TEST QUESTIONS - EXAM II (PARTIAL).

1. STATE GAUSS'S LAW IN YOUR OWN WORDS. Write down the Equation and support your answer with a diagram.

2. Given a charge q and a force measuring device how would you discover the presence of an $\vec{E}$-field

3. Show that for a point charge located at $r=0$ the total flux of the $\vec{E}$-field through any closed surface surrounding $r=0$ is $\frac{Q}{\varepsilon_0}$.

4. For a dipole (two equal and opposite charges separated by some length ℓ) the total flux of $\vec{E}$ through any surface surrounding the dipole is zero. Why does a dipole have a non-zero field everywhere.

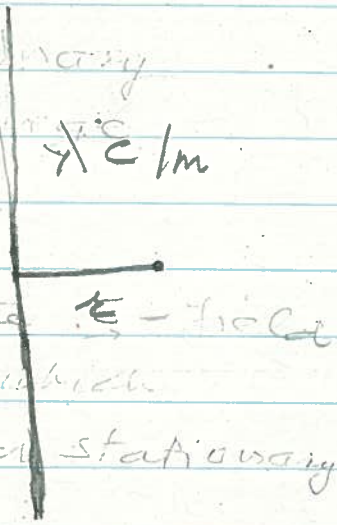
5. Under stationary conditions if you place a charge $-Q$ on a conductor where will the charge reside? Why?

6. For Prob 5 what is the direction of the $\vec{E}$ field on the surface of the conductor.

TEST QUESTIONS - EXAM II (PARTIAL):

7. Write down and plot the E-field due to a conducting sphere of radius R which has a charge Q (assume stationary conditions).

8. In a line charge we have a uniform charge density of λ C/m. Discuss the symmetry of the E-field and use Gauss's law to calculate the $\vec{E}$-field at a distance r_0 from Q under stationary conditions.



9. We are told that a thin sheet carrying a uniform charge density σ C/m^2 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 field:

$\vec{E} = 0$ if $x < 0$ and $x > d$

$\vec{E} = -\frac{\sigma}{\epsilon_0}\hat{x}$ if $0 < x < d$.

10. An insulating sphere of radius R has a charge Q uniformly distributed in it. Prove that the $\vec{E}$-field produced by it is

$$\vec{E}(r) = \frac{\rho r}{3\epsilon_0}\hat{r} \quad \text{for } r < R$$

and

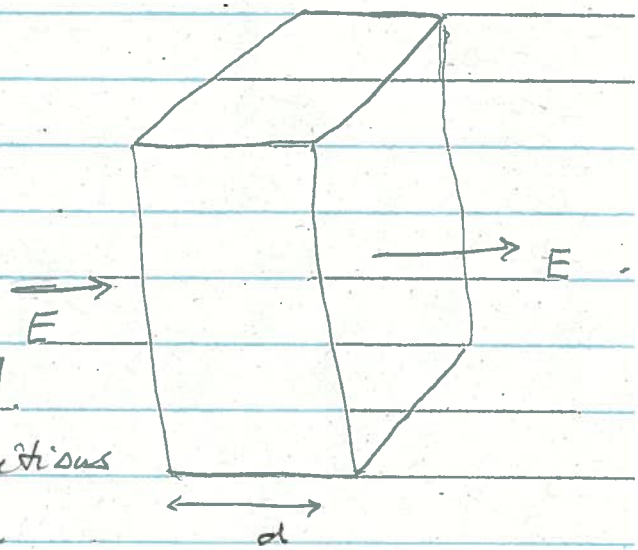
$$= \frac{Q}{4\pi\epsilon_0 r^2}\hat{r} \quad \text{for } r > R$$

where r is the distance from its center.

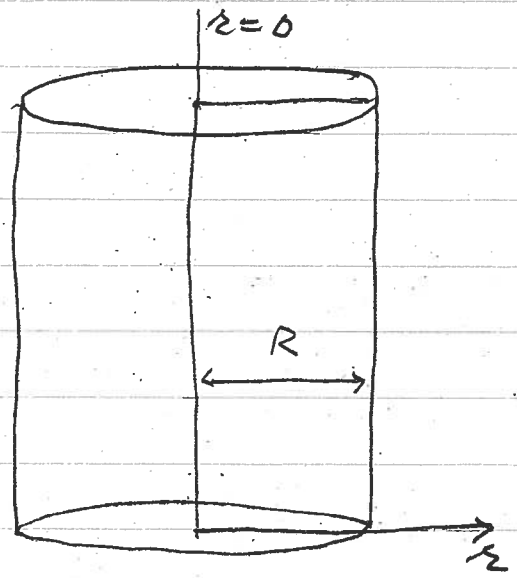
and

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

11. A conductor of thickness d is placed as shown in a uniform $\vec{E}$-field [i.e. $\vec{E} \perp$ surface] under stationary conditions. What are the charge densities that appear on its surface? Why?



12 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 E-field jumps by $\frac{\sigma}{\varepsilon_0}$ where $\sigma = \frac{Q}{2\pi RL}$



(assume that L is very large).

13. What is conservative force? Give one example.

14 What is potential energy? Please dont write mgh.

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

$$\Delta P = -\Sigma \vec{F}_E \cdot \Delta \vec{S}$$

$$\Delta V = -\Sigma \vec{E} \cdot \Delta \vec{S}$$

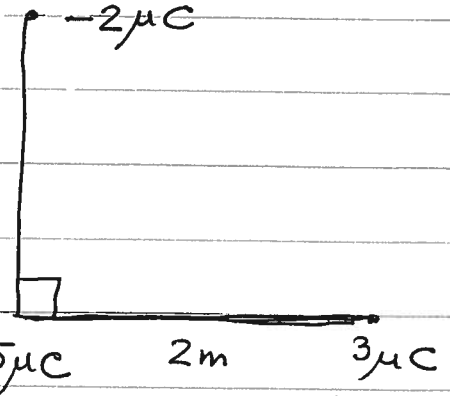
16. Show that the Coulomb Force

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

is a Conservative force.

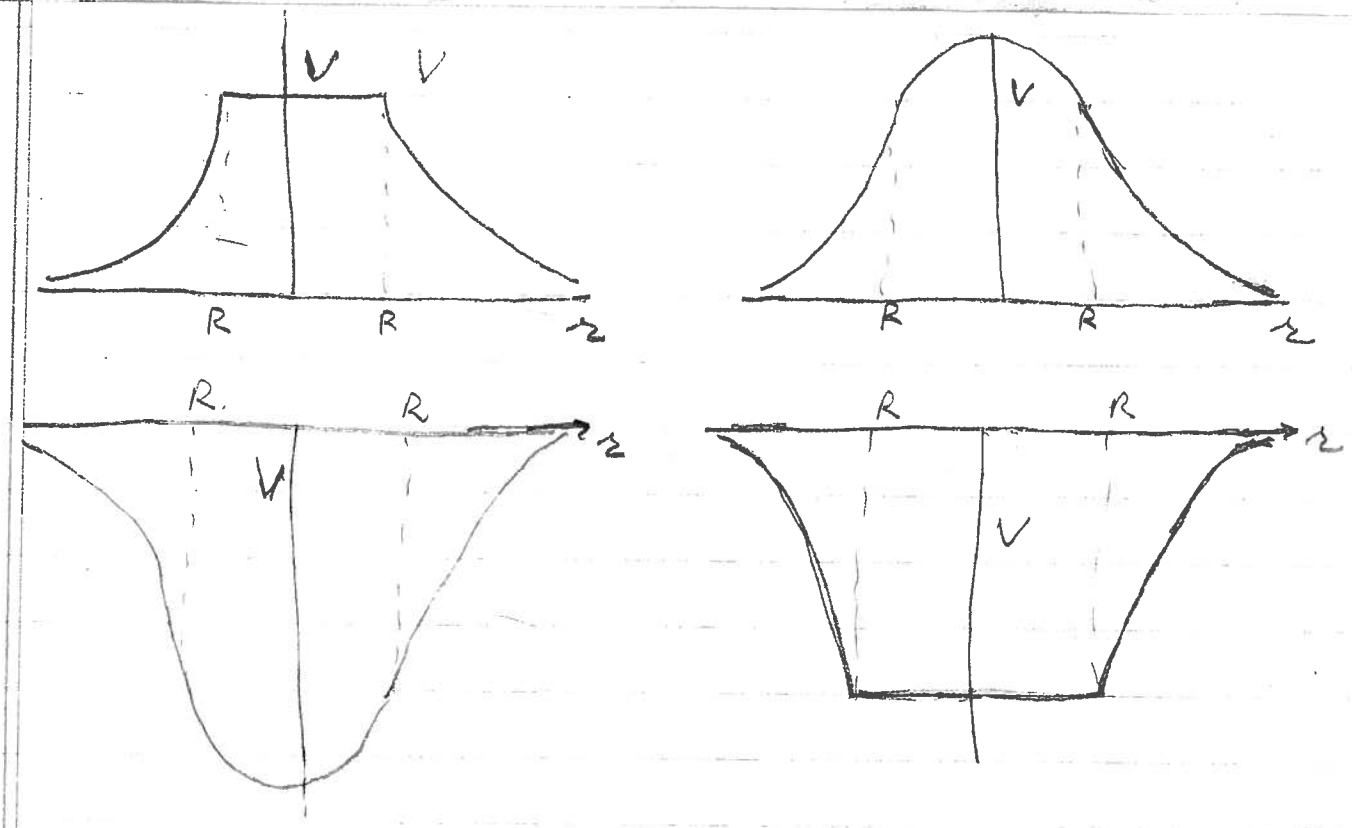
17. Which potential is larger: 0.1m away from a charge of 10μC or 0.3m away from a charge of 30μC? why?

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



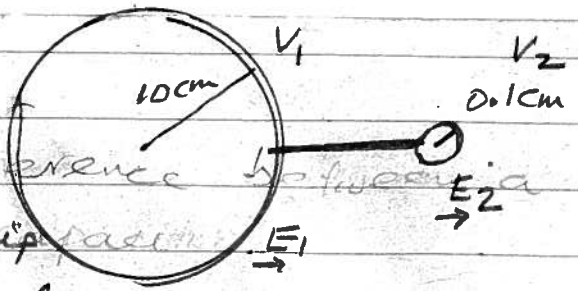
19. Sketch the potential due to a charge $-|q|$ placed at $r=0$. Sketch the concomitant potential energy for a) $+q'$, b) $-|q'|$.

20 The figures shows the variation, with r, of the potential V(r) due to a spherical distribution of charge (of radius R) centered at r=0. Which of the spheres is hollow and which of the charges is negative? Why?



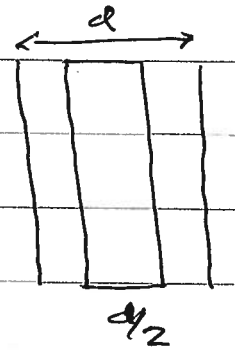
21. Two conducting spheres are connected by a copper wire. If you

21. Place some charge on this system what is the relationship between (i) the potentials V_1, V_2 and (ii) the $\vec{E}$ fields E_1, E_2 on the surfaces of the sphere.



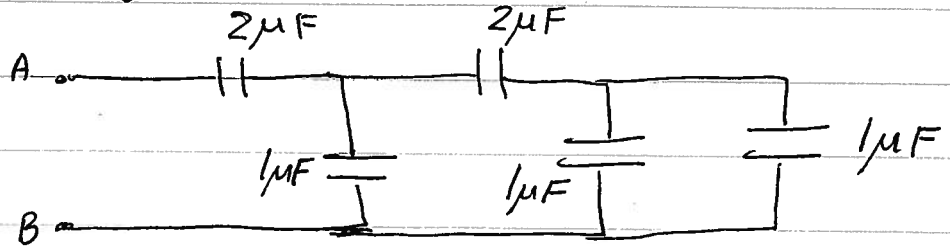
22. Begin with a parallel plate capacitor filled with air. Plate area A, separation d. Put charges ±Q on the plates. What is the potential difference between the plates?

23. Place a conductor of area A and thickness $\frac{d}{2}$ between the plates of Prob 22. What is the potential difference between the plates? Why?



24. Place a dielectric of thickness d, area A and dielectric const. k = 2. ~~What is~~ between the plates of Prob 22. What is the potential difference? Why?

25. What is the capacitance between points A and B



17. Attach a 12V battery across AB. Calculate

the charge on Each capacitor.

26. 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?

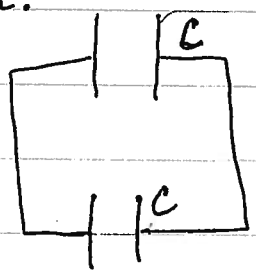
27. Show that an $\vec{E}$-field stores $\eta_E = \frac{1}{2}\epsilon_0 E^2$ Joules/m^3 of energy.

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

29. 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 exprimment?



30 2nd. 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 dielectric. Now how much energy in C_0? Where did the extra energy come from?

31 3rd. 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.

32 4th. A 100μF capacitor is charged to 40V. 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 caused by the collapse of the $\vec{E}$ field in the capacitor [sp. ht. of water = 1 cal/gm].

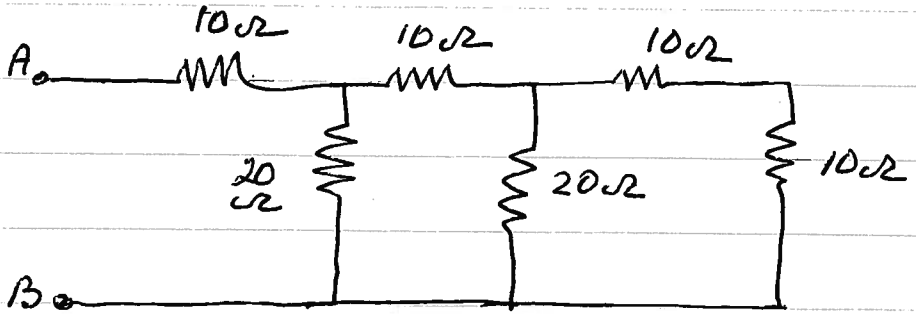
33 5th. Explain the physical basis of Kirchoff's Rules for Circuits.

34 ~~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)

35 ~~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? ($|e| = 1.6\times10^{-19}$ C).

36 ~~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}.

37 ~~29~~.

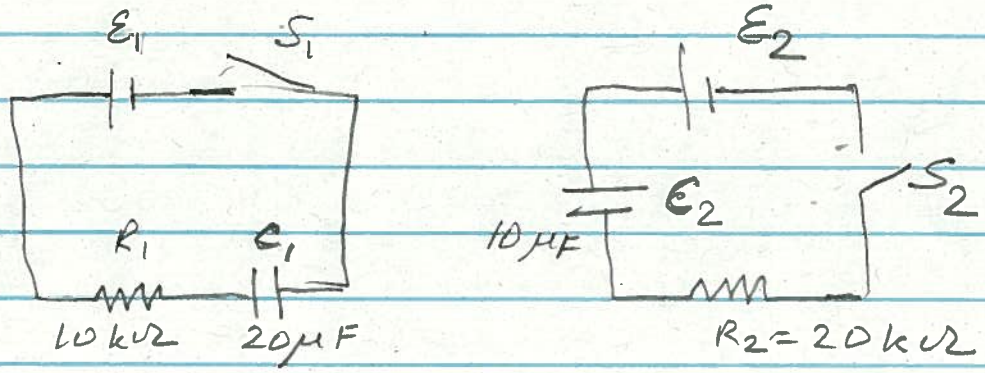


Calculate R_{AB}.

38 ~~30~~. If you apply 10 V across AB what are the currents in the resistors.

39. Show that RC has the dimensions of time.

40 Shown are two circuits



which capacitor will reach 6 Volts 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?