McGill University
Faculty of Engineering

CLASS TEST 2
NOVEMBER 2003

COURSE ECSE 353
ELECTROMAGNETIC FIELDS AND WAVES

Examiner:	J. P. Webb	Co-Examiner:	None
Signature:	_____	Signature:	_____
Date:	November 5, 2003	Time:	08:35-09:25

- 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-546L or R or V (VB) or G) 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] Which of the following statements is true for any ferromagnetic material?
   - A It contains iron
   - B In it the flux density, **B**, is directly proportional to the field intensity, **H**
   - C The magnetization within it can be increased without limit
   - D For a given **H**, many values of **B** are possible.

2. [4] The same, steady, current density flows in two materials, A and B, with conductivities σ_A and σ_B, and permittivities ε_A and ε_B, respectively. If $\sigma_A > \sigma_B$ and $\varepsilon_A < \varepsilon_B$, what can be said about the power densities in the two materials, p_A and p_B?
   - A Nothing; it depends on the ratios σ_A/ε_A and σ_B/ε_B
   - B $p_A < p_B$
   - C $p_A > p_B$
   - D $p_A = p_B$

3. [6] When a pair of electrodes (perfect conductors) is immersed deep in a lake (conductivity = 0.1 Sm^{-1}), and a voltage of 5V applied between them, a current of 1A flows. Find the capacitance between the electrodes when they are in the air.
   - A 17.7 pF
   - B 442 pF
   - C 1 F
   - D 2 F

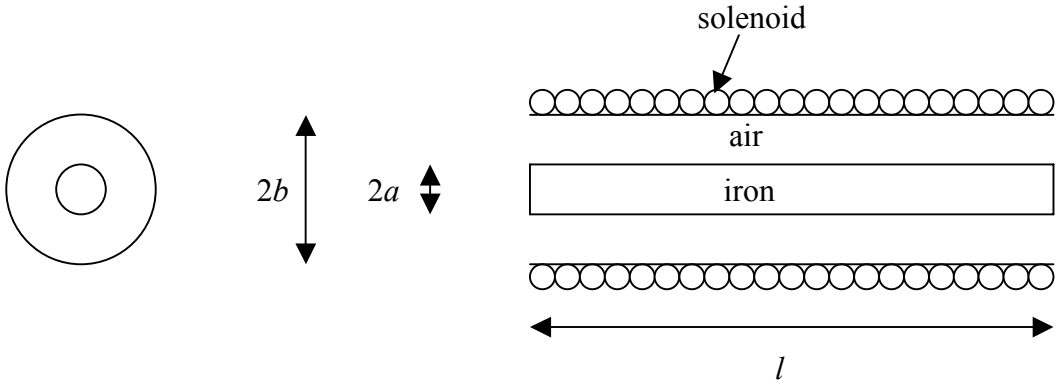
4. [6] A sphere has a uniform magnetization $M_o \mathbf{a}_z$. Find the equivalent magnetization surface current density on the surface of the sphere, in spherical coordinates (R, θ, ϕ).
   - A $M_o \sin\theta \ \mathbf{a}_\phi$
   - B $M_o \cos\theta \ \mathbf{a}_\phi$
   - C $-M_o \sin\theta \ \mathbf{a}_\phi$
   - D $-M_o \cos\theta \ \mathbf{a}_\phi$

TURN TO NEXT PAGE

PART B

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

5. [30] A cylindrical solenoid consists of N turns of fine wire carrying a steady current I. The radius of the cross-section of the solenoid is b and its length is l. Inside the solenoid, and coaxial with it, is a cylinder of iron of the same length, l, but smaller radius, a. The relative permeability of the iron is μ_r.



(a) Find the magnetic flux density, **B**, as a function of distance, r, from the axis of the solenoid, both in the air and in the iron. Ignore fringing effects at the ends of the solenoid. Assume that the magnetic field is zero outside the solenoid.

(b) Find the magnetic energy stored in the air. Find the magnetic energy stored in the iron.

(c) Find the inductance of the solenoid.

END OF QUESTIONS **FORMULAS FOLLOW**