University of Toronto
Faculty of Applied Science and Engineering
Department of Electrical and Computer Engineering

ECE110S – Electrical Fundamentals
Term Test 1 – February 5, 2015, 6:30 – 8:00 p.m.

($e = 1.6 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m, g = 9.81 N/kg)

ANSWER ALL QUESTIONS ON THESE SHEETS, USING THE BACK SIDE IF NECESSARY.

1. Non-programmable calculators (Casio FX-991MS & Sharp EL-520X) are allowed.
2. For full marks, you must show methods, state UNITS and compute numerical answers when requested.
3. Write in PEN. Otherwise, no remarking request will be accepted.
4. There is one extra blank page at the end for rough work.

Last Name: _____

First Name: _____

Student Number: _____

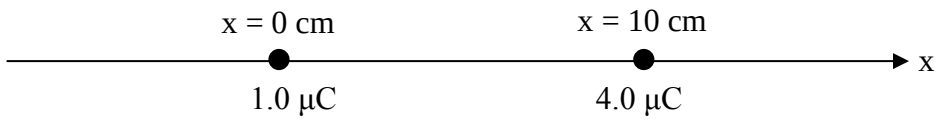
Tutorial Section:
(YOU LOSE ONE MARK FOR NOT MARKING YOUR TUTORIAL SECTION CORRECTLY**)**

- ☐ 01 GB405 Mon. 1-3 p.m.
- ☐ 02 BA1210 Fri. 4-6 p.m.
- ☐ 03 WB342 Fri. 1-3 p.m.
- ☐ 04 GB304 Thu. 1-3 p.m.
- ☐ 05 GB304 Wed. 12-2 p.m.
- ☐ 06 WB342 Wed. 12-2 p.m.
- ☐ 07 BA1200 Fri. 4-6 p.m.
- ☐ 08 WB342 Mon. 3-5 p.m.
- ☐ 09 RS208 Fri. 4-6 p.m.
- ☐ 10 SF2202 Wed. 4-6 p.m.
- ☐ 11 SF3201 Thu. 10-12 p.m.
- ☐ 12 WB342 Wed. 4-6 p.m.

Question	Mark
1	
2	
3	
TOTAL	

Q1 [10 marks] Two stationary charges, one of 1.0 μC and the other of 4.0 μC, are separated by a distance of 10 cm as shown in the figure below.

a) On the diagram below sketch the E-field lines between the charges. (3 marks)



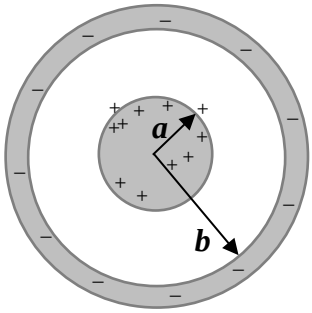
b) Determine the location of the point between the charges on the x-axis where the E-field is zero? (3 marks)

$\frac{10}{3}$ (cm)

c) A third charge of -2.0 μC is placed mid-way between the two positive charges. Calculate the total force on this new charge. (4 marks)

$21.6i$ (N)

Q2 [10 marks] Consider two concentric conductors, an inner sphere of radius ***a*** and an outer spherical shell of radius ***b*** as shown in the figure. The inner sphere has a positive charge and the outer spherical shell has a negative charge equal in magnitude to that of the inner sphere.



a) What is the electric field anywhere in the space outside of the outer spherical shell? (1 marks)

zero

b) For ***a*** = 2 cm and ***b*** = 7 cm, if the magnitude of the electric field is 3×10^6 N/C at radius r = 5 cm in the space between the two concentric conductors, what is the charge on each of these conductors? (3 marks)

8.34×10^{-7} (C)

c) Derive the capacitance of this system of conductors (Note: an expression in terms of ***a*** and ***b*** is required). (4 marks)

$$c = \frac{4\pi\varepsilon_0}{\frac{1}{a}-\frac{1}{b}}$$

d) Assume that the outer shell has a diameter that approaches infinity, what is the energy stored in the center conductor if its radius is equal to the radius of earth (6.371×10^6 m)? (2 marks)

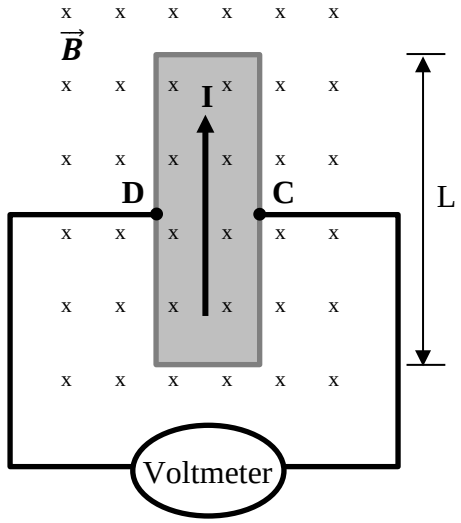
4.91×10^{-10} (J)

Q3 [10 marks]

a) The rectangle shows the top view of a copper slab of length *L* and thickness *T* (thickness *T* not shown in the figure) placed in a uniform magnetic field ($\vec{B}$) pointing into the page. Please note that the copper slab is non-deformable. A constant current I is passed through the copper slab from the bottom to the top (wires bringing the current into and out of the slab are not shown). Moreover, a voltmeter is connected to the rectangular slab at locations labeled *C* and *D*. Circle the correct observation listed below and justify your answer. (4 marks)

i) Electrostatic potential (i.e. voltage) at *C* is higher than *D*.
ii) Electrostatic potential (i.e. voltage) at *C* is lower than *D*.
iii) Electrostatic potential (i.e. voltage) at *C* is the same as *D*.

← e^- are moving from top to bottom, force on e^- are pointing from right to left, e^- will accumulate on left side



b) Figure below shows a straight metallic wire (in the shape of a cylinder) placed in a uniform magnetic field of B = 1.5 T pointing into the page. A current I_0 flows through the wire (connections are not shown) and the wire is elevated from the floor. If mass density of the wire (ρ_o) is 8920 kg/m^3 and wire radius is 0.5 cm, what is the magnitude and direction (from left to right or from right to left) of the current needed to keep the wire afloat above the floor. (6 marks)
{Hint: magnitude of the gravitation force on an object is given by: $\boldsymbol{F_G = m\,g}$, where *m* is the object's total mass and *g* is a constant equal to 9.81 m/s^2}

4.577 (A) from left to right