

National Exams May 2002

98-Elec-A7

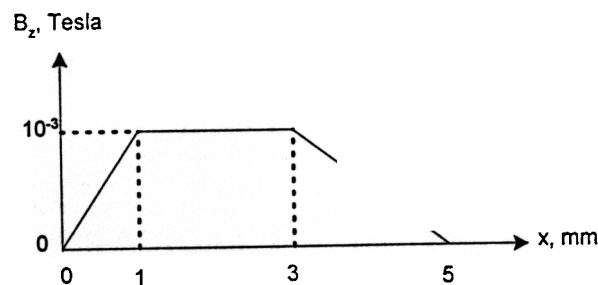
Electromagnetics

3 Hours' Duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a Closed Book exam.
3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
4. All questions are of equal value.
5. Aids: $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$, $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$.

1. A charge distribution consists of two infinite, parallel plates of charge. The positive plate is $1 \mu\text{m}$ thick, the negative $2 \mu\text{m}$ thick. The neutral layer between the plates is $1 \mu\text{m}$ thick. The total charge of the system is zero and the charge density of the positive plate is 2 C/m^3 . The relative permittivity of the medium (both neutral and charged) is 12.
- Plot the electric field, E , produced specifying values and,
 - determine the potential of the outside of the negative plate with respect to the outside of the positive plate.
2. The magnetic field of a current distribution possesses only the z-component, depends only on the x-coordinate and is plotted in the figure below.



Plot the current distribution responsible for the field, specifying values and directions.

$$\text{Aid: } \text{curl} \vec{H} = \left(\frac{\partial H_z}{\partial y} - \frac{\partial H_y}{\partial z}, \frac{\partial H_x}{\partial z} - \frac{\partial H_z}{\partial x}, \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} \right)$$

3. A parallel plate capacitor consists of two circular, co-axial metallic plates of 5 cm radius separated by a 1 mm gap. A 0.5 mm thick layer of dielectric of relative permittivity 2.5 is attached inside the gap to one of the plates. The dielectric strength of air is assumed to be 10^6 V/m , that of the dielectric 10^7 V/m . What is the upper limit on electric energy that can be stored in the capacitor?
4. A transmission line consists of two parallel, thin metallic ribbons 1 cm wide separated by a 0.5 mm thick layer of dielectric of relative permittivity 2.25.
- Using suitable approximations calculate propagation velocity and characteristic impedance of the transmission line.
5. A 10A current flows initially in a circular horizontal current loop of 1 m radius. Viewed from above the current circulates clockwise. Located at the centre of the 1 m loop a small horizontal, circular wire loop of 1 cm diameter with a small gap at its northernmost point. If the 10A current in the 1 m loop drops linearly to zero

in .05 second, what is the magnitude and polarity of the voltage appearing across the gap in the small loop?

6. The internal impedance of a pulse generator is 50 Ohm, its EMF is a 50 μ s long pulse of 12 V amplitude. The generator drives a 10 km long section of a 50 ohm, 2×10^8 m/s transmission line terminated in a 25 Ohm load.

Plot the line voltage and current as a function of position 10 μ s after the leading edge of the pulse has arrived at the load.

7. A 75 cm long section of a 50 Ohm, 2×10^8 m/s transmission line is terminated in a 100 Ohm resistor.

What is the input impedance of the line section at 100 MHz?

8. The inside dimensions of an X-band waveguide are 2.25×1 cm. The waveguide is filled with dielectric of relative permittivity 2.25.
- (i) What is the range of frequencies in which a single mode will propagate in the waveguide and,
 - (ii) what is the attenuation of the dominant mode of a 3.33 GHz signals, expressed in dB/cm?