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

ECE110S – Electrical Fundamentals
Term Test 1 – February 15, 2017, 6:30 – 8:00p.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: Solutions

Student Number: ______________________________

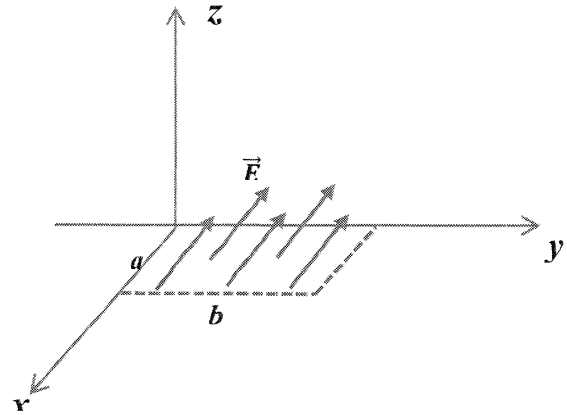
Tutorial Section:
(YOU LOSE ONE MARK FOR NOT MARKING YOUR TUTORIAL SECTION CORRECTLY)

- ☐ 01 GB404 Mon. 3-5 p.m.
- ☐ 02 SF2202 Mon. 3-5 p.m.
- ☐ 03 WB342 Thu. 12-2 p.m.
- ☐ 04 WB342 Thu. 4-6 p.m.
- ☐ 05 GB404 Fri. 4-6 p.m.
- ☐ 06 GB304 Thu. 12-2 p.m.
- ☐ 07 WB341 Tue. 3-5 p.m.
- ☐ 08 SF2202 Wed. 10-12 p.m.
- ☐ 09 GB405 Tue. 12-2 p.m.
- ☐ 10 BA1240 Tue. 3-5 p.m.
- ☐ 11 SF2202 Fri. 9-11 a.m.
- ☐ 12 SF2202 Wed. 4-6 p.m.

Question	Mark
1	
2	
3	
TOTAL	

Q1 [10 marks]

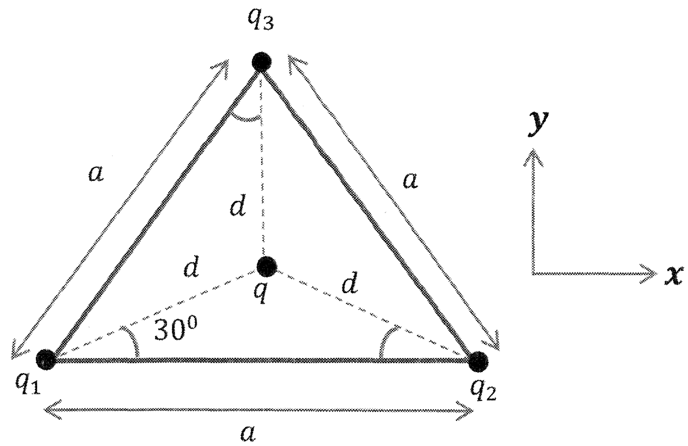
a) [4 marks] Figure shows a uniform electric field $\vec{E} = \sqrt{3}\,\hat{j} + \hat{k}$ penetrating through the top surface of a box (box itself is not shown) with dimensions $a = 3$m by $b = 4$m which is located in the x-y plane. What is the value and sign of electric flux through the top surface?



$$\Phi = E_z A$$
$$= 12\ Nm^2/C$$

b) [6 marks] Positive charges $q_1 = q_2 = 2\ nC$ are placed at the vertices of a triangle as shown. A charge q (positive or negative) is to be placed inside the triangle (as shown) such that it experiences no net force. What should be the value and sign of charge q_3?

Note: $q_1,\ q_2, and\ q_3$ are stationary.



X-comp
forces cancel

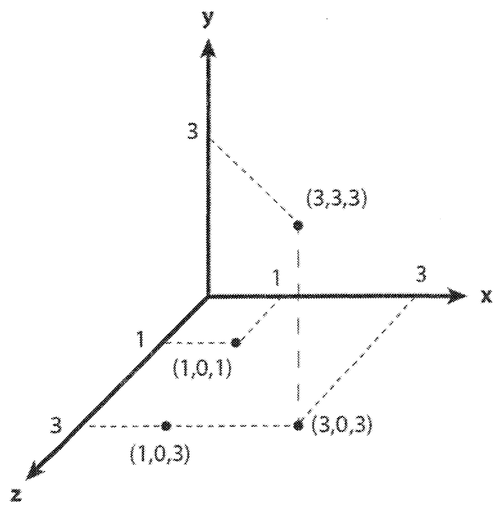
y-comp

$F_{q_1y} + F_{q_2y} = F_{q_3y}$

$q_3 = 2nC$

Q2 [10 marks]

There are 2 infinite non-conducting sheets, each with a surface charge density σ of -2 C/m^2. The first sheet resides on the x-y plane (i.e. the plane described by the equation z = 0); the second sheet resides on the y-z plane (i.e. the plane described by the equation x = 0). All positions are defined in Cartesian coordinates (x,y,z).



a) [2 marks] State the position(s) where a -1 C charge has the greatest electric potential energy.

y-axis

b) [3 marks] A -1 C charge moves from the position (1,0,1) to (3,0,3). What is the electric potential energy difference?

$U = -q\vec{E}\cdot r$

$= -\frac{4}{\varepsilon_0}$ J

c) [2 marks] A -1 C charge moves from the position (1,0,1) to (3,3,3). What is the electric potential energy difference?

y-comp no effect

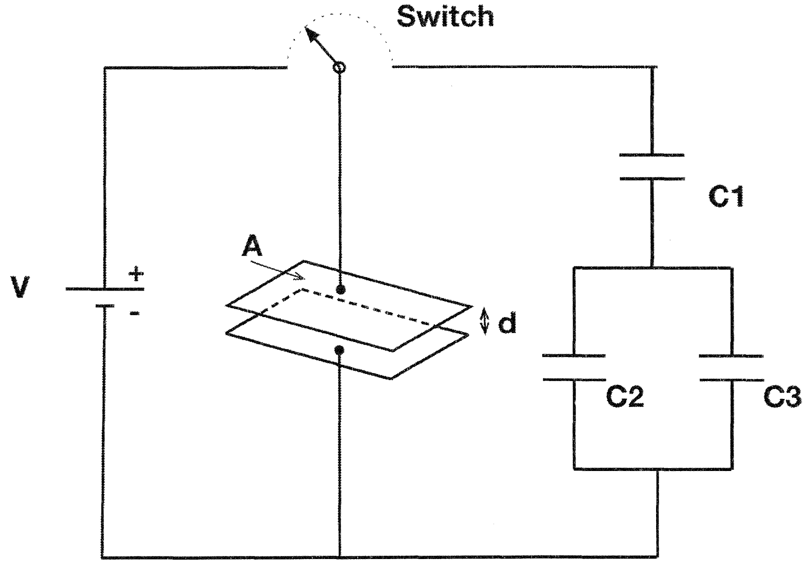
answer same as part b)

d) [3 marks] A +1 C charge moves from the position (3,3,3) to (1,0,3). What is the potential difference (i.e. voltage)?

$$\Delta V = E \Delta r$$
$$= -\frac{2}{\varepsilon_0}$$

Q3 [10 marks]

Consider a parallel plate capacitor, which consists of two conducting plates, each with an area A = 4 cm^2 and separated by a distance d of 0.2 cm. The capacitor is connected to a battery with output voltage, V = 5.2 V as shown in the figure below.



a) [2 marks] Calculate the energy stored in the parallel plate capacitor when the capacitor is connected directly to the battery.

$$U = \frac{1}{2} C V^2 = 2.4 \times 10^{-11}\ J$$

b) [2 marks] The parallel plate capacitor, in part a), is then disconnected from the battery. A dielectric, with dielectric constant k = 8, is inserted between the plates. Calculate the new energy stored in the capacitor?

q stays constant

$$U_{new} = 2.98 \times 10^{-12}\ J$$

c) [6 marks] The parallel plate capacitor, in part b), with the dielectric in place, is then connected to the bank of capacitors shown on the right hand side of the figure. The capacitors have values of C1 = 5 pF, C2 = 6 pF, and C3 = 9 pF. Calculate the charge stored in C1 and the final voltage across the parallel plate capacitor.

$C_{eq(123)} = 3.76 pF$

Volt & q conserved

$q_{eq} = 1.91 \times 10^{-12} C$

$q_{PP} = 7.29 \times 10^{-12} C$

$V = 0.513 V$