

國立交通大學九十學年度碩士班入學考試試題

科目名稱：電磁學(253)

考試日期：90 年 4 月 21 日 第 2 節

系所班別：電子物理學系

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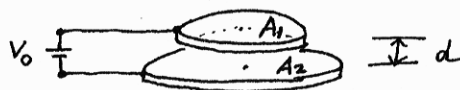
*作答前, 請先核對試題、答案卷(試卷)與准考證上之所組別與考試科目是否相符!!

(A) Multiple Choice (5% each)

1. A capacitor consists of two parallel conducting circular discs of areas A_1 and A_2 . The discs are separated by a distance d , with $A_1 < A_2$, and $d \ll \sqrt{A_1}, \sqrt{A_2}$ (see Fig. 1). A potential difference V_0 is maintained across the capacitor. The attractive force between the discs is

(a) $\epsilon_0 V_0^2 A_1 / (2 d^2)$, (b) $\epsilon_0 V_0^2 d^2 / (2 A_2)$, (c) $\epsilon_0 V_0^2 A_1 / d^2$, (d) $\epsilon_0 V_0^2 A_2 / d^2$, (e) $\epsilon_0 V_0^2 \sqrt{A_1 A_2} / d^2$.

Fig. 1



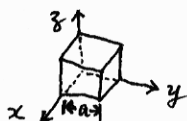
2. The principle of conservation of electric charge must be satisfied at all times and under any circumstances. It is represented mathematically by the equation of continuity that can be derived from

(a) Gauss's Laws for both the electric field and the magnetism,
 (b) Faraday's Law and the Ampere's Law,
 (c) Ampere's Law and the Gauss's Law for the electric field,
 (d) Gauss's Law for the magnetism and the Faraday's Law,
 (e) Faraday's Law and the Gauss's Law for the electric field.

3. An empty cubic box is made up of conducting walls. The length of the sides is a (see Fig. 2). All of the walls except the one at $z = 0$ are grounded. The electric potential inside the box might have a form represented by

(a) $\cos(\pi x/a) \sin(\pi y/a) \sinh(\sqrt{2}\pi(a+z)/a)$,
 (b) $\sin(2\pi x/a) \sin(\pi y/a) \sinh(\sqrt{2}\pi(a-z)/a)$,
 (c) $\cos(\pi z/a) \sin(\pi x/a) \sinh(\sqrt{2}\pi(a+y)/a)$,
 (d) $\sin(\pi x/a) \sin(2\pi y/a) \sinh(\sqrt{5}\pi(a-z)/a)$,
 (e) $\sin(2\pi x/a) \sin(\pi y/a) \sinh(\sqrt{3}\pi(z-a)/a)$.

Fig. 2



4. A particle having a magnetic moment $\vec{\mu}$ experiences a magnetic force due to an external magnetic field $\vec{B}$. The force is given by $\vec{F} = \vec{\nabla}(\vec{\mu} \cdot \vec{B})$. If $\vec{\mu} = \mu_0 \hat{x}$ and $\vec{B} = -(A_0/y) \hat{x}$, the magnetic force will be

(a) zero, (b) $(A_0 \mu_0 / y) \hat{x}$, (c) $(A_0 \mu_0 / y^2) \hat{y}$, (d) $-(A_0 \mu_0 / y^2) \hat{x}$, (e) $-(2A_0 \mu_0 / y^3) \hat{y}$,

5. The electric field of an electromagnetic wave is given by $\vec{E}(\vec{x}, t) = E_0 \cos(ax + bt) \hat{z}$, where a, b are positive constants. Which statement is correct?

(a) The magnetic field is $\vec{B} = (E_0 a / b) \cos(ax + bt) \hat{y}$.
 (b) The velocity of the wave is $(b/a) \hat{z}$.
 (c) The Poynting vector $\vec{S} = E_0^2 a / (\mu_0 b) \sin(ax + bt) \cos(ax + bt) \hat{x}$, where μ_0 is the permeability of free space.
 (d) The wavelength of the wave is $2\pi/b$.
 (e) The polarization of the wave is along $\hat{y}$.

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6. A conducting rod of length $l = 0.60$ m rotates with a constant angular speed $\omega = 3.0$ rad/s about a pivot at one end. A uniform magnetic field (magnitude $B = 1.2$ T) is directed perpendicular to the plane of rotation (see Fig. 3). The potential of the moving end relative to the pivoting end of the rod, $V_M - V_P$, is
 (a) +1.3 V, (b) -1.1 V, (c) +0.65 V, (d) -1.9 V, (e) +0.43 V.

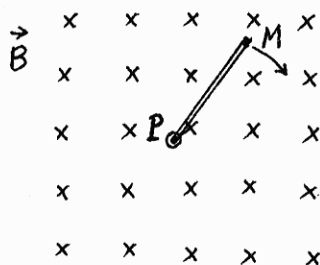


Fig. 3

7. A point charge q is at a distance d away from a semi-infinite dielectric κ (see Fig. 4). The attractive force acting upon the charge q is (a) $\left(\frac{\kappa-1}{\kappa+1}\right)^2 \frac{q^2}{16\pi\epsilon_0 d^2}$, (b) $\left(\frac{\kappa-1}{\kappa+1}\right) \frac{q^2}{4\pi\epsilon_0 d^2}$, (c) $\left(\frac{\kappa+1}{\kappa-1}\right) \frac{q^2}{4\pi\kappa\epsilon_0 d^2}$, (d) $\left(\frac{\kappa-1}{\kappa+1}\right) \frac{q^2}{16\pi\epsilon_0 d^2}$, (e) $\left(\frac{\kappa-1}{\kappa}\right) \frac{q^2}{16\pi\epsilon_0 d^2}$.

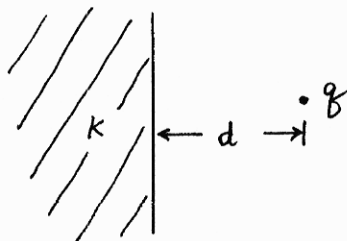


Fig. 4

8. Which statement is correct about the description of static $\vec{E}$ and $\vec{B}$ fields just outside a good conductor?
 (a) The component of the electric field that is parallel with the conductor surface can be finite.
 (b) The component of the electric field that is normal to the conductor surface must always be zero.
 (c) The component of the magnetic field that is parallel to the conductor surface can be finite.
 (d) The component of the magnetic field that is normal to the conductor must be zero.
 (e) None of the above.

Section (B) in the following page

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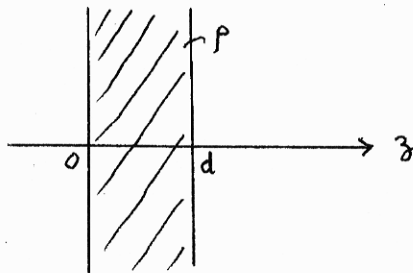
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(B) Problems (15% each)

1. A slab of insulating material (infinite in both x and y directions) has a charge density ρ . The thickness (along z direction) of the slab is d (see Fig. 4). Find the electric field $\vec{E}$ in both the exterior and the interior regions of the slab for the following two cases:

- (a) $\rho = \rho_0$ is a constant throughout the slab, and
(b) $\rho = C_0 x$, where C_0 is a constant.

Fig. 4



2. (a) Calculate the magnetic field at a point P on the symmetry axis of a circular current loop with a radius r and a current I . The point P is at a distance x away from the center of the loop.
- (b) An insulating circular disc of radius R has a uniform surface charge density σ . The disc is rotating about its symmetry axis with a constant angular speed ω . Calculate the magnetic field at a point P on the symmetry axis. The point P is at a distance x away from the center of the disc.
3. Two conducting plates are parallel to each other. The plates have the same area A and are separated by small distance d such that $d \ll \sqrt{A}$. The left plate has a net charge Q_1 and the right plate has a net charge Q_2 . Calculate the total charge on each of the four surfaces of the two plates.
4. A resistor is constructed by shaping a material of resistivity ρ into a hollow spherical shell of inner and outer radii r_1 and r_2 , respectively. Calculate the expression for the resistance between the inner and the outer shell.

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