Test Questions - E III

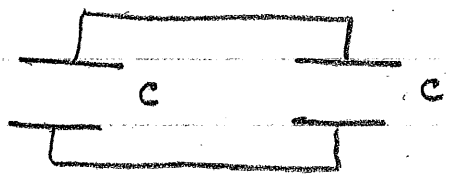
1. Show that in order to place a charge Q on a capacitor C, it is necessary to perform $\frac{Q^2}{2C}$ Joules of work.

2. Show that in a dielectric the energy density in the $\underline{E}$ fields is

$$\eta_E(k) = \frac{1}{2} k \varepsilon_0 E_k^2$$

where $E_k = \frac{\sigma}{k\varepsilon_0}$ and k is the dielectric constant.

3. Given two identical capacitors (C). Charge one to Q and store energy $\frac{Q^2}{2C}$. Next connect the two as shown

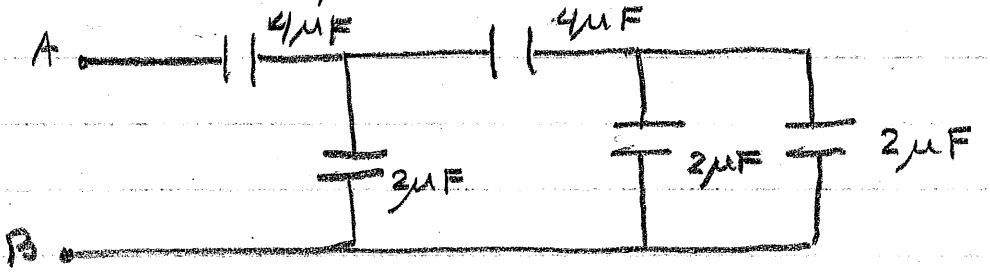


What is the total energy now? What do we learn from this experiment?

4. Given a capacitor filled with a dielectric, $C_k = \frac{k\varepsilon_0 A}{d}$. Connect it to a battery and charge it to $\pm Q_0$. How much energy is stored in C_k? Disconnect battery. Remove the dielectric. Now how much energy in C_0? Where did the extra energy come from.

5. A 100μF capacitor is charged to 40 V. It is allowed to discharge through a resistor (of negligible mass) immersed in 10 gms of water. What is the rise in the temperature of water? [Sp. Ht. of water = 1 cal/gm, Electrical equivalent of heat 4·18 Joule/cal].

6. What is the equivalent capacitance between points A and B?



7. Attach a 12V battery across AB. Calculate the charge on each capacitor.

8. Cu has one free Electron per atom. Its atomic mass is 64 and density is 8·9gm/cm³. What is the total number of mobile electrons in one m^3 of Copper (one mol has 6.02×10^3 atoms and mass of one mol is 64gms).

9. If a Cu wire of diameter 2mm carries a current of 1amp what is the drift speed electrons in the wire?

10. If the wire of Prob 9 is at 300K, what is the thermal r.m.s. speed of the electrons? What causes V_D to be so much smaller than V_{rms}.

11. Show that if you apply an $\underline{E}$-field to a conductor, it responds by setting up a current density

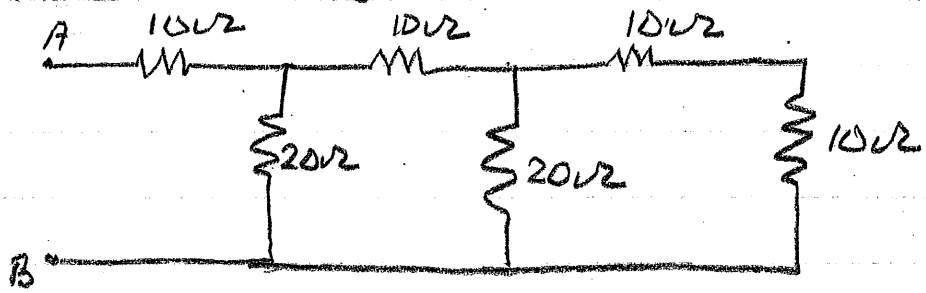
$$\underline{J} = \sigma \underline{E}$$

where σ is the electrical conductivity.

12. A certain wire has a resistance of 0.5Ω. What happens to the resistance if you
i) double its radius leaving length unaltered
ii) halve both length and radius. Why?

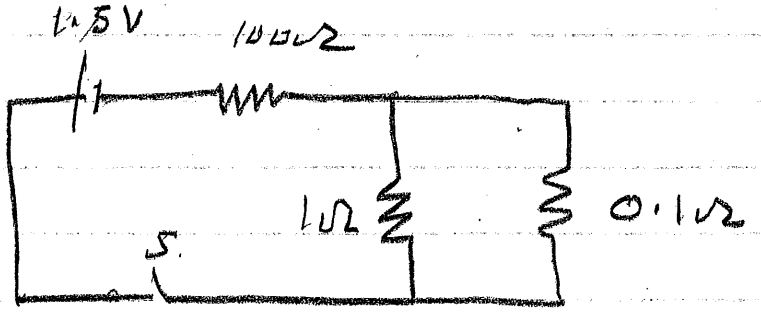
13. Explain the physical bases of Kirchhoff's rules for electrical circuits.

14. Calculate R_{AB}

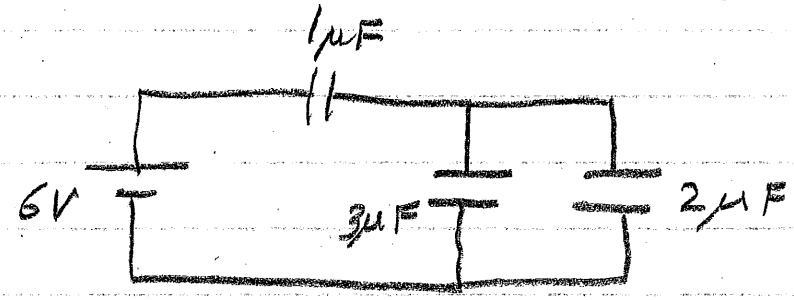


14. If you apply 10V across AB what are the currents in the resistors? Why?

15 When you close the switch which resistor will have i) the smallest current ii) the largest current? Why?



16. In the circuit which capacitor has i) the most charge, ii) the least charge.



17. Show that RC has the dimensions of Time.

18. Why does the characteristic time for an RC circuit depend on both R and C?

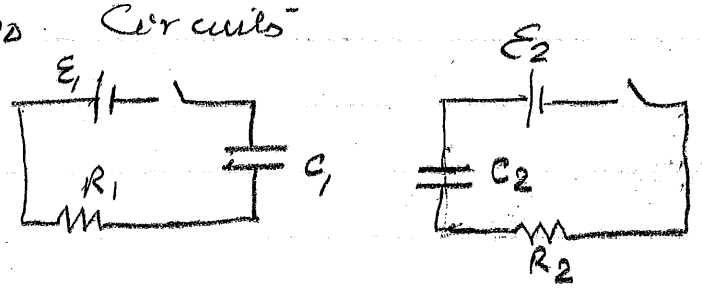
19. Shown are two circuits

$R_1 = 10\,k\Omega$

$C_1 = 20\,\mu F$

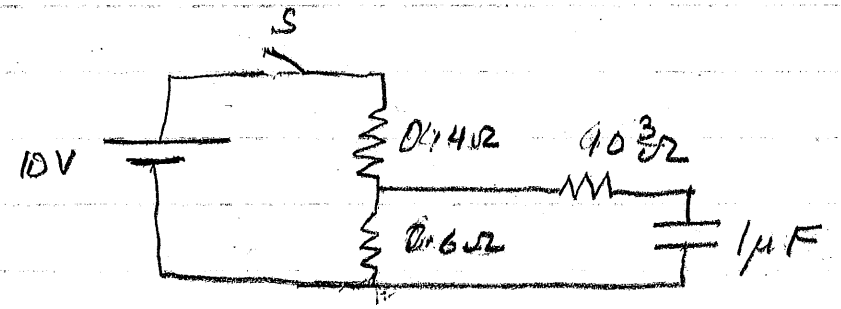
$R_2 = 20\,k\Omega$

$C_2 = 10\,\mu F$



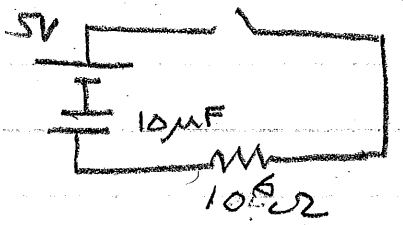
Which capacitor will reach 6 volts first if both switches are closed at t=0 and a) $\varepsilon_1 = \varepsilon_2 = 9$ Volts b) $\varepsilon_1 = 9$ Volts, $\varepsilon_2 = 10$ Volts? Why?

20. In the circuit shown, (i) what is the charge on the capacitor plates a long time after S is closed? Why?

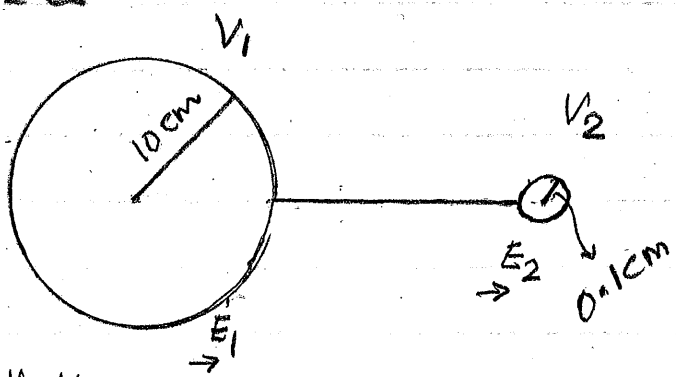


(ii) What is the time constant of the discharge cycle when S is eventually opened? Why?

21. In the circuit shown what is the current between the capacitor plates, immediately after the switch is closed? Why?



22. Two conducting spheres are connected by a copper wire. If you place some charge on this system what will be the relationship between (i) the potentials V_1, V_2 and (ii) the $\underline{E}$-fields E_1, E_2 on the surfaces of the spheres? Why?



23. How do you distinguish between an $\underline{E}$-field and a $\underline{B}$-field given a test charge q?