國立中山大學100學年度碩士班招生考試試題

科目：電磁學【通訊所碩士班乙組】

1. Please answer questions about static electric fields.
   (a) (5%) Under what conditions will the electric field intensity be both solenoidal and irrotational?
   (b) (5%) If the electric potential at a point is zero, dose it follow that the electrical field intensity is also zero at that point? Explain.
   (c) (5%) Why are there no free charges in the interior of a good conductor under static conditions?
   (d) (5%) If $\nabla^2 \mathbf{U} = 0$, why does it not follow that **U** is identically zero?
   (e) (5%) Assume that fixed charges +Q and –Q are deposited on the plates of an isolated parallel-plate capacitor.
   (i) Dose the electric field intensity in the space between the plates depend on the permittivity of the medium?
   (ii) Dose the electric flux density depend on the permittivity of the medium? Explain.

2. Please answer questions about static magnetic fields.
   (a) (5%) Which postulate of magnetostatics denies the existence of isolated magnetic charges?
   (b) (5%) State the law of conservation of magnetic flux. (5%)
   (c) (5%) Does the magnetic field intensity due to a current distribution depend on the properties of the medium?
   (d) (5%) What is meant by the internal inductance of a conductor?
   (e) (5%) What is the relation between the force and the stored magnetic energy in a system of current-carrying circuits under the condition of constant flux linkages?

3. To investigate the electromagnetic coupling of cellular phone antennas and a human head, a phantom head – a plastic container filled with a solution that approximately resembles the dielectric and conductive properties of a human head – is used for measurements. In particular, solutions are made that have the relative permittivity and loss tangent equal to the corresponding average head tissue parameters at two frequency bands allocated for wireless communications in North America: (i) $\varepsilon_r = 44.8$ and $\tan\delta_c = 0.408$ at $f = 835$ MHz and (ii) $\varepsilon_r = 41.9$ and $\tan\delta_c = 0.293$ at $f = 1.9$ GHz. Assume that the phantom solution has the same permeability as that of a vacuum.
   (a) (5%) Find the attenuation constant of a uniform plane wave propagating through the phantom solution.
   (b) (10%) If the rms electric field intensity of the wave at its entry into the solution is $E_0 = 50$ V/m, determine the time-average power absorbed in the first cm of depth into the solution per 1 cm^2 of cross-sectional area, that is, in the first 1 cm × 1 cm × 1 cm of the solution past the interface, at each of the frequencies.

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4. To determine the frequency, f, and electric-field rms intensity, E_{i0}, of a uniform plane wave traveling in air, a perfectly conducting plate is introduced normally to the wave propagation and electromotive force (emf) induced in a small square wire loop of area 6.25 cm^2 is measured. By varying the orientation and location of the loop, it is found that the rms emf in it has a maximum of 5 mV at a distance of 80 cm from the conducting plate (with the plane of the loop being perpendicular to the magnetic field vector of the wave). It is also found that the first adjacent minimum (zero) of the rms emf is at 60 cm from the conducting plate (for the same orientation of the loop).
(10%) What are f and E_{i0}?

5. RG-402U semi-rigid coaxial cable has an inner conductor of 0.91 mm, and a dielectric diameter (equal to the inner diameter of the outer conductor) of 3.02 mm. Both conductors are copper with conductivity of 5.8×10^7 S/m, and the dielectric material is Teflon with dielectric constant of 2.08 and loss tangent of 0.0004.
(10%) Find the characteristic impedance (in ohm) and the attenuation (in dB/m) of the line at 1 GHz.

6. Consider a TE_{02} mode propagating through an air-filled rectangular metallic waveguide of transverse dimensions $a = 38.1$ cm and $b = 190.05$ cm (WR-1500 waveguide).
(a) (5%) Determine the cutoff frequency of this mode.
(b) (10%) Find the power-handling capacity of the waveguide for this mode, i.e., the maximum time-average power that can be carried by the TE_{02} mode prior to an eventual dielectric breakdown at a frequency of $f = 1.8$ GHz. Note that the dielectric strength of air is $E_{cr0} = 3\times10^6$ V/m).