$

$\Delta V_e = 7.21\times10^{-8}$

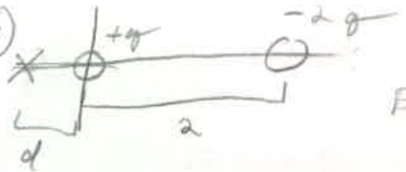
20.8) a) 0, the forces have equal magnitude and opposite direction

b) 0, again, equal magnitude opposite direction

c) Voltage does not have a direction and since the charges are at the same distance from the test charge, we can find Voltage from one and double it.

$V = 2\times\frac{kq}{r} = \frac{2(8.99\times10^{9})(2\times10^{-6})}{(.8)} = 4.5\times10^{4}$ V

20.9) a)



$$E = \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2}$$

$$E = \frac{-k(q)}{d^2} + \frac{k(2q)}{(2+d)^2} = 0$$

$$\frac{1}{d^2} = \frac{2}{(2+d)^2} \qquad (2+d)^2 = 2d^2$$

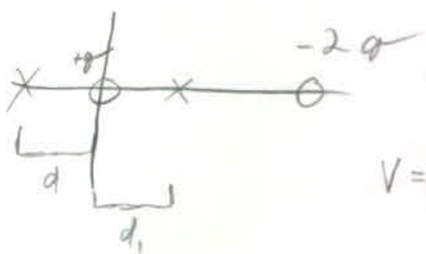
$$-d^2 + 4d + 4 = 0$$

$$\frac{-4 \pm \sqrt{4^2 - 4(-1)(4)}}{-2} = 2 \pm 2\sqrt{2}$$

$2 - 2\sqrt{2}$ is between charges, and field cannot be zero there since they point in the same direction, so

$E = 0$ at $x = -(2 + 2\sqrt{2}) = -4.83\ m$

b)



$$V = \frac{kq_1}{r_1} + \frac{kq_2}{r_2}$$

$$V = \frac{kq}{d} + \frac{k(-2q)}{(2+d)} = 0$$

$$\frac{1}{d} = \frac{2}{(2+d)} \qquad 2 + d = 2d$$

$$2 - d = 0$$

$$d = 2$$

so one point $V = 0$ is $x = -2$

$$V = \frac{kq}{d_1} + \frac{k(-2q)}{(2-d_1)} = 0$$

$$\frac{1}{d_1} = \frac{2}{(2-d_1)} \qquad (2-d_1) = 2d_1$$

$$2 - 3d_1 = 0$$

$$d_1 = 2/3$$

the other point is $x = 2/3$

20.11) In Book

20.20) Closest approach will occur when all Kinetic Energy is converted to potential

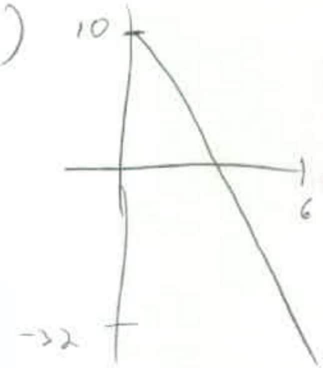
$KE = \frac{1}{2} m_\alpha v_\alpha^2 = \frac{1}{2}(6.64\times10^{-27})(2\times10^7)^2$

$U = q_\alpha V = q_\alpha \frac{Kq_g}{r} = \frac{(2\times1.6\times10^{-19})(8.99\times10^9)(79\times1.6\times10^{-19})}{r}$

When $KE = U$

$\frac{1}{2} m_\alpha v_\alpha^2 = q_\alpha \frac{Kq_g}{r}$ $\qquad r = \frac{2Kq_\alpha q_g}{m_\alpha v_\alpha^2} =$

20.21)



a) $V = a + bx$

$= 10 - 7(x)$

$V(0) = 10$

$V(3) = -11$

$V(6) = -32$

b) $E = \frac{-\partial V}{\partial x} = -b$

$E(0) = 7\ \hat{x}$

$E(3) = 7\ \hat{x}$

$E(6) = 7\ \hat{x}$

20.31) a) $Q = CV = (4\times10^{-6})(12) = 48\times10^{-6}\ C$

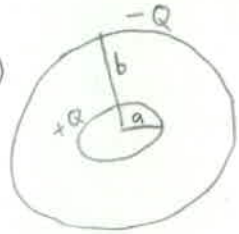
b) $Q = CV = (4\times10^{-6})(1.5) = 6\times10^{-6}\ C$

20.32) a) $Q = CV$ $\quad C = \frac{Q}{V} = \frac{10\times10^{-6}}{10} = 1\times10^{-6}F$

b) $V = \frac{Q}{C} = \frac{100\times10^{-6}}{1\times10^{-6}} = 100\ V$

20.35) In Book

20.38) a)



$C = \frac{Q}{\Delta V}$ so we have to find ΔV

$$\Delta V = -\int_a^b \vec{E}\cdot d\vec{s}$$

USE Gauss' Law

$$\int E\cdot da = \frac{q_{enc}}{\varepsilon_0}$$

$$E\cdot 4\pi r^2 = \frac{+Q}{\varepsilon_0} \quad \text{if } a<r<b$$

$$\Delta V = -\int_a^b \frac{Q}{4\pi\varepsilon_0 r^2}\, dr = \frac{Q}{4\pi\varepsilon_0} r\Big]_a^b = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{b}-\frac{1}{a}\right]$$

$$K = \frac{1}{4\pi\varepsilon_0}$$

$$\Delta V = KQ\left[\frac{a-b}{ab}\right]$$

$$C = \frac{Q}{\Delta V} = \frac{Q\,ab}{KQ[a-b]} = \frac{ab}{K(a-b)}$$ as desired

b) $\Delta V = KQ\left[\frac{1}{b}-\frac{1}{a}\right]$

if $b\to\infty$ $\quad \Delta V = \frac{-KQ}{a}$

so $C = \frac{Q}{|\Delta V|} = \frac{Qa}{KQ} = \frac{a}{K} = 4\pi\varepsilon_0 a$

20.39) a) In Parallel means $C_T = C_1 + C_2 = 5+12 = 17\mu F$

b) potential difference same as battery, 9V

c) $Q = CV$ $\quad Q_1 = (5\mu F)(9V) = 45\times10^{-6}C$

$Q_2 = (12\mu F)(9V) = 108\times10^{-6}C$

20.40) a) In series means $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$

$\frac{1}{C_T} = \frac{1}{5} + \frac{1}{12} = \frac{5+12}{60}$ $\quad C_T = \frac{60}{17}\ \mu F$

c) $\Delta V = 9\,V = V_1 + V_2 = \frac{Q}{C_1} + \frac{Q}{C_2}$

$9 = \frac{Q}{5\times10^{-6}} + \frac{Q}{12\times10^{-6}} = \frac{Q(5\times10^{-6} + 12\times10^{-6})}{(60\times10^{-12})}$

$Q = \frac{9(60\times10^{-12})}{(17\times10^{-6})} = \frac{9(60)}{17}\times10^{-6} = 31.76\ \mu C$

b) $V_1 = \frac{Q}{C_1} = \frac{31.76\times10^{-6}}{5\times10^{-6}} = 6.35\ V$

$V_2 = \frac{Q}{C_2} = \frac{31.76\times10^{-6}}{12\times10^{-6}} = 2.65\ V$

41) In Book

44) a) $C_{23} = C_2 + C_3 = C + 5C = 6C$

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_{23}} = \frac{1}{3C} + \frac{1}{6C} = \frac{2+1}{6C}$

$C_T = 2C$

b) C_1 has to store the same charge as C_{23}
but $C_3 > C_2$ so

$Q_1 > Q_3 > Q_2$

c) $C_1 < C_{23}$ but same charge so by $\Delta V = \frac{Q}{C}$

$\Delta V_1 > \Delta V_{23}$

$\Delta V_1 > \Delta V_2 = \Delta V_3$

alternatively, Q_1 is largest and C_1 smallest
so ΔV_1 is largest, while $\Delta V_2 = \Delta V_3$ since they
are in parallel

44 d) If C_3 increases, C_T must increase so Q_T increases, then Q_1 has to increase so $\Delta V_1 \uparrow$, $\Delta V_2 \downarrow$ and $\Delta V_2 = \Delta V_3 = \frac{Q_2}{C_2} = \frac{Q_3}{C_3}$

Since C_3 increases Q_3 must increase, but Q_2 must decrease since $\Delta V_2 \downarrow$

so $Q_1 \uparrow$ $Q_2 \downarrow$ $Q_3 \uparrow$

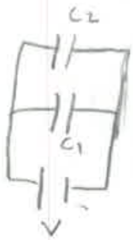
47) a) $U = \frac{1}{2} C V^2 = \frac{1}{2}(3\times10^{-6})(12)^2 = 2.16\times10^{-4}\,J$

b) $U = \frac{1}{2} C V^2 = \frac{1}{2}(3\times10^{-6})(6)^2 = 5.4\times10^{-5}\,J$

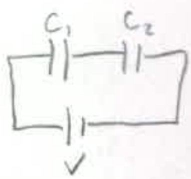
48) $U = \frac{1}{2} C V^2$

$300 = \frac{1}{2}(30\times10^{-6}) V^2$ $\quad V = \sqrt{2\times10^{7}}$

$V = 4.47\times10^{3}\,V$

49) 

a) $U = \frac{1}{2} C_1 V^2 + \frac{1}{2} C_2 V^2 = \frac{1}{2}(30\times10^{-6})(100)^2 = 0.15\,J$

b) 

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{25\times10^{-6}} + \frac{1}{5\times10^{-6}}$

$C_T = \frac{(25)(5)\times10^{-12}}{30\times10^{-6}} = 4.17\times10^{-6}\,F$

$U = 0.15 = \frac{1}{2} C V^2 = \frac{1}{2}(4.17\times10^{-6}) V^2$

$V = \sqrt{\frac{2(0.15)}{(4.17\times10^{-6})}} = 268\,V$

53) a) $C = \frac{\kappa \varepsilon_0 A}{d} = \frac{(2.1)(8.85\times10^{-12})(1.75\times10^{-4})}{4\times10^{-5}} = 8.13\times10^{-11}\,F$

b) $\Delta V_{max} = E_{max}\, d = (60\times10^{6})(4\times10^{-5}) = 2.4\times10^{3}\,V$

$\downarrow$ get from table 20.1

54) $Q_{max} = C\Delta V_{max}$

$\Delta V_{max} = E_{max}\ d$

$C = \frac{\kappa \varepsilon_0 A}{d}$ κ, E_{max} from table 20.1

a) $Q = \frac{\kappa \varepsilon_0 A}{d}(E_{max}\ d) = 1(8.85\times10^{-12})(5\times10^{-4})(3\times10^{6}) = 1.3\times10^{-8}\ C$

b) $Q = \kappa \varepsilon_0 A E_{max} = 2.56(8.85\times10^{-12})(5\times10^{-4})(24\times10^{6}) = 2.7\times10^{-7}\ C$

57) $Q = C\Delta V$

$C = \frac{\kappa \varepsilon_0 A}{d}$ $\kappa = 1$ for air

$Q = \frac{\varepsilon_0 A \Delta V}{d} = \frac{(8.85\times10^{-12})(25\times10^{-4})(250)}{(1.5\times10^{-2})} = 3.69\times10^{-10}\ C$

a) the charge is $3.69\times10^{-10}\ C$ before and after immersion, the plates are charged outside the water, and there is no reason immersion would change the Q already stored

b) $C_I = \frac{\kappa \varepsilon_0 A}{d} = \frac{80(8.85\times10^{-12})(25\times10^{-4})}{(1.5\times10^{-2})} = 1.18\times10^{-10}\ F$

$\Delta V = \frac{Q}{C} = \frac{3.69\times10^{-10}}{1.18\times10^{-10}} = 3.13\ V$

c) $\Delta U = \frac{1}{2} C_I V_I^2 - \frac{1}{2} C_0 V_0^2$

$= \frac{1}{2}\left(\frac{\kappa_{water}\varepsilon_0 A}{d}\right)(V_I)^2 - \frac{1}{2}\left(\frac{\kappa_{air}\varepsilon_0 A}{d}\right)(V_0)^2$

$= \frac{1}{2}\left(\frac{\varepsilon_0 A}{d}\right)(\kappa_{water} V_I^2 - \kappa_{air} V_0^2) = \frac{1}{2}\left(\frac{(8.85\times10^{-12})(25\times10^{-4})}{0.015}\right)(80(3.13)^2 - 1(250)^2) =$

$-4.5\times10^{-8}\ J$

74) Originally $10\mu F$ capacitor has

$Q = C\Delta V = (10\mu F)(15 V) = 150\mu C$

then the battery adds a charge q to each capacitor, and the total voltage drop must be 50 V so

$$V = \Delta V_1 + \Delta V_2$$

$$50 = \frac{q}{5\mu F} + \frac{150\mu C + q}{10\mu F}$$

$$50(10\times10^{-6}) = 2q + 150\times10^{-6} + q$$

$$3q = 350\times10^{-6} \qquad q = 117\times10^{-6}\ C$$

$$\Delta V_1 = \frac{117\mu C}{5\mu F} = 23.3\ V$$

$$\Delta V_2 = \frac{150\mu C + 117\mu C}{10\mu F} = 26.7\ V$$