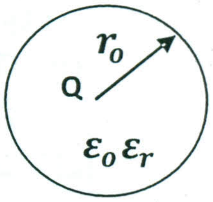
Mansoura University
Faculty of Engineering
Electrical Engineering Dept.

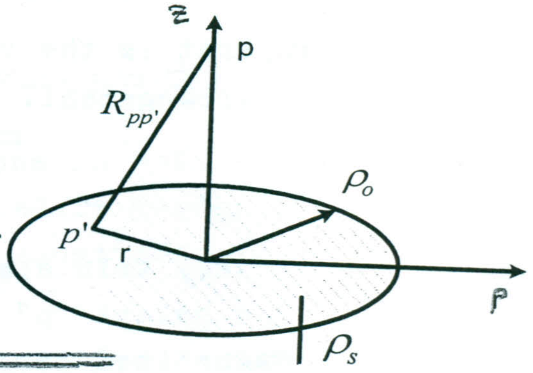
January, 09, 2013, Second Year
ELECTROMAGNETIC FIELDS EXAM
Time Allowed 3 H

Answer All Questions:

(1) **a-** Given is a point charge in the middle point of a dielectric sphere with the relative permittivity ε_r and the radius r_o. Find the electric flux density $\vec{D}$, the electric field intensity $\vec{E}$ and the potential of the field of this arrangement. (The dielectric sphere is in empty space). Draw a sketch of the course of $\Phi_{(r)}$ and $\vec{E}_{(r)}$ against r.



b- Given is a conducting, charged and infinitely thin disk with the homogeneously distributed surface charge density ρ_s in the vacuum. The radius of the disk is ρ_o. Find the potential and the electric field intensity $\vec{E}$ on the axis of the disk as shown in figure. Draw a graphical sketch for the course of ϕ and $\vec{E}$.



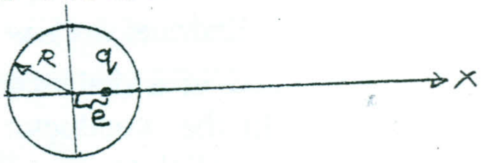
(2) **a-** Two parallel infinitely great conducting plates in the y, z directions are located at x = −d and x=+d. The space between them is filled with a dielectric medium with a space – dependent permittivity $\varepsilon = 4\varepsilon_0 \Big/ \left(\frac{x}{d}\right)^2 + 1$.

The plate at x = d is held at a time-independent potential difference V_0 with respect to the plate at x= −d.

(i) Find the electric field and the potential distribution between the plates.

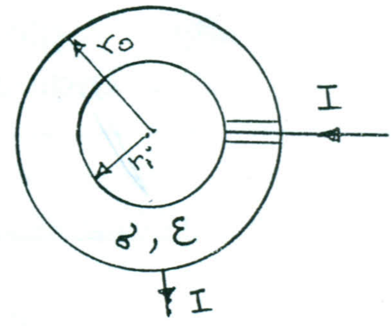
(ii) Find the polarization $\vec{P}$ and the density of polarization charge ρ_p.

b- Given is a point charge q, which exists eccentric in a conducting hollow sphere as illustrated. Find ϕ, $\vec{E}$ and $\vec{D}$ at any arbitrary point in the field space.



P.T.O.

(3) a- Given are two concentric sphere shells having the radii r_i and r_o ($r_o > r_i$). The material of both shells is of a very high coductivity ($\delta \simeq \infty$) and between them exists a good coducting material having the constant conductivity "δ" and the constant dielectric permittivity "ε".



(i) Calculate $\vec{J}$, $\vec{E}$, $\vec{D}$ and ρ_v within the material, if a current "I" is lead to the inside electrode and is taken off again at the outside electrode. Calculate also the resistance between both electodes.

(ii) What is the value of the so called time constant of the arrangement?

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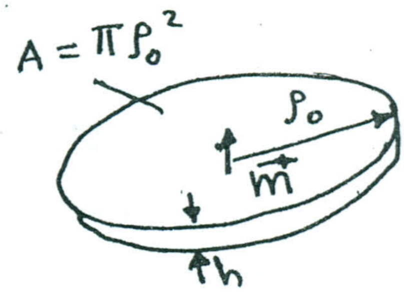
b- A very thin disk of the radius "ρ_0" and the height "h" ($h \ll \rho_0$) is homogeniously magnetized perpendicular to it's area ($\vec{M} = M\,\vec{a}_z$).



i) How great should a current flowing at it's edge be to produce the same magnetic field?

ii) How great is the magnetic moment of the disk?

iii) How great are $\vec{B}$ and $\vec{H}$ at the middle point of the disk?

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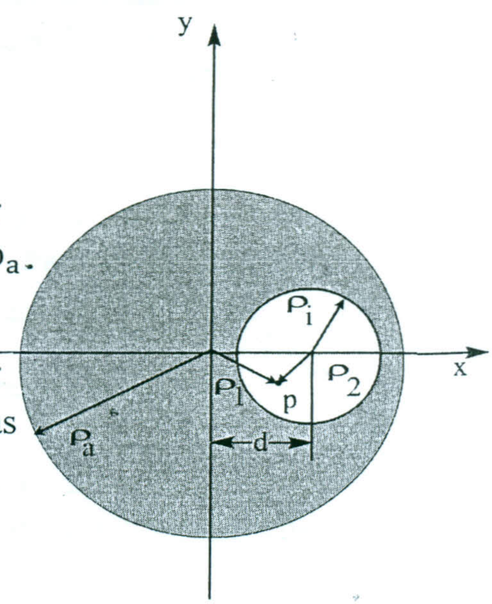
(4) a- A cylindrical conductor of the radius ρ_a has a cylindrical formed hollow space of radius ρ_i . The axis of the cylindrical conductor and the cylindrical hollow space are parallel to each-other and in a distance d to each-other, where $d+\rho_i<\rho_a$. In the conductor flows the d.c. current I parallel to the axis of the arrangement and homogenously distributed on the whole conductor area. Calculate the magnetic field in the hollow as well as in the conductor.



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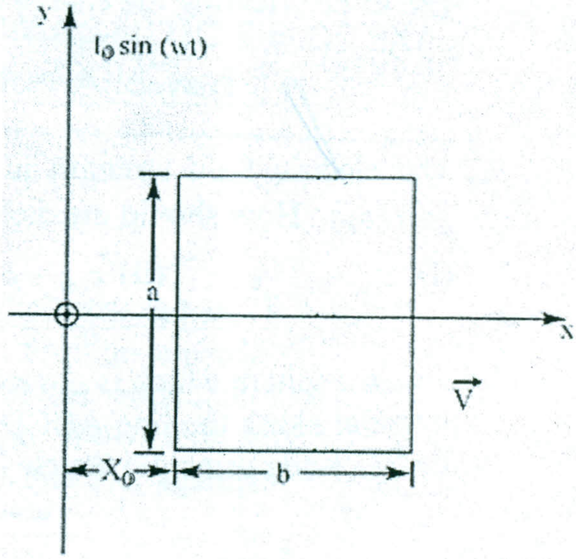
4- b-

An alternating current $i = I_0 \sin(\omega t)$ flows in an infinitly long straight line existing in vacuum.
At a distance x_0 from the wire exists a rectangular closed loop as illustrated.
<u>Calculate</u> the induced e.m.f. in the loop, if the loop is moved by the velocity $\vec{V} = V\,\vec{a}_x$ in the x direction.



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(5) a- Write the complete Maxwell´s equations in both integral and differential forms giving the boundary conditions to be satisfied as well as the material equations.

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b- <u>The complex vectors:</u>

$$\vec{E} = \vec{A}\, e^{-j\beta_1 x}\ \vec{a}_y$$

$$\vec{H} = \sqrt{\frac{\varepsilon_{r_1}\varepsilon_0}{\mu_0}}\vec{A}\, e^{-j\beta_1 x}\ \vec{a}_z = \frac{1}{\eta_1}\vec{A}\, e^{-j\beta_1 x}\ \vec{a}_z$$

describe an incident (in the positive x direction) propagating wave in a non-conducting dielectric ($\varepsilon = \varepsilon_0\varepsilon_{r_1}$, $\mu = \mu_0$) with the phase constant β_1 and the wave impedance η_1. This wave strikes at $x = 0$ another not conducting dielectric having the material parameters $\varepsilon = \varepsilon_0\varepsilon_{r_2}$, $\mu = \mu_0$, which fills the whole half space $x \geq 0$.
Calculate the wave fields in both regions $x \leq 0$ and $x \geq 0$.

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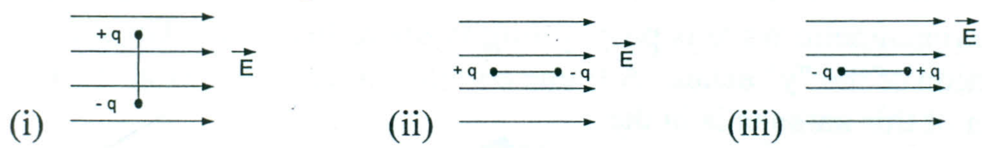
(6) <u>Give the correct answer out of the following statements:</u>

(A) An electric dipole takes the stable equilibrium position in a homogeneous electric field as shown in fig.



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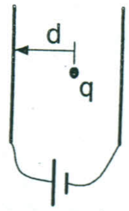
(6)

(B) A charge "q" exists in the field of an infinitely great plate capacitor. The force affecting the charge is

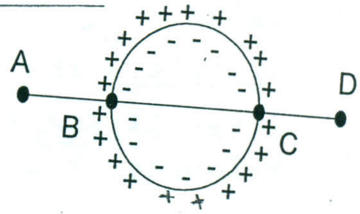


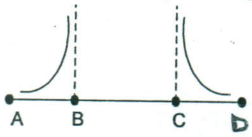
(i) $\neq f(d)$ (ii) $\sim 1/d$ (iii) $\sim 1/d^2$

(C) The electric field strength in a cylindrical capacitor should be attained constant ($\neq f(\rho)$). How should the dielectric constant ε(ρ) be chosen

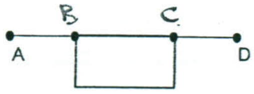
(i) $\varepsilon_{(\rho)} \sim 1/\rho^2$ (ii) $\varepsilon_{(\rho)} \sim \rho$ (iii) $\varepsilon_{(\rho)} \sim 1/\rho$

(D) Given a sphere which is covered with surface dipoles. The potential along the line ABCD will be measured. Thereby the following principle course is given.

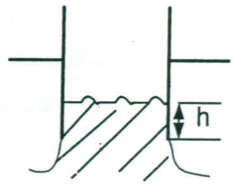


(i) 

(ii) 

(iii) 

(E) The hight "h" of a liquid dielectric in a plate capacitor is by a constant voltage "U"

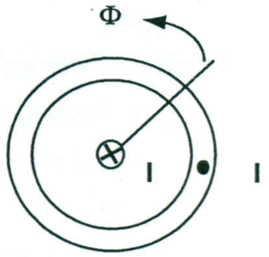


(i) $h \sim E^2$ (ii) $h \sim D^2$ (iii) $h \sim Q^2$

(F) Given a spherical capacitor filled with mineral oil $\varepsilon > \varepsilon_0$. What happens to the energy of the capacitor if the liquid is let off from the capacitor where Q remains constant?

(i) $W > W_{oil}$ (ii) $W < W_{oil}$ (iii) $W = W_{oil}$

(G) Given is a coaxial cable having the current "I" as illustrated. The magnetic field intensity "H_Φ" at the inside space is

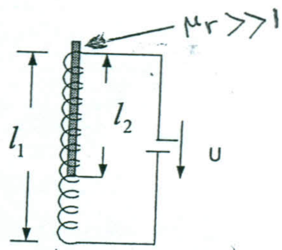


(i) $H_\Phi > 0$ (ii) $H_\Phi < 0$ (iii) $H_\Phi = 0$

(H) What is valid for the penetration depth δ

(i) $\delta \sim 1/\varpi$ (ii) $\delta \sim 1/\sqrt{\varpi}$ (iii) $\delta \neq f(\varpi)$

(I) In the arrangement, an equilibrium state is achieved for



(i) $l_2 > l_1$ (ii) $l_2 < l_1$ (iii) $l_2 = l_1$

(J) A plane electromagnetic wave is propagating in the x direction. The electric field has the direction of the "y" aches. A frame coil is used as a receiving antenna. The best situation of this antenna is in the

(ii) xy plane (ii) xz plane (iii) yz plane