Physics 220

Final Exam

Time : 2:30 hrs.

#1. Using appropriate diagrams and reasoning, define the following terms:

a) Magnetization curve

b) Hysteresis, coercive force, remanence point.

c) Spontaneous magnetization, Curie temperature.

d) Ferromagnetic , antiferromagnetic and Ferrimagnetic.

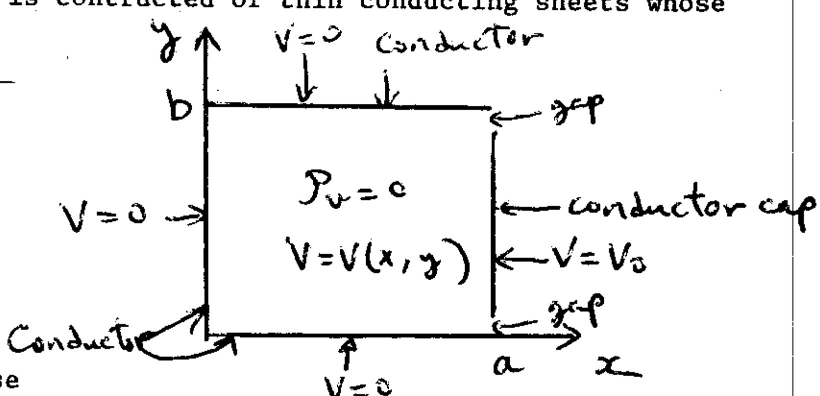
#2. Two circular plates of radius(a) separated by a distance (d) form an ideal capacitor : Assume that the dielectric is a perfect insulator with uniform D-field (i.e. neglect the fringing field at the edge of the plates). The capacitor is being charged by a constant current I.

(a) Find the H-field at a point P on the cylindrical surface of the dielectric.

(b) Find the magnitude and direction of the Poynting vector S at P.

(c) Integrate $\vec{S}.\vec{n}$ over the cylindrical surface of the dielectric, and show that the result is equal to the time rate of change of the stored electrostatic energy.

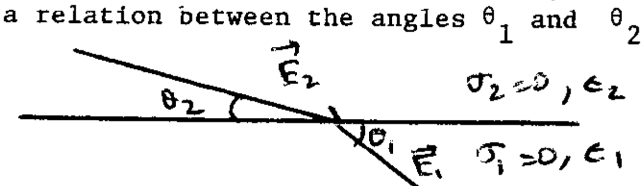
#3. A through of infinite length is contructed of thin conducting sheets whose cross section is shown in the adjacent figure. A conducting lid is placed at x = a , with small gaps between the lid and the trough. If $\rho_v = 0$ within the trough, $V = V_o$ on the lid , and $V = 0$ on the three trough walls, find the expression for V within the trough. (Hint: use the method of separation of variables in rectangular coordinates).



4. A. The magnetic vector potential is given by $\vec{A} = ke^{-\alpha y} \sin \alpha x \ \hat{a}_z$ where k and α are constants. Find $\vec{B}$.

B. Suppose we wish to produce a magnetic field of the form : $\vec{H} = K \sin x \ \hat{a}y$ where K is a constant . Find the current density that will produce this field.

C. Consider the boundary between two perfect dielectrics, as shown in figure. Determine a relation between the angles θ_1 and θ_2.



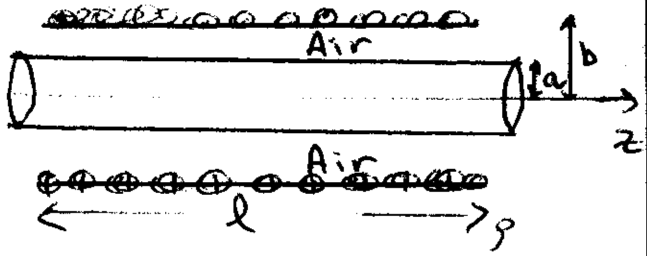
5. Two spherical conductors are located in vacuum. Conductor 1, of radius R, is grounded (i.e. at zero potential). Conductor 2 is so small that it may be treated as a point charge. It bears the charge (q) and is located at a distance (d) from the grounded sphere. What is the charge induced on the grounded sphere ? (Use the method of images and the concept of coefficient of potential).

#6. A closely wound long solenoid has a concentric magnetic rod inserted as shown: In the center region,

Find :

a) $\vec{H}, \vec{B}, \vec{M}$ in both air and magnetic rod.

b) Find $\vec{J}_{sM}$ on surface of rod and $\vec{J}_M$ within rod.



#7. A spherical charge distribution has a volume charge density that is a function only of (r) , the distance from the center of the distribution, i.e. $\rho = \rho(r)$. If $\rho(r)$ is given as below, determine the electric field as a function of r. Integrate the result to obtain an expression for the electrostatic potential $\varphi(r)$, subject to the restriction $\varphi(\infty) = 0$

a) $\rho = \frac{A}{r}$ with A = constant for $0 \leqslant r \leqslant R$;
$\rho = 0$ for $r > R$

b) $\rho = \rho_o$ (i.e. constant) for $0 \leqslant r \leqslant R$

$\rho = 0$ for $r > R$.

#8. Find the force between a point charge (q) and an uncharged conducting sphere of radius (a). The point charge is located a distance (r) from the center of the sphere, where $r > a$. Find an approximate expression valid for $r >> a$.

#9. A uniform electric field $\vec{E}_o$ is set up in a medium of dielectric constant K. Prove that the field inside a spherical cavity in the medium is

$$\vec{E} = \frac{3 K \vec{E}_o}{2 K + 1}$$

#10. A . Given a spherical charge distribution of radius R, uniform charge density ρ_o. Determine the self energy of the distribution by direct integration of

$$U = \frac{1}{2} \int_V \rho(r) \varphi(r)\, dv + \frac{1}{2} \int_S \sigma(r) \varphi(r)\, da.$$

B. A point charge q is located between two parallel, grounded, conducting planes which are separated by a distance (d). Find the locations of the infinite number of image charges. Express the force on charge (q) by an infinite series.