

國立中央大學八十七學年度碩士班研究生入學試題卷

所別：太空科學研究所

不分組 科目：

電磁學

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1.

Short questions and problems.

(25%)

- Derive Coulomb's law from Gauss's law.
- State the charge and E-field inside a conductor. Explain. Give boundary conditions at a conductor-free space interface.
- Write/state Poisson's and Laplace's equations.
- Write/state the Child-Langmuir law.
- Write/state the point form for Ohm's law.
- Write/state Kirchhoff's current law.
- Write the differential form of Maxwell's equations. Are they all independent? Explain.
- Express Lorentz's force equation.
- State plasma frequency.
- State Doppler effect.

2.

Consider two spherical conductors with radii a and b ($a > b$) that are connected by a conducting wire. The distance of separation between the conductors is assumed to be very large in comparison to a so that the charges on the spherical conductors may be considered as uniformly distributed. A total charge Q is deposited on the spheres. Find (a) the charge densities on the two spheres, (b) the electric field intensities at the sphere surfaces, (c) the capacitance of this two-sphere system, and (d) the electrostatic energy densities inside and on the two spheres. (e) Which sphere has easier breakdown due to voltage surges caused by lightning, explain.

(25%)

3.

A small circular loop of radius b that carries a current I (a magnetic dipole).

- Find the magnetic dipole moment. (5%)
- Calculate the magnetic energy density at the center of the loop. (5%)
- If r is the distance from the center of the loop, for $r \gg b$, express the vector and scalar magnetic potential. (5%)
- Derive the magnetic flux density for $r \gg b$. (5%)

4.

A copper strip of length of 2 meters pivoted at the midpoint is rotating with an angular velocity $\omega = 6\pi \times 10^3 \mathbf{a}_z$ rad/s in a uniform magnetic field $\mathbf{B} = 3 \mathbf{a}_x + 4 \mathbf{a}_z$ T. Determine (a) the induced emf between the midpoint and one of the ends of the strip, and between the two endpoints. (b) Evaluate the charges at the midpoint and the two ends. (10%)

5.

A uniform plane wave with $\mathbf{E} = \mathbf{a}_x E_x$ propagates in a lossless simple medium ($\epsilon_r = 4$, $\mu_r = 1$, $\sigma = 0$) in the z -direction. Assume that E_x is sinusoidal with a frequency 10 MHz and has a maximum value of 0.1 mV/m at $t=0$ and $z = 300$ m.

- Write the instantaneous expression for \mathbf{H} . (5%)
- Find the refractive index and the phase velocity of the wave. (5%)
- Determine the average power density over one period. (5%)
- If there is a free electron in the medium, will \mathbf{E} and \mathbf{B} of the plane wave apply any forces on the electron? If yes, which one is larger? (5%)

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