McGill University
Faculty of Engineering

CLASS TEST 2
NOVEMBER 2002

COURSE ECSE 353
ELECTROMAGNETIC FIELDS AND WAVES

Examiner:	J. P. Webb	Co-Examiner:	None
Signature:	____________	Signature:	____________
Date:	November 6, 2002	Time:	10:35-11:25

- This is a closed book examination. No books or notes are permitted, except for the Formula Sheet attached.
- The Faculty Standard Calculator (Casio fx-991 or Sharp EL-546) only is permitted.
- All units are SI unless otherwise stated
- This is a 50 minute exam
- The marks indicated in square brackets at the start of each question are out of 50.

INSTRUCTIONS:

- Answer all questions.
- Put your name and student ID also on the Answer Sheet provided.
- **Part A** is multiple choice. There is one correct answer for each question. Mark your answers on the Answer Sheet, not on this examination paper. Only the answers on the Answer Sheet will be considered.
- **Part B**: Put your answers in the spaces provided on the Answer Sheet.

WHEN INSTRUCTED, TURN TO NEXT PAGE AND START THE EXAM

PART A

Part A is multiple choice. There is one correct answer for each question. Mark your final answers on the Answer Sheet. Only the answers on the Answer Sheet will be considered.

1. [4] A battery is open circuit, i.e., nothing is connected to its terminals. The line integral of the electric field, **E**, along a path inside the battery from the negative terminal to the positive terminal is equal to:
   A zero
   B the magnitude (absolute value) of the potential difference between the terminals
   C the electromotive force of the battery
   D the negative of the electromotive force of the battery

2. [4] Assuming steady currents and static fields, the line integral of magnetic field, **H**, along a closed path which is the edge of a surface *S* is:
   A zero
   B equal to the current passing through *S*
   C equal to the magnetic flux through *S*
   D non-zero whenever there is a source of magnetic field (e.g. a current) nearby

3. [6] The half space $y<0$ (region 1) is filled with a linear magnetic material, permeability μ_1. The half space $y>0$ (region 2) is filled with another linear magnetic material, permeability μ_2. There is a surface current $\mathbf{J}_s = J_s\mathbf{a}_z$ on the interface, $y=0$. The magnetic flux density at $y=0$, just inside region 1, is given by $B_x\mathbf{a}_x + B_y\mathbf{a}_y$. Find the magnetic flux density at $y=0$, just inside region 2.

   A $\mu_2\left(\frac{B_x}{\mu_1} - J_s\right)\mathbf{a}_x + B_y\mathbf{a}_y$ B $\mu_2\left(\frac{B_x}{\mu_1} + J_s\right)\mathbf{a}_x + B_y\mathbf{a}_y$

   C $\left(\frac{\mu_2}{\mu_1}B_x - J_s\right)\mathbf{a}_x + B_y\mathbf{a}_y$ D $\left(\frac{\mu_2}{\mu_1}B_x + J_s\right)\mathbf{a}_x + B_y\mathbf{a}_y$

4. [6] Throughout a solid magnetic material, the static magnetic flux density is $\mathbf{B} = \mathbf{a}_\phi B_0$ (spherical coordinates R, θ, ϕ). Assuming there is *no* free current in the material, find the volume magnetization current density.

   A $\frac{B_0}{\mu_o R}\mathbf{a}_R$ B $\frac{B_0}{\mu_o R\sin\theta}\mathbf{a}_R$

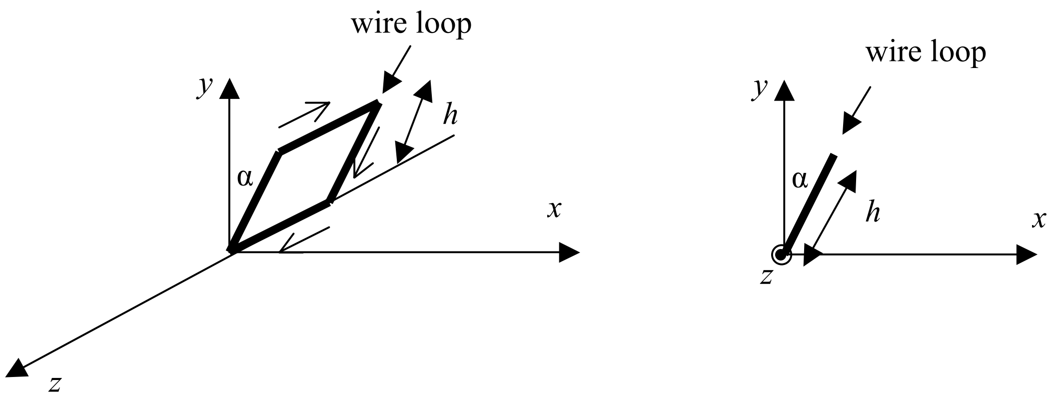
   C $\frac{B_0}{\mu_o R\tan\theta}\mathbf{a}_R$ D $\frac{B_0}{\mu_o R}\left(\mathbf{a}_R\frac{1}{\tan\theta} - \mathbf{a}_\theta\right)$

TURN TO NEXT PAGE

PART B

In Part B, put your answer in the spaces provided on the Answer Sheet.

5. [30] A square loop of wire of side h=1cm is made of copper wire with a circular cross-section, radius b=1mm. The conductivity of copper is 5.7x10^7 S/m. The loop is placed as shown in a uniform magnetic flux density $\mathbf{B}=B\mathbf{a}_x$, where B=50μT (the earth's field).



(a) Find the flux linking the loop, in terms of the angle α shown (between the y-axis and one side of the loop).

Now suppose that α increases at the rate of ω=10 radians per second, i.e. $\alpha = 10t$ where t is time.

(b) Find the current flowing around the loop, in the direction shown, as a function of time.

END OF QUESTIONS **FORMULAS FOLLOW**