

UNIVERSITY OF TORONTO  
FACULTY OF APPLIED SCIENCE AND ENGINEERING

Final Examinations, April 1995

First Year - Program 05

ECE 150S - Electricity and Magnetism

Exam Type: A

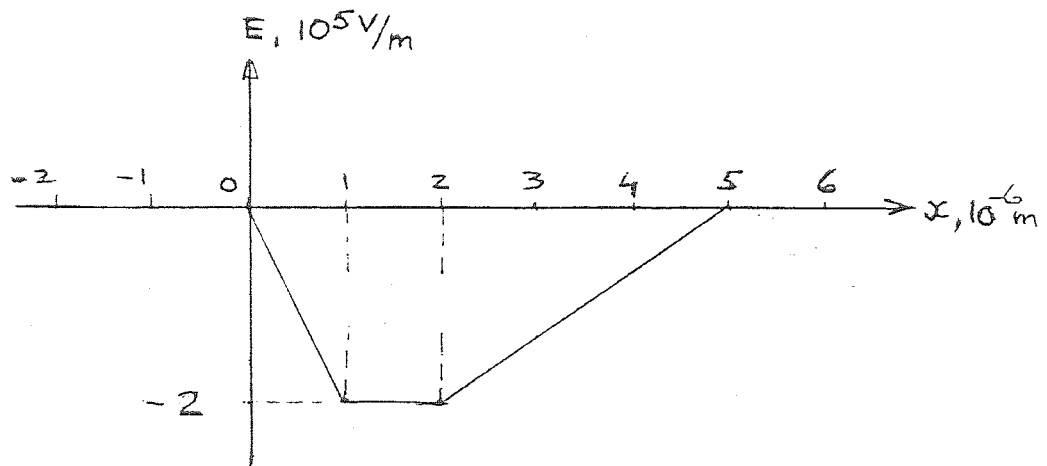
Examiner: S. Dmitrevsky

All questions are of equal value and any five constitute a complete paper.

Write in ink!

Aids:  $\epsilon_0 = 8.85 \times 10^{-12}$  Farad/meter,  
 $\mu_0 = 4 \pi \times 10^{-7}$  Henry/meter.

1. The x-component of an electric field  $\vec{E}(x) = (E(x), 0, 0)$  in an  $(x, y, z)$  Cartesian coordinate system is plotted in the attached figure. If the relative permittivity of the medium is 5,
  - (i) determine, plot and describe verbally the electric charge distribution producing the field and,
  - (ii) calculate the potential of the point  $(-1, 2, 3) \cdot 10^{-6}\text{m}$  with respect to the point  $(4, 7, -2) \cdot 10^{-6}\text{m}$ .



$$F = qvB$$

$$N = C(mB)(t)$$

$$T = \frac{N \cdot q}{Cm} = \frac{kg}{Cm}$$

2. The frequency of a sinusoidal magnetic field is  $10^6$  Hertz. The peak value of the energy density is  $10^{-17}$  Joule/m<sup>3</sup>. Calculate the peak value of the voltage induced by the field in a circular loop of  $10^{-1}$ m radius, if the plane of the loop is inclined at  $30^\circ$  with respect to the direction of the field.

$$2\pi r^2 B \cos \theta \sin(\omega t)$$

$$\text{Induced } \mathcal{E} = - \frac{d}{dt} \int B \cdot dA$$

3. The horizontal component of the terrestrial magnetic field is  $5 \times 10^{-6}$  Tesla. The needle of a magnetic compass is deflected by  $6^\circ$  from magnetic north by a current flowing in a circular loop of 10 cm radius. The centre of the loop is located at the centre of the compass needle, its horizontal diameter is aligned in the north-south direction and its plane is inclined at  $60^\circ$  to the horizontal plane. What is the magnitude of the loop current?



4. The charge of  $-1.6 \times 10^{-19}$  C is uniformly distributed on a circular loop of  $5 \times 10^{-11}$ m radius lying in a horizontal plane. The centre of the loop is occupied by a charge of  $+1.6 \times 10^{-19}$  C. Calculate the magnitude and the direction of the electric field at a point  $10^{-10}$ m above the positive charge, and the electric potential with respect to infinity at that point.

5. A 2 Volt battery of 5 Ohm internal resistance drives a parallel combination of a 10 Ohm resistor and a 1 mH inductor through an on-off switch. Determine the battery and the 10 Ohm resistor currents

- (i) immediately following the closing of the switch,
- (ii) very long time thereafter and,
- (iii) immediately following the subsequent opening of the switch.

6. A  $10^4$  eVolt proton ( $e = 1.6 \times 10^{-19}$  C,  $M = 1.67 \times 10^{-27}$  kg) moves horizontally north in a vertical magnetic field of 0.1 Tesla pointing up. Its straight line trajectory is maintained by electric field of a parallel plate capacitor of  $10^{-3}$ m plate separation. Determine the required orientation, polarity and voltage of the capacitor.