TEST QUESTIONS – EXAM II (Partial)

1. Sketch the $\vec{E}$ field due to a conducting sphere of radius R ~~and~~ which has a charge Q. (Assume Stationary Conditions).

2. In Prob 1 where is the charge Q located.

3. What is the direction of the $\vec{E}$-field at the surface of a conductor under Stationary conditions.

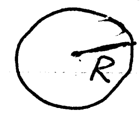
4. We are told that a thin sheet Carrying a uniform charge density σ c/m² will produce an $\vec{E}$-field of $\pm \frac{\sigma}{2\epsilon_0}\hat{n}$ where $\hat{n}$ is perpendicular to the sheet. How would you use two sheets to produce the following field.

$$x < 0 \quad \vec{E} = 0$$

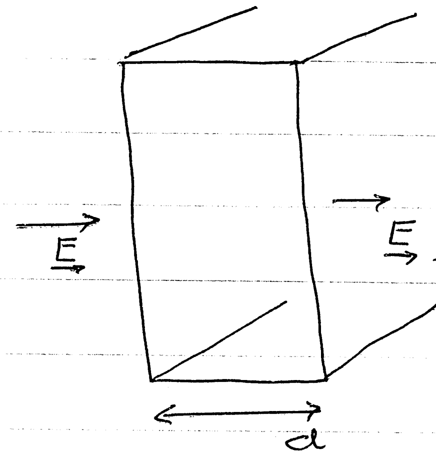
$$0 < x < d \quad \vec{E} = \frac{\sigma}{\epsilon_0}\hat{x}$$

$$x > d \quad \vec{E} = 0.$$

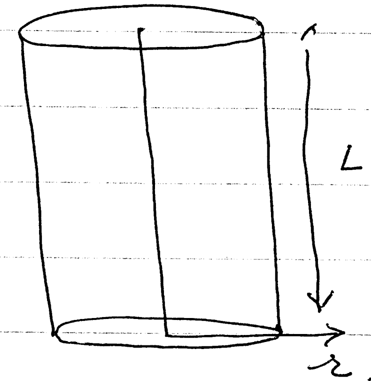
5. Shown is a hollow sphere of radius R which carries a charge Q uniformly distributed on its surface. Show that as r goes from $r<R$ to $r>R$ the $\underline{E}$ field jumps by $\frac{\sigma}{\varepsilon_0}$ where $\sigma = \frac{Q}{4\pi R^2}$.



6. A conductor of thickness d is placed as shown in a uniform $\underline{E}$-field [ie. $\underline{E} \perp$ Surface]. Under stationary conditions what are the charge densities that appear on its surface? Why?



7. A hollow cylinder of radius R carries a charge Q on its surface. Show that as r goes from $r<R$ to $r>R$ the $\underline{E}$-field jumps by $\frac{\sigma}{\varepsilon_0}$ where $\sigma = \frac{Q}{2\pi R L}$. [Assume that L is very large].



8. Why is there a minus sign on the right of these equations:

$$\Delta P = -\sum \vec{F}_E \cdot \Delta \vec{s}$$

$$\Delta V = -\sum \vec{E} \cdot \Delta \vec{s}$$

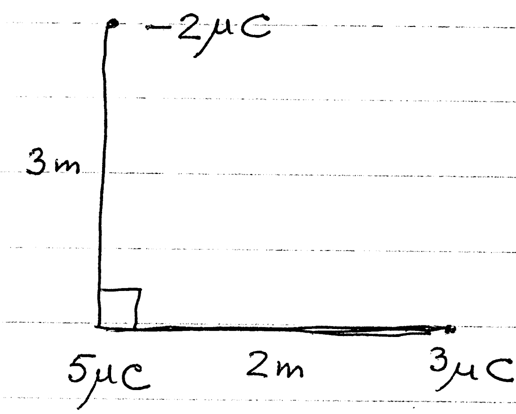
9. Show that the Coulomb Force

$$\vec{F}_E = \frac{q_1 q_2}{4\pi \varepsilon_0 r^2} \hat{r}$$

is a Conservative force.

10. Which potential is larger: 0.1m away from a charge of $10\mu C$ or 0.3m away from a charge of $30\mu C$? why?

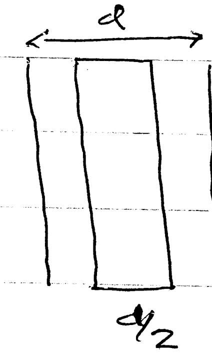
11. Calculate the potential energy of the charge configuration shown here.



12. Sketch the potential due to a charge $-|q|$ placed at $r=0$. Sketch the concomitant potential energy for a) $+q'$, b) $-|q'|$.

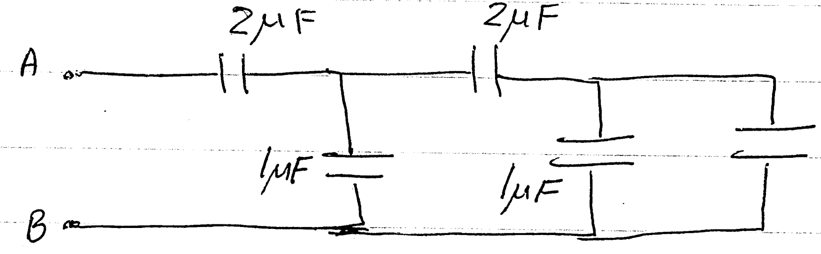
13. Begin with a parallel plate capacitor filled with air. Plate area A, separation d. Put charges $\pm Q$ on the plates. What is the potential difference between the plates?

14. Place a conductor of area A and thickness $\frac{d}{2}$ between the plates of Prob 13. What is the potential difference between the plates? Why?



15. Place a dielectric of thickness d, area A and dielectric const. $k = 2$. ~~What is~~ between: ~~the p~~ the plates of Prob 13. What is the potential difference? Why?

16. What is the capacitance between points A and B



17. Attach a 12V battery across AB. Calculate

the charge on each capacitor.

18. In order to place a charge Q on a capacitor C_0 the battery has to perform $U_E = \frac{Q^2}{2C_0}$ Joules of work. Where does this energy go?

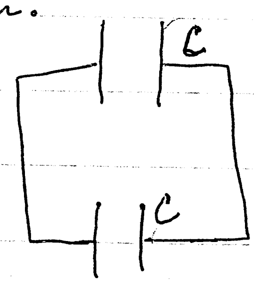
19. Show that an $\vec{E}$-field stores $\eta_E = \frac{1}{2} \epsilon_0 E^2$ Joules/m^3 of energy.

20. Show that in a dielectric, the energy density in the $\vec{E}$-field is

$$\eta_E(k) = \frac{1}{2} k \epsilon_0 E_k^2.$$

where $E_k = \frac{\sigma}{k\epsilon_0}$.

21. 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 expriment?



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

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

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

where σ is the electrical conductivity.

24. A $100\mu F$ capacitor is charged to $40V$. It is allowed to discharge through a resister (of negligible mass) immersed in 10gms of water. What is the rise in the temperature of water caused by the collapse of the $\vec{E}$ field in the capacitor. [sp. ht. of water = 1cal/gm].

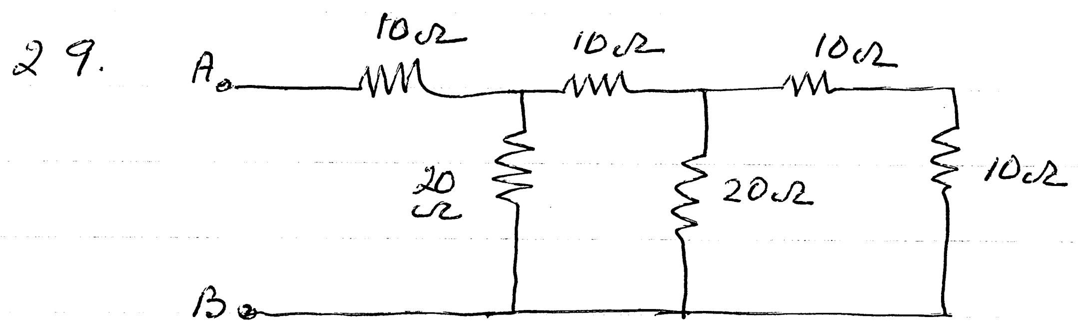
25. Explain the physical basis of Kirchoff's Rules for Circuits.

26. Cu has one free electron per atom. Its atomic mass # is 64 and density is 8.9 gm/cm^3. What is the total "free" charge in One m^3 of Cu. (One mol has 6×10^{23} particles, mass of one mol of Cu is 64gm)

27. A Cu wire of diameter 1mm carries a Current of 5 Amps. What is v_D, the drift speed of electrons in the wire?
($|e| = 1.6 \times 10^{-19}$ C).

28. If the wire 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}.

29.

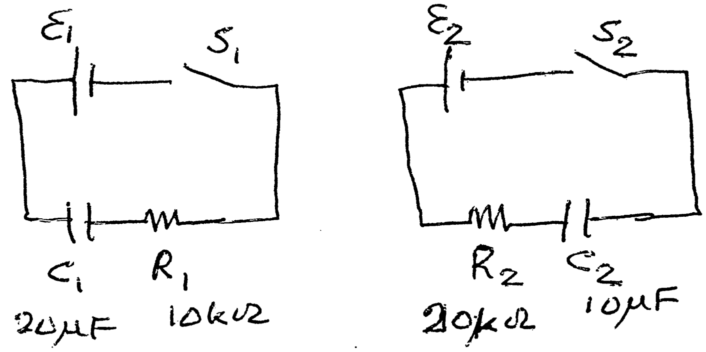


Calculate R_{AB}.

30. If you apply 10 V across AB what are the currents in the resistors.

31. Show that RC has the dimensions of time.

32. Shown are two circuits. Which capacitor will reach 6V first if both switches are closed at $t=0$ and a) $\mathcal{E}_1 = \mathcal{E}_2 = 12$ Volts or (b) $\mathcal{E}_1 = 12$ Volts, $\mathcal{E}_2 = 9$ Volts? Why?



33 An insulating sphere of radius R has a charge Q uniformly distributed over its volume. Show that inside the sphere the $\vec{E}$ field varies as

$$\vec{E} = \frac{1}{\varepsilon_0} \frac{\rho r}{3} \hat{r}$$

where $\rho = \frac{Q}{(\frac{4\pi}{3} R^3)}$ is the charge density.

34. Two conducting spheres are connected by a copper wire. If you place some charge on this system what is the relationship between i) the potentials V_1, V_2 and ii) the E-fields, E_1, E_2 on the surfaces of the spheres.