

NATIONAL EXAMS, MAY 2011

07-ElecA7, 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 positive point charge  $+5e$  is surrounded by a uniform spherical surface charge layer of total charge  $-2e$  and radius  $2 \times 10^{-11} \text{ m}$ , and another surface charge layer of total charge  $-3e$  and radius of  $5 \times 10^{-11} \text{ m}$ . Both spheres are centered on the positive point charge.

What are the values of electric fields on the inside and outside surfaces of the two spheres?

Note:  $e = 1.6 \times 10^{-19} \text{ C}$ .

2. A 2 ampere current loop consists of a four vertical semicircular sections of 10cm diameter standing on the sides of a horizontal square of 10cm sides. Viewed from above the current circulates clockwise.

What are the magnitude and direction of magnetic flux density vector at the centre of the square?

3. Internal resistance of an AC generator is 50 ohms. The EMF of the generator are AC voltages of 500 MHz and 1000 MHz of common amplitudes of 2 volts RMS. The generator drives a load through a section of coaxial line of 75 ohm characteristic impedance and  $2 \times 10^8 \text{ m/s}$  propagation velocity. The load consists of a 50 ohm resistance in parallel with a short-circuited section of coaxial line with the same characteristics as the line specified above. What are the shortest lengths of the load line and the short circuited section of the load if:
  - (i) the load resistance is matched to the generator at 500 MHz and,
  - (ii) no 1000 MHz power is delivered to the 50 ohm resistive portion of the load?

4. Internal impedance and EMF of a generator are 377 ohms and a step-function of 3 volt amplitude. The generator drives an infinite transmission line of 377 ohm characteristic impedance and  $3 \times 10^8$  propagation velocity. A 377 ohm resistor is connected across the line at 3 km distance away from generator terminals.?

What are the generator terminal voltage and current 25 microseconds after the leading edge of the step-function has been launched on the line?

5. A 1000 MHz horizontally polarized (electric field) plane wave propagates, in a direction from NW to SE and  $30^\circ$  down. Power density of the wave is  $4 \text{ W/m}^2$ . Magnetic field of the wave is monitored by a vertical circular loop of  $10 \text{ cm}^2$  area slowly rotating about its vertical diameter.

Determine:

- (i) orientation of the loop for which the induced EMF in the loop will be maximum and,
- (ii) the RMS value of the maximum.

6. Inside dimensions of a rectangular waveguide cavity are 1cm x 2cm x 3cm.

What are the lowest resonant frequencies of the cavity?

7. The dimensions of a rectangular current loop located in a vertical east-west plane are 10cm x 5 cm. A 3A DC current circulates in the loop. Viewed due north the current circulates clockwise. A uniform magnetic field of 0.5 testlas pointing north-west envelops the loop.

What is the magnitude and sense of the torque acting on the loop?

8. A 50 cm long vertical current element located on a conducting ground plane radiates a 10 MHz signal. 5 km away from the element on the ground plane the amplitude of the signal is 0.1 millivolts per meter. When the frequency is switched from 10 MHz to 5 MHz with current amplitude kept constant, what should be the length of the current element if the signal amplitude at the new frequency, at a point 2.9 km above the original 5 km point is 0.1 mV/meter?