McGill University
Faculty of Engineering

CLASS TEST 1
OCTOBER 2006

COURSE ECSE 353
ELECTROMAGNETIC FIELDS AND WAVES

Examiner:	J. P. Webb	Co-Examiner:	None
Signature:	_____________	Signature:	_____________
Date:	October 11, 2006	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-991 or Sharp EL-546L or R or V (VB) or G) 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.

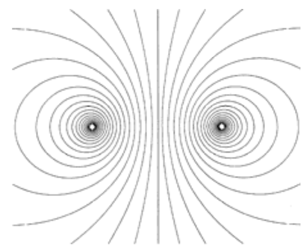
WHEN INSTRUCTED, TURN TO NEXT PAGE AND START THE EXAM

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] Which of the following quantities is a vector?
   - A permittivity
   - B electric flux
   - C polarization
   - D polarization volume charge density

2. [4] Which of the following does this figure represent?
   - A the equipotentials of a pair of equal charges
   - B the equipotentials of a pair of opposite charges
   - C the electric field lines of a pair of equal charges
   - D the electric field lines of a pair of opposite charges



3. [6] A coaxial cable connects computer 1 to computer 2. The input impedance of computer 2 is purely resistive. Due to the capacitance of the cable, the rise time of the voltage pulses arriving at computer 2 is too big: it needs to be reduced by a factor of two. The cable dielectric has inner radius *a* and outer radius 3*a*. What value of outer radius would fix the problem?
   - A 1.5 a B $\sqrt{3}\,a$
   - C 3 a D 9 a

4. [6] Inside a polarized material, the electric field is $\mathbf{a}_R/R$ and the polarization is $\varepsilon_0\mathbf{a}_R$, where ε_0 is the permittivity of free space. Find the volume charge density.
   - A 0   B $\frac{1}{R^2}\varepsilon_0$
   - C $\frac{2}{R}\varepsilon_0$ D $\frac{(1+2R)}{R^2}\varepsilon_0$

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PART B

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

5. [30] We learned in class that an infinite sheet of surface charge, density ρ_s, lying in the *y*-*z* plane in infinite free space creates this electric field:

$$\mathbf{E} = \begin{cases} E_0 \mathbf{a}_x & \text{in } x > 0 \\ -E_0 \mathbf{a}_x & \text{in } x < 0 \end{cases}$$

where $E_0 = \rho_s / (2\varepsilon_0)$. Now suppose that the free space in $x < 0$ is replaced by a semi-infinite, uniform dielectric with permittivity ε. The surface charge ρ_s remains unchanged. Assume that the electric field is still *x*-directed and uniform in each region, but possibly different between the regions:

$$\mathbf{E} = \begin{cases} E_1 \mathbf{a}_x & \text{in } x > 0 \\ -E_2 \mathbf{a}_x & \text{in } x < 0 \end{cases}$$

We want to find the constants E_1 and E_2. Here's how:

(a) Find the polarization in the dielectric, in terms of E_2, ε and ε_0

(b) Find the polarization volume and surface charge densities, again in terms of E_2, ε and ε_0

(c) Give an equivalent system, consisting of charges in *free space only*, that has the same electric fields as the dielectric+air system we have been considering.

(d) Use the equivalent system to get values for E_1 and E_2 in terms of ρ_s, ε and ε_0.

END OF QUESTIONS **FORMULAS FOLLOW**