 Name:_____ Student #:_____

CARLETON UNIVERSITY

Final
EXAMINATION
April 2010

Duration: 3 hours

Department name and course number: Electronics ELEC 3105 A

Course Instructor(s): R. Gauthier Number of students: 50

AUTHORIZED MEMORANDA:

CALCULATOR, 8.5x11" DOULE SIDE FORMULA SHEET (to be submitted with the exam)

Students MUST count the number of pages in this examination paper **before** beginning to write, and report any discrepancies immediately to a proctor. This question paper has 11 pages.

This examination question paper MAY NOT be taken from the examination room.

This exam consists of 10 questions, which should be answered on this exam paper in the space provided. Attempt all questions. 10 marks are allocated to each question. Best grade on 9 of the 10 questions is used to form the exam grade. The total number of marks for the examination is 90.

The solution must be clearly indicated. Multiple solutions or solutions that are not clearly identified will be marked incorrect. If additional space is required please use the back of the page or if necessary request an exam booklet. Clearly state all assumptions made. In the event that a question seems to be missing information proceed to the next question, returning to the offending question time permitting. **Clearly mark the units for all final answers**. **Clearly indicate axis/units for any graphs**. **SHOW YOUR WORK!**

$\varepsilon_o = 8.854\times10^{-12}\,\frac{F}{m}$ $\mu_o = 4\pi\times10^{-7}\,\frac{H}{m}$

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

Question 6 (10 marks)

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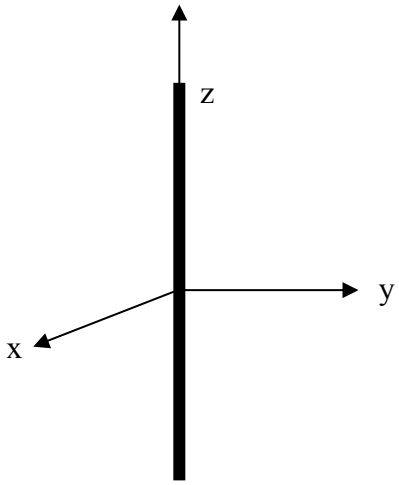
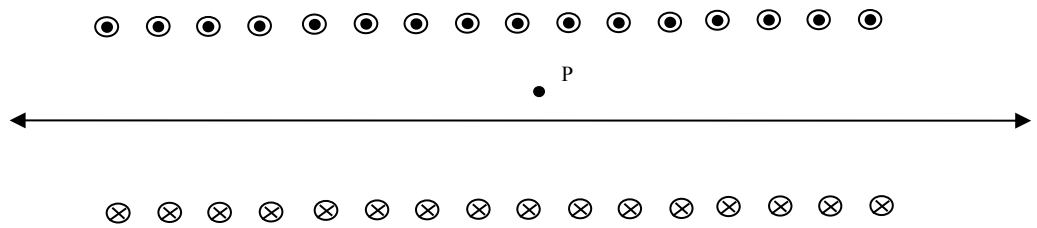


olve this question using the Biot-Savard law. All other approaches give zero points.

An infinite length straight wire carries a current of 1A in the $\hat{z}$ direction. With the wire extending along the z axis and passing through the origin, find the magnetic field vector at the point (3m, 0, 0) produced by this wire.

Question 2 (10 marks)

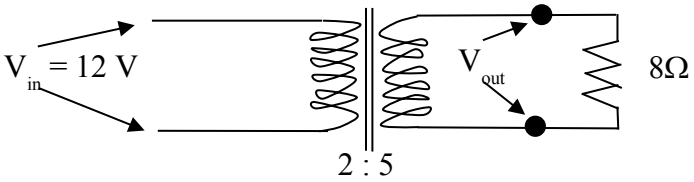


The side view cut through an infinite solenoid is shown in the figure. The radius of the wire loops making up the coils (r_i) is 10 cm. The solenoid has a turn density of 100 turns per cm and carries a current of 1 A. (Current out of the top and in on the bottom as shown in the figure). The solenoid is wound around a core material with relative magnetic permeability of 3.6.

a) Starting from Ampere's law, determine the magnitude and direction of the magnetic field at a point (P) internal to the solenoid.

b) Taking $\vec{B}$ as uniform across the solenoid's cross section, determine the magnetic flux passing through a single coil loop of the solenoid.

Question 3 (10 marks)

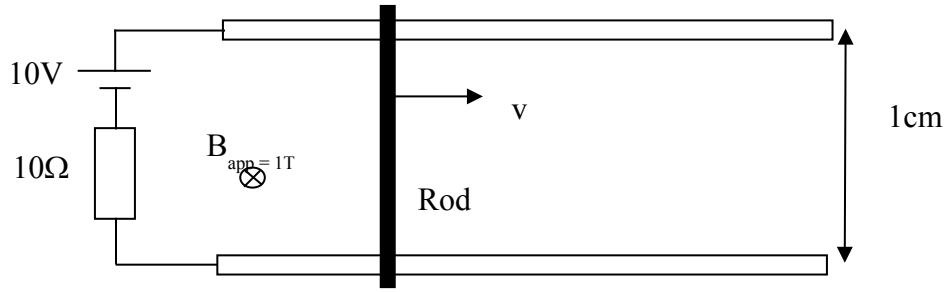


a) The difference between an ideal and a real transformer has to do with the loss mechanisms that are present in the transformer. Discuss these loss mechanisms and indicate how they can be minimized through the design of the transformer.

b) For the transformer shown in the figure determine the output voltage (V_{out}) of the secondary and the current in the attached 5Ω resistor.

c) What is the effective load resistance as seen by the source?

Question 4 (10 marks)



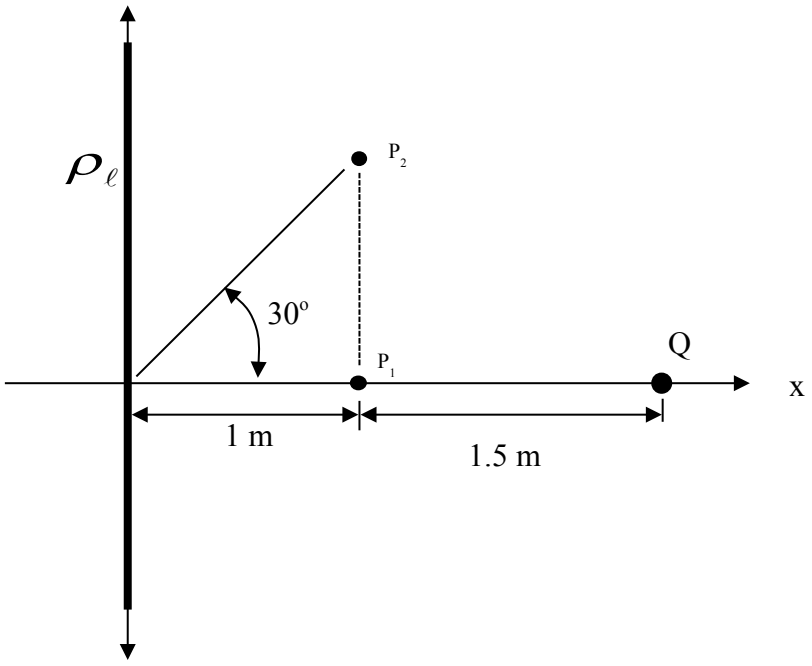
A linear motor is shown in the figure.

a) If the movable rod is displaced towards the right at v = 100 m/s, determine the magnitude and direction of the current passing through the rod.

b) The characteristic motor equation is: $$v = \frac{V_{bat}}{(B_{app}L)} - \frac{RF_{load}}{(B_{app}L)^2}$$

Make a plot of v versus F_{load} . Identify the regions in this plot were the motor is acting as a motor and the regions in the plot were the motor is acting as a generator. Determine the numerical value of the stall load force and no load velocity and indicate were these points are on the trace you made.

Question 5 (10 marks)



A point charge Q = 1C and an infinite line of charge density ρ_ℓ contribute to the total electric field in a region of space.

a) At the point P_1 shown determine the value of the linear charge density such that the net electric field is twice that produced by the point charge alone.

b) For the value of the charge density determined in part a), what is the electric field vector at the point P_2.

Question 6 (10 marks)

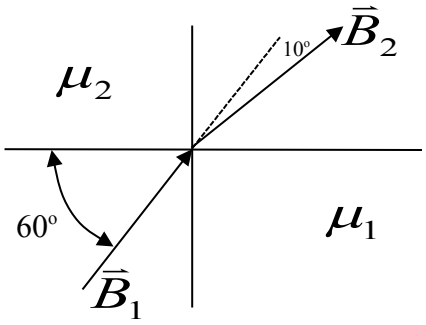


Figure for a)

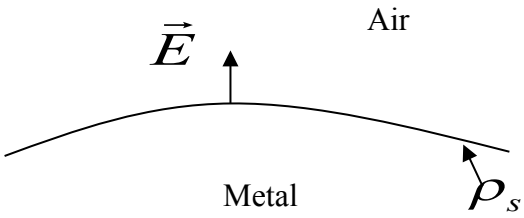
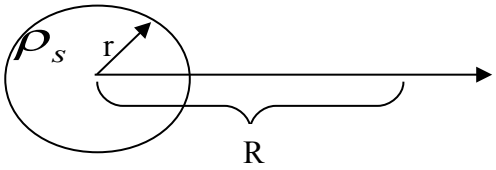


Figure for b)

a) Determine the ratio of $\mu_1 : \mu_2$ such that the magnetic field deviation angle is 10°.

b) The metal air interface contains a surface charge density $\rho_s = 1\frac{C}{m^2}$. Determine the magnitude and direction of the electric field at any point just above the surface of the metal.

Question 7 (10 marks)



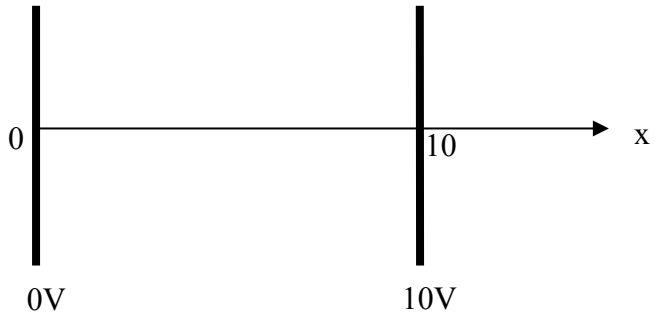
A metallic sphere of radius r = 1 cm is known to contain a positive surface charge Q_s . At a distance R = 1m from the sphere's center the potential, V(R), is measured at 2 volts.

a) Determine the surface charge on the metal sphere.

b) Determine the potential that would be measured at a distance of 0.5 m from the sphere's center.

c) Determine the capacitance of the sphere.

Question 8 (10 marks)



A volume charge density, located in the region between two metal flat surfaces, linearly increases in numerical value as given by the following expression: $\rho_v(x) = x\frac{C}{m^3}$. The metal surface on the right is placed at 100 volts while the metal surface on the left is at 0 volts. The x axis separation of the metal surfaces is 10 m. Take the metal surfaces as infinite in extent and parallel to the (y, z) plane.

a) Treating this as a 1-D problem and starting from $\nabla^2 V = -\frac{\rho}{\varepsilon}$ determine the expression for the potential, *V(x),* in the region between the metal surfaces. Make certain to apply the boundary conditions in order to determine any integration constants.

Question 9 (10 marks)

a) An electric dipole $\vec{p} = 1\frac{C}{m}\left(\frac{\hat{x}+\hat{y}}{\sqrt{2}}\right)$ is placed in a uniform electric field given by $\vec{E} = 6\frac{V}{m}(\hat{z})$. Determine the torque vector on the dipole. Make a simple diagram showing coordinate axis, the dipole, electric field vector and direction of rotation.

b) A magnetic dipole $\vec{m} = 1Am^2\left(\frac{\hat{x}+\hat{y}}{\sqrt{2}}\right)$ is placed in a non-uniform magnetic field given by $\vec{B} = 1T\left(\frac{\hat{x}+\hat{y}+xy\hat{z}}{\sqrt{3}}\right)$. Determine the net magnetic force on the magnetic dipole. Evaluate the force at the point *(x = 1m, y= 2m, z = 0m).*

Question 10 (10 marks)

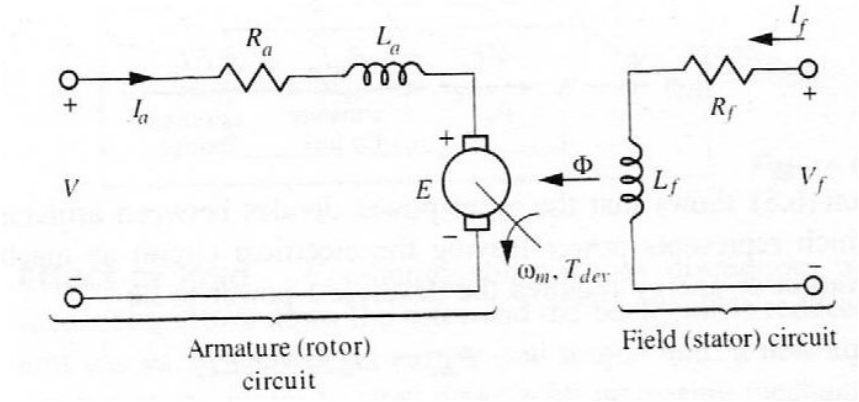


Figure 10

Parameters (I_a = 50A, R_a = 1 Ω, R_f = 1000 Ω, V = 100 volts, V_f = 250 volts)

In steady state operation the voltage *E* of the motor is 50 volts and the motor rotation rate ω_m is 5000 rpm. For the motor determine the following:

a) Determine the motor constant, K_e, which relates motor voltage and rotation rate or torque and armature current.

b) Calculate the motor torque at 5000 rpm.

c) Calculate the new motor voltage *E'* at 1000 rpm.

d) Calculate the new current, I'_a at 1000 rpm.

e) What is the overall efficiency of the motor at 1000 rpm? A full efficiency calculation requires that the power dissipated in the field circuit section be included.