McGill University
Faculty of Engineering

FINAL EXAM
DECEMBER 2005

VERSION A

COURSE ECSE 353
ELECTROMAGNETIC FIELDS AND WAVES

Examiner:	J. P. Webb	Co-Examiner:	S. McFee
Signature:	_____________	Signature:	_____________
Date:	Monday, December 19, 2005	Time:	14:00

- 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 180 minute exam
- The marks indicated in square brackets at the start of each question are out of 180.

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. [5] Which of the following is a microwave frequency?
   A 1 MHz B 10 MHz
   C 100 MHz D 10 GHz

2. [5] Which of these statements is true, concerning the radiation intensity in the far-zone:
   A the radiation intensity of a general antenna varies inversely with the square of the distance from the antenna
   B the radiation intensity of a general antenna does not vary with the angle coordinates (θ,ϕ)
   C the radiation intensity of an isotropic radiator varies inversely with the square of the distance from the antenna
   D the radiation intensity of an isotropic radiator does not vary with the angle coordinates (θ,ϕ)

3. [5] In a linearly-polarized plane electromagnetic wave, at a fixed point in space:
   A the electric field always points in one direction
   B the electric field does not rotate
   C at any instant, the magnetic and electric fields point in the same direction
   D the electric field is always horizontal

4. [5] Approaching a negative point charge the electrostatic potential, relative to infinity:
   A increases without limit
   B decreases without limit
   C increases but does not go above a certain value
   D decreases but does not drop below a certain value

5. [5] What is the unit of magnetic flux?
   A Wb m^{-2} B T C Wb D T m^{-2}

6. [5] A square pulse propagates along a lossless transmission line with characteristic resistance R_0 towards a load resistance R_L. When it arrives at the load, there is a reflected pulse. The voltage of the reflected pulse has the same sign as the voltage of the incident pulse, but lower amplitude. Which of the following statements is true?
   A $R_L = 0$ B $R_L < R_0$
   C $R_L = R_0$ D $R_L > R_0$

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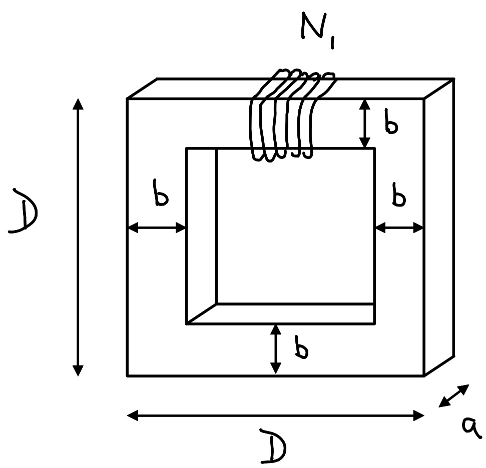
PART B

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

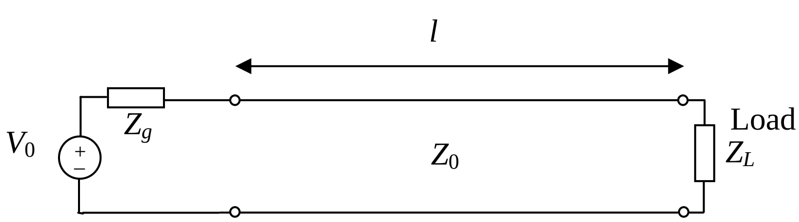
7. [30] The figure shows an iron core, with permeability μ. A coil of N_1 turns of fine wire is wrapped around the core and a phasor current I flows in the wire, at angular frequency ω. Assume that b and a are much smaller than D.



(a) Estimate the phasor magnetic flux in the core.

(b) If a second coil with N_2 turns is wrapped around the core, find the amplitude of the open circuit voltage appearing across its terminals.

8. [30] A lossless coaxial cable is filled with a dielectric with dielectric constant 3. It has a characteristic impedance Z_0=50Ω and length l=30cm. The source generates a sinusoidal signal with phasor voltage V_0=5+j0 V, at frequency 1GHz. It has an internal impedance Z_g=j25Ω. Find the phasor current through the load, Z_L=j25Ω.



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9. [30] A semiconductor material fills the half space $y<0$; air fills the other half space. The permittivity of the semiconductor (*not* the complex permittivity) is ε_s. At frequency ω, the phasor electric field at the interface, $y=0$, is:

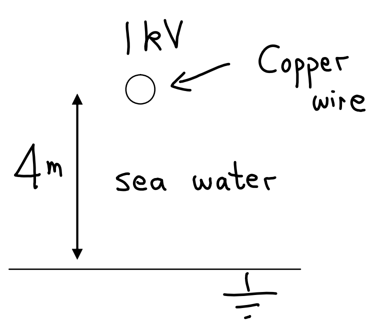
$$E_0\left(\mathbf{a}_x - \mathbf{a}_y\right)$$

on *both sides* of the interface.

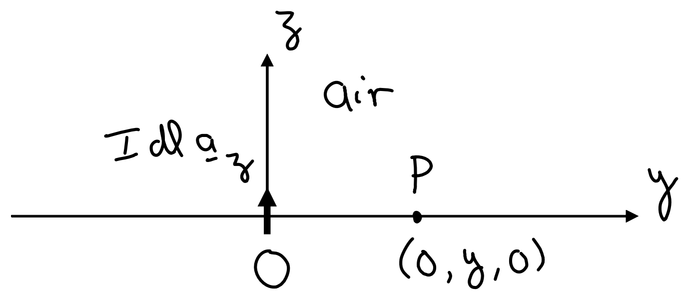
(a) Find the phasor surface charge density on the plane $y=0$.

(b) Without assuming any relationship between electric field and current density, determine the y component of phasor current density in the semiconductor, at $y=0$.

10. [30] A long copper wire of radius 1 cm runs in the ocean parallel to the seabed at a height of 4 m. The seabed can be taken to be an infinite conducting plane at potential $V=0$. The wire is at $V=+1$ kV (DC). Find the current flowing from the wire to the seabed for each 1m length of the wire. (The conductivity of sea water is 4 Sm^{-1}. Assume that the ocean is infinitely deep.)



11. [30] The Hertzian dipole $Idl\mathbf{a}_z$ is located at the origin of a rectangular coordinate system, as shown. The free-space wavenumber is k. Give an expression for the magnetic field, $\mathbf{H}$, at point P, $(0,y,0)$. The answer should be in rectangular coordinates and should be in terms of Idl, k and y. Do *not* assume that P is in the far zone of the dipole.



END OF QUESTIONS **FORMULAS FOLLOW**