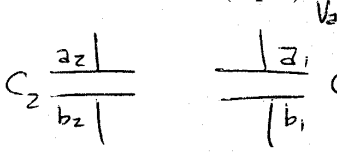
Exam 2, Physics 208 **Name Printed in Ink:** Key Yellow

Prof.Saslow, 7/5/02 **Section:** _____

Don't waste time on problems you aren't sure of. Be clear and concise. A cluttered response will not get full credit.

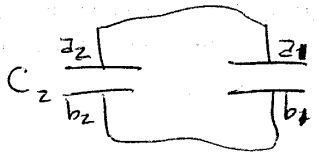
1. Two capacitors $C_1 = 36\ \mu$F and $C_2 = 18\ \mu$F have charges $Q_1 = 12\ \mu$C and $Q_2 = +27\ \mu$C, plates a1 and a2 being +, b1 and b2 being −.
   a. (8 pts) Find the voltage differences and electrical energy for each capacitor.



$V_{a_2}-V_{b_2}$ $\Delta V_1 = \frac{Q_1}{C_1} = \frac{1}{3} = 0.333\text{V}$, $\Delta V_2 = \frac{Q_2}{C_2} = +\frac{27}{18} = +1.5\text{V}$

$U_1 = \frac{1}{2}C_1(\Delta V_1)^2 = 2\mu\text{J}$, $U_2 = \frac{1}{2}C_2(\Delta V_2)^2 = 20.25\mu\text{J}$

   b. (12 pts) Now connect the plates, a1 to a2 and b1 to b2. Find $V_{a1} - V_{b1}$ and $V_{a2} - V_{b2}$, the charges on each plate, and the electrical energy for each capacitor.



C_1 & C_2 are in parallel, with $Q_{a_2} \equiv Q_{a_1} + Q_{b_2} = 27+12 = 39\mu\text{C}$

Then $\Delta V' = +(V_{a_1}-V_{b_1}) = +(V_{a_2}-V_{b_2}) = \frac{Q}{C_1+C_2} = \frac{39}{54} = 0.722\text{V}$

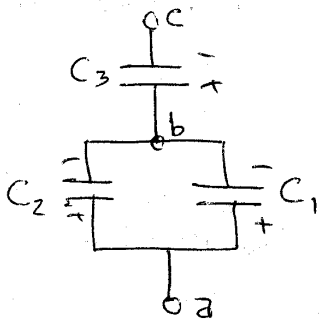
$U_1' = \frac{1}{2}C_1(\Delta V')^2 = 9.39\mu\text{J}$, $U_2' = \frac{1}{2}C_2(\Delta V')^2 = 4.69\mu\text{J}$

$Q_2' = C_2\Delta V_2' = C_2\Delta V' = 13\mu\text{C}$, $Q_1' = C_1\Delta V_1' = C_1\Delta V' = 26\mu\text{C}$

Note: $U_1' + U_2' = 14.08\mu\text{J} = U_{final}$; $U_1 + U_2 = 22.25\mu\text{J} = U_{initial}$

so $U_{final} < U_{initial}$

2. (15 pts) Consider three capacitors. $C_1 = 35\ \mu$F and $C_2 = 55\ \mu$F are in parallel, and $C_3 = 45\ \mu$F is in series with them. $V_c = -30$ V and $V_a = -12$ V. Find the charge and voltage difference for each capacitor. Find V_b.



$C' = C_1 + C_2 = 90\mu\text{F}$

$C = (C_3^{-1} + C'^{-1})^{-1} = (45^{-1} + 90^{-1})^{-1} = 30\mu\text{F}$

$Q = C\Delta V = (30\mu\text{F})(18\text{V}) = 540\mu\text{C}$

$Q_3 = Q$ (top is negative)

$\Delta V_3 = \frac{Q_3}{C_3} = \frac{540\mu\text{F}}{45\mu\text{C}} = 12\text{V}$

Thus $V_b = V_c + \Delta V_3 = -30 + 12 = -18\text{V}$

$\Delta V_1 = \Delta V_2 = V_a - V_b = 6\text{V}$ (top are negative)

$Q_1 = C_1\Delta V_1 = 210\mu\text{C}$

$Q_2 = C_2\Delta V_2 = 330\mu\text{C}$

Note: $Q_1 + Q_2 = 540\mu\text{C} = Q$, as expected