McGill University **CLASS TEST 2**
Faculty of Engineering **NOVEMBER 2007**

COURSE ECSE 353
ELECTROMAGNETIC FIELDS AND WAVES

Examiner:	J. P. Webb	Co-Examiner:	None
Signature:	_____	Signature:	_____
Date:	November 2, 2007	Time:	11:35-12:25

- This is a closed book examination. No books or notes are permitted, except for the Formula Sheet attached.
- The Faculty Standard Calculator (Casio fx-115, Casio fx-991, Casio fx-570ms, Sharp EL-520, or Sharp EL-546) only is permitted.
- All units are SI unless otherwise stated
- Unless otherwise stated: *x,y,z* are rectangular (Cartesian) coordinates; r, ϕ, z are cylindrical coordinates; and R, θ, ϕ are spherical coordinates.
- 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] Kirchhoff's Current Law is a consequence of which of the following equations?

   A $\mathbf{J} = \sigma(\mathbf{E}+\mathbf{E}_i)$

   B $\text{EMF} = \oint_C (\mathbf{E} + \mathbf{E}_i) \cdot d\mathbf{l}$

   C $\nabla \cdot \mathbf{J} = 0$

   D $P = \int_V \mathbf{E} \cdot \mathbf{J} \, dv$

2. [4] Which of the following is a true statement about the change of magnetic field intensity, **H**, and magnetic flux density, **B**, across an interface between two materials?

   A The normal part of **H** must be continuous.

   B The normal part of **H** must be discontinuous if the materials have different permeabilities.

   C The tangential part of **B** must be continuous if the materials have the same permeability.

   D The tangential part of **B** must be discontinuous if there is surface current on the interface.

3. [6] The magnetic flux density in a region of space is $\mathbf{B} = -\mathbf{a}_x y t^2$ where t is time. Only one of the following expressions could possibly be the electric field, **E**, in the same region. Which is it?

   A $\mathbf{a}_x y^2 t$ B $\mathbf{a}_z y^2 t$

   C $2\mathbf{a}_x y^2 t$ D $2\mathbf{a}_z y^2 t$

4. [6] A long solenoid consists of 100 turns cm^{-1} of fine wire wrapped around a cylinder of material with relative permeability 10. Current is flowing in the wire, producing a magnetization of 10^5 Am^{-1} in the material. Find the current.

   A 1.00 A B 1.11 A

   C 100 A D 111 A

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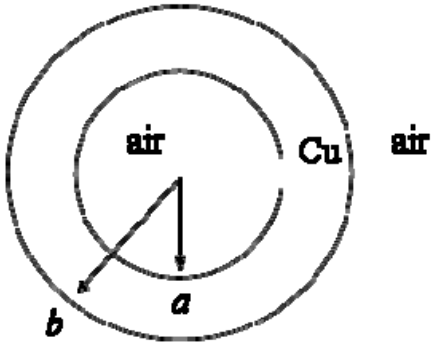
PART B

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

5. [30] Consider the spherical copper shell shown in the figure. The conductivity of copper is σ. Steady current is injected on the inner surface $R=a$, and extracted on the outer surface $R=b$ by an external circuit (not shown). The current density in the copper at $R=a$ is:

$$\mathbf{J} = J_0 \mathbf{a}_R \qquad \text{at } R=a$$



(a) What is the total current injected at $R=a$?

(b) What is the total current extracted at $R=b$?

(c) What is the total current flowing outwards through the surface of the sphere with radius R, where $a<R<b$?

(d) Find the current density **J** in the copper as a function of R. [Hint: assume $\mathbf{J} = J_R(R)\mathbf{a}_R$].

(e) Find the potential difference between $R=a$ and $R=b$.

(f) Find the resistance between $R=a$ and $R=b$.

END OF QUESTIONS FORMULAS FOLLOW