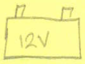
Hwk 4

6| 

positive work must be done on the battery if we hope to get energy from it later on

$W = q(V_B - V_A)$

$W = (3.6\times10^5)(12V - 0V)$

$\boxed{W = 4.32\times10^6\ J}$

8| a) use Conservation of Energy

$\Delta PE = \Delta KE$

$q(V_B - V_A) = \frac{1}{2} m v_f^2$

$\Rightarrow v_f^2 = (2q/m)\,\Delta V$

$v_f = \sqrt{(2q/m)\Delta V} = \sqrt{2(1.602\times10^{-19}C)(120V)/(1.67\times10^{-27}kg)}$

$\Rightarrow \boxed{v_f = 1.52\times10^5\ m/s}$

b) similarly $v_f = \sqrt{(2q_p/m_p)\Delta V} = \boxed{6.50\times10^6\ m/s}$

10| we know: $v_i = 20.1\ m/s$ $q = 5.00\times10^{-6}C$ $m = 2kg$ $t_f = 4.10s$

first, find the acceleration

$y_f - y_i = 0 = \frac{1}{2}at_f^2 + v_i t_f$

$\Rightarrow a = -2v_i/t_f = -9.805\ m/s^2$

now, the force on the ball is

$F = -mg + qE = ma$

but $E = -(\Delta V/\Delta x)$ so

$-mg - q(\Delta V/\Delta x) = m(-9.805\ m/s^2)$

$\Rightarrow q(\Delta V/\Delta x) = -mg + m(9.805\ m/s^2)$

$\Delta V = (m(\Delta x)/q)[-g + 9.805\ m/s^2]$

and Δx = distance ball traveled up before stopping

$\Delta x = \frac{1}{2}at_{1/2}^2 + v_0 t_{1/2}$

$\Delta x = \frac{1}{2}(-9.805\ m/s^2)(2.05s)^2 + (20.1\ m/s)(2.05s) = 20.6m$ (continued)

10) continued...

if we use $g = 9.8\ m/s^2$ we get

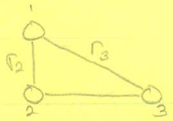
$$\Delta V = [(2kg)(20.6m)/(5\times10^{-6}C)][4.88\times10^{-3}m/s^2]$$
$$= 40.2\times10^3 V = \boxed{40.2\ kV}$$

if we use $g = 9.80665$ we get

$$\Delta V = [(2kg)(20.6m)/(5\times10^{-6}C)][-1.77\times10^{-3}m/s^2]$$
$$= -14.6\times10^3 V = \boxed{-14.6\ kV}$$

↳ this answer is not consistent with a downward electric field!

14)



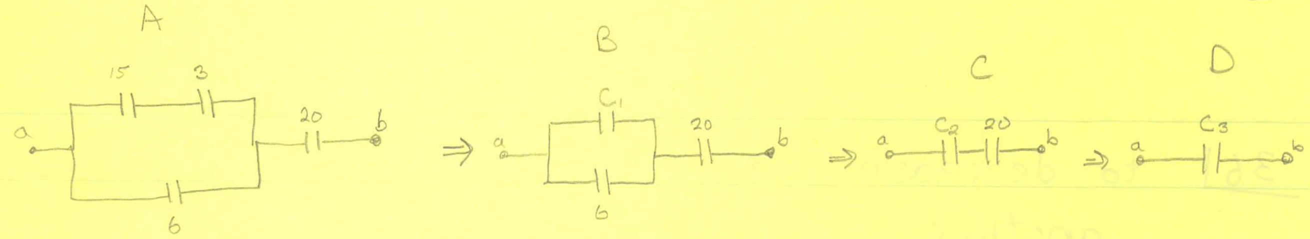
energy to move to infinity = electrostatic potential $\cdot q_1$

$$V_1 = V_{12} + V_{13}$$
$$V_1 = \frac{k_e q_2}{r_2} + \frac{k_e q_3}{r_3}$$
$$r_3 = \sqrt{(3\times10^{-2}m)^2 + (6\times10^{-2}m)^2} = 6.7\times10^{-2}m$$
$$V_1 = (8.988\times10^9\ N\cdot m^2/C^2)[(2\times10^{-6}C)/(3\times10^{-2}m) + (4\times10^{-6}C)/(6.7\times10^{-2}m)]$$
$$V_1 = 1.14\times10^6\ V$$
$$\Rightarrow E = (8\times10^{-6}\ C)(1.14\times10^6\ V) = \boxed{9.12\ J}$$

26)

$$C = \varepsilon_0 A/d$$
$$\Rightarrow d = \varepsilon_0 A/C$$
$$d = \frac{(8.85\times10^{-12}C^2/Nm^2)(21\times10^{-12}m^2)}{(60\times10^{-15}F)} = 3.099\times10^{-9}m = \boxed{30.99\ \text{Å}}$$

33)



a)

to find the equivalent capacitance we make the series of capacitor substitutions shown above

$$C_1 = \left[\frac{1}{15\mu F} + \frac{1}{3\mu F}\right]^{-1} = 2.5\mu F$$

$$C_2 = C_1 + 6\mu F = 8.5\mu F$$

$$C_3 = \left[\frac{1}{C_2} + \frac{1}{20\mu F}\right]^{-1} = \boxed{5.96\mu F}$$

b)

now we must work backwards, using $Q = CV$

$$Q = C_3(15V) = 89.4\mu C$$

this is the charge across each capacitor in picture C, so for the $20\mu F$ capacitor $\boxed{Q_{20} = 89.4\mu C}$ and the voltage across the equivalent capacitor C_2 is given by

$$V_{C_2} = Q/C_2 = (89.4\mu C)/(8.5\mu F) = 10.5V$$

this the voltage across C_1 and the $6\mu F$ capacitor in picture B, so

$$Q_6 = V_{C_2}(6\mu F) = 10.5V(6\mu F) = \boxed{63.1\mu C} = Q_6$$

the charge on the equivalent capacitor C_1 is given by

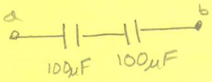
$$Q_{C_1} = V_{C_2} C_1 = (10.5V)(2.5\mu F) = 26.25\mu C$$

which is equal to the charge on either the $15\mu F$ or the $3\mu F$ capacitor, so

$$\boxed{Q_{15} = 26.25\mu C \qquad Q_3 = 26.25\mu C}$$

(over)

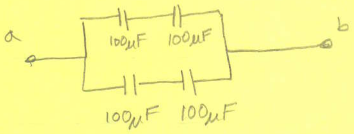
36| to decrease the voltage across the capacitor, add another one in series with it



now each one gets only half the voltage applied across ab, but the capacitance has been reduced to

$C = \left[\frac{1}{100\mu F} + \frac{1}{100\mu F}\right]^{-1} = 50\mu F$

so add more in parallel



now $C = 50\mu F + 50\mu F = 100\mu F$

and if 90V is applied across ab the most voltage across any 1 capacitor is only $\boxed{45\,V}$, which is below its tolerance

59| $E = \frac{1}{2} C \Delta V^2$ energy stored in a capacitor

$\Rightarrow \Delta V = \sqrt{2E/C}$

$\Delta V = \sqrt{2(300J)/(30\times10^{-6} C/V)}$

$\boxed{\Delta V = 4.47\,kV = 4.47\times10^{3}\,V}$

What's a field?

The electric field is ratio of the electric force on a test particle to the electric charge of that test particle. It has a specific value and direction for any given position in space. To measure the strength and/or presence of a non-zero field one must observe a charged object. If no other forces are acting on it (or if the other force acting it can be accounted for) and the charge of the object is known/measured then $\vec{E}$ can be determined from the eqtns of motion.

Tutorial Problem

1. The electric force on the charge would be the same at any of the 3 positions. From the previous question we know that the force is proportional to the electric field, which is the same at 1, 2, and 3.

2. a) the force would be doubled, because the electric force is proportional to q_A and q_B

$F_0 \propto q_A q_B$, $F \propto q_A(2q_B)$

b) the field would be doubled because it is proportional to q_B

$E_0 \propto q_B$ $E \propto (2q_B)$

c) the electric field would be unchanged b/c the field is not dependent on q_A