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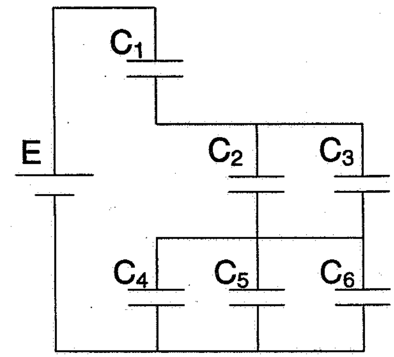
Name: ______________________

Recitation Instructor: Knobbe Morss Parks Potashnik Slaunwhite Stevens

Problem 1, 25 points total. E = 100 V and all capacitors are 20 μF.



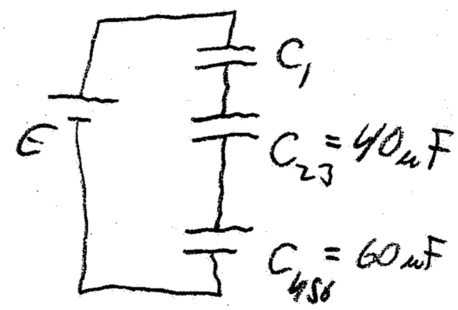
(a) [13 points] How much energy is stored in the capacitor network?

(b) [12 points] Find the voltage across each capacitor.

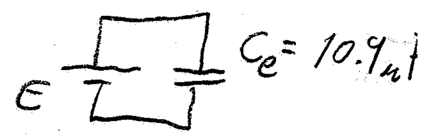
$\mathcal{U} = \frac{1}{2} C_e E^2 = 55\ mJ$ ✓

$V_1 = \frac{q_1}{C_1} = \frac{q_e}{C_1}$ $q_e = C_e E = 1091\ \mu C$

$= 54.5 V$ ✓



$V_2 = V_3 = V_{23} = \frac{q_{23}}{C_{23}} = \frac{q_e}{C_{23}} = 27.3 V$ ✓



$V_4 = V_5 = V_6 = E - V_1 - V_2 = 18.2 V$ ✓

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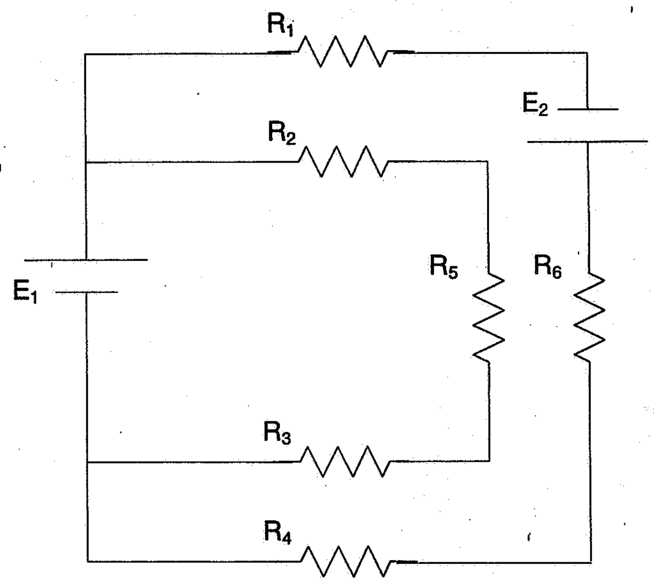
Problem 2, 27 points total.

$E_2 = 10$ V. The current through R_5 is 0.020 A.
$R_1 = 100\ \Omega$, $R_2 = 200\ \Omega$, $R_3 = 300\ \Omega$,
$R_4 = 400\ \Omega$, $R_5 = 500\ \Omega$, $R_6 = 600\ \Omega$.



(a) **[7 points]** What is E_1?

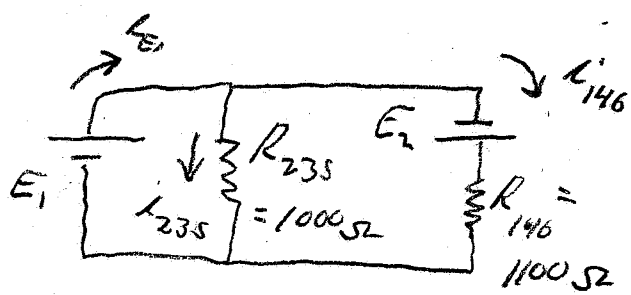
(b) **[7 points]** What is the voltage across R_6?

(c) **[7 points]** How much power is supplied by E_1?

(a) $E_1 = i_{235} R_{235}$

$= (0.020A)(1000\Omega)$

$= 20\ V$ ✓



(b) $V_6 = i_6 R_6 = i_{146} R_6$

$E_1 + E_2 - i_{146} R_{146} = 0$

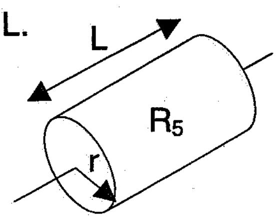
$i_{146} = 27.2\ mA$

$V_6 = 16.4\ V$ ✓

(c) $i_{E_1} = i_{235} + i_{146} = 47.2\ mA$

$P_{E_1} = i_{E1} \mathcal{E}_1 = 944\ mW$ ✓

(d) **[6 points]** Suppose R_5 was in the shape of a cylinder with radius r and length L.



(i) If the radius was doubled the resistance would (circle one):

decrease **remain the same** **increase**

(ii) If the length was doubled the current through R_6 would (circle one):

decrease **remain the same** **increase**

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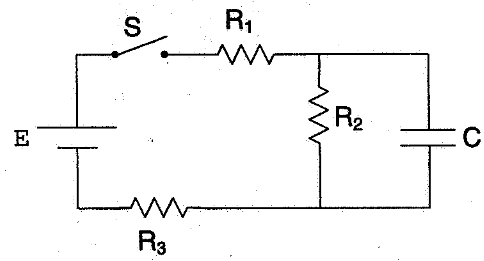
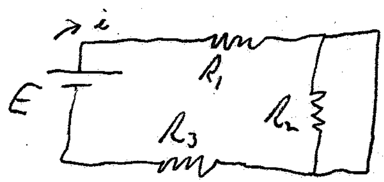


Problem 3, 24 points total. E = 10V, R_1 = 10 Ω, R_2 = 20 Ω, R_3 = 30 Ω, C = 2 μF. The switch is initially open and the capacitor is initially uncharged. The switch is then closed.

(a) [12 points] Immediately after the switch is closed, find:

- V_1 the voltage across resistor R_1.
- i_c = the current through C.
- P = the battery power.



$i = \frac{E}{R_1 + R_3} = 0.25A$

$V_1 = iR_1 = 2.5V$ ✓

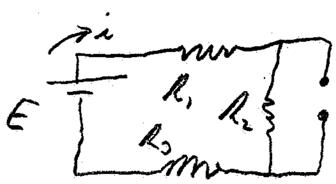
$i_c = i = 0.25A$ ✓

$P = iE = 2.5W$ ✓

(b) [8 points] A long time after the switch is closed, find:

- V_2 = voltage across resistor R_2.
- U = the energy stored by C.

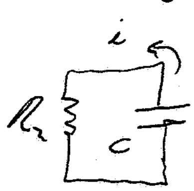
$i = \frac{E}{R_1 + R_2 + R_3} = 0.17A$



$V_2 = iR_2 = 3.3V$ ✓

$U = \frac{1}{2}CV_c^2 = \frac{1}{2}CV_2^2 = 11\mu J$ ✓

(c) [4 points] If the switch was opened again, what would be the time constant for the capacitor discharge?



$\tau = R_2 C = 40\mu s$ ✓

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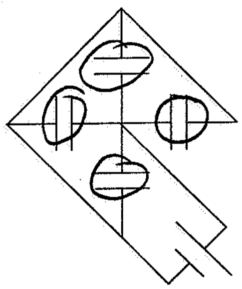
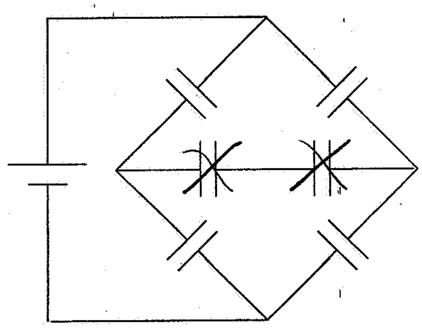
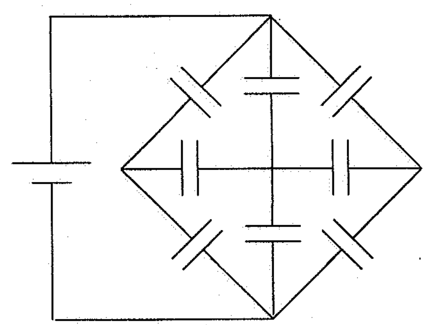
Problem 4, 24 points total. Following are several unrelated questions.

(A) [9 points] For each circuit below: Circle every capacitor that is in parallel with at least one other capacitor; Draw an "X" through every capacitor that is in series with at least one other capacitor.







(B) [15 points] A solid conducting sphere, radius 1.0 cm, is at a potential of 300 V. (Assume a potential reference of V = 0 at infinity.)

(i) What is the potential at the center of the sphere?

$V = 300\,V$ b/c the sphere is an equipotential.

(ii) What is the potential at a distance of 2.0 cm from the center of the sphere?

$V(r) = \frac{kq}{r}$ so $V(2\,cm) = \frac{1}{2} V(1\,cm) = 150\,V$

(iii) What is the net charge on the sphere? (Reminder: $k = \frac{1}{4\pi\varepsilon_o} = 8.99\times10^9 \frac{Nm^2}{C^2}$)

$q = \frac{V(r)\,r}{k}$

$= \frac{(300\,V)(0.010\,m)}{k} = 0.33\,nC$