EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS

2019/2020 ACADEMIC YEAR

SECOND YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION (SCIENCE)

PHYS 212: ELECTRICITY AND MAGNETISM 1

STREAM: B.Sc., B.Ed. (SCI) & B.Sc. (COMPUTER) TIME: 2 HOURS

EXAMINATION SESSION: DECEMBER YEAR: 2019

INSTRUCTIONS

- **Read the question paper carefully**
- **Answer question ONE and any other THREE questions**
- **Show all the workings clearly**
- **Use the constants provided below whenever necessary**

Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12}\ C^2/N.m^2$
Charge of an electron (e)	$q_e = -1.6021917 \times 10^{-19} C$
Charge of a proton (p)	$q_p = +1.6021917 \times 10^{-19} C$
Coulombs constant	$k_e = 8.99 \times 10^9\ N.m^2/C^2$
Mass of an electron	$m_e = 9.11 \times 10^{-31}\ kg$

QUESTION ONE (40 MARKS)

a) i. State the properties of electric charge **(3 Marks)**

ii. Calculate the number of electrons whose total charge is approximately equal to 1C of charge. **(2 Marks)**

b) i. State the principle of superposition of electric forces **(3 Marks)**

ii. 2-point charges are located on the positive x-axis of a co-ordinate system. Charge $Q_1 = 1$ nC is 2 cm from the origin and charge $Q_2 = -3$ nC is 4 cm from the origin. What is the total force exerted by these 2 charges on a charge $Q_3 = 5$ nC located at the origin? Gravitational forces are negligible **(5 Marks)**

c) i. Show that the acceleration of a charged particle in a uniform electric field is given by, $a = \frac{qE}{m}$ **(3Marks)**

ii. An electron is projected horizontally into the region of a uniform electric field as shown in Figure 1 with an initial velocity $v_i = 3.00 \times 10^6$ m/s and an electric field E = 200 N/C. The horizontal length of the plates is $\ell = 0.100$ m. Find the acceleration of the electron while it is in the electric field. **(2 Marks)**

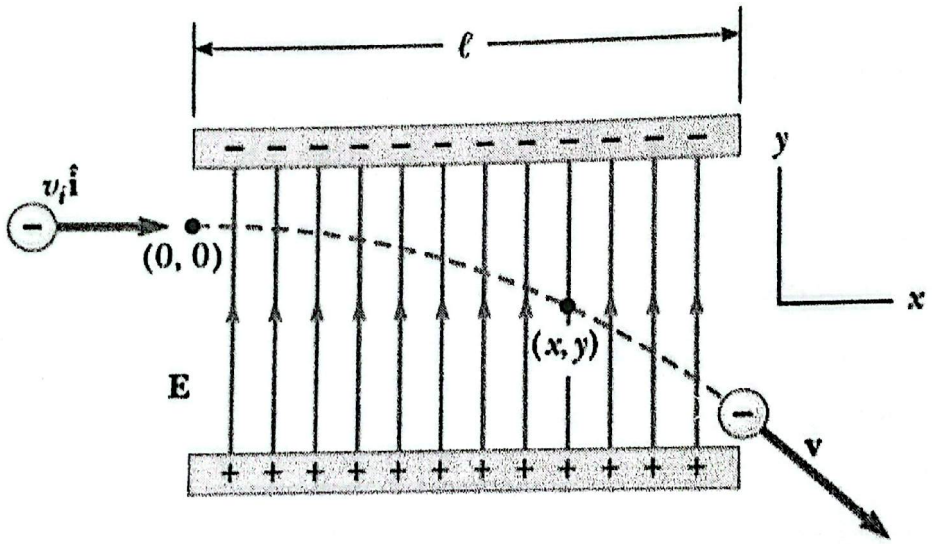

Figure 1

d) i. Differentiate between electromotive force (emf) and potential difference (pd) **(2 Marks)**

ii. A battery has an electromotive force of **12.0 V** and an internal resistance of **0.05 Ω**. Its terminals are connected to a load resistance of **3.00 Ω**. Find the terminal voltage of the battery **(4 Marks)**

e) i. State Kirchhoff's junction and loop rules **(2 Marks)**

ii. Use Kirchhoff's loop rule to find the current I in the circuit shown in Figure 2 **(3 Marks)**

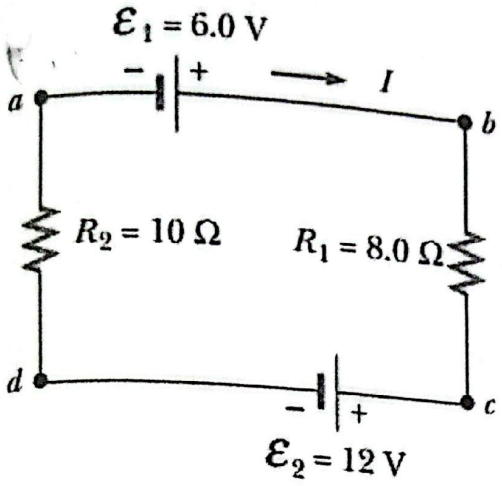

Figure 2

f) Express Faraday's law of induction in equation form and define the relevant terms in the equation **(2 Marks)**

g) Show that the total energy stored in a magnetic field of an inductor is given by; $U = \frac{1}{2}LI^2$ where I is current and L is the inductance **(4 marks)**

h) i. Differentiate between electric potential and electric potential energy **(2 marks)**

ii. A proton is released from rest in a uniform electric field that has a magnitude of $8.0 \times 10^4\ ^V/_m$. The proton undergoes a displacement of $0.50\ m$ in the direction of electric field E. Find the change in electric potential between any 2 points A and B **(3 marks)**

Question 2 (10 Marks)

a). Figure 3 shows the electric field lines for two point charges separated by a small distance. Determine the ratio q_1/q_2. **(1 mark)**

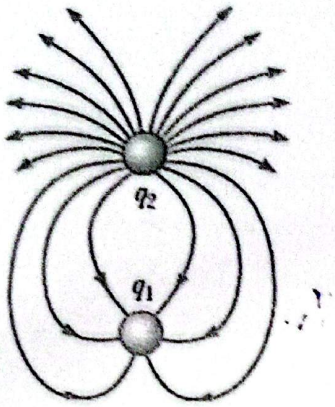

Figure 3

b). A uniformly charged ring of radius 10.0 cm has a total charge of 75.0 μC. Find the electric field on the axis of the ring at 1.00 cm **(3 marks)**

c). For the dipole shown in Figure 4, find the electric field **E** at *P* due to the dipole, where *P* is a distance $y >> a$ from the origin. **(6 marks)**

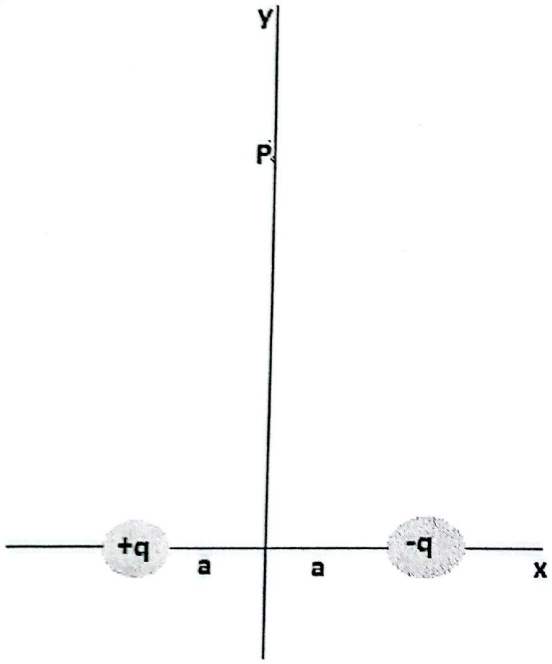

Figure 4

Question 3 (10 Marks)

a). State Gauss's law **(1 mark)**

b). State two properties of a conductor in electrostatic equilibrium **(1 mark)**

c). The following charges are located inside a submarine: 5.00 μC, -9.00 μC, 27.0 μC, and -7.0 μC.

i. Calculate the net electric flux through the hull of the submarine **(2 marks)**

ii. Is the number of electric field lines leaving the submarine greater than, equal to, or less than the number entering it? **(1 mark)**

d). A thin spherical shell of radius a has a total charge Q distributed uniformly over its surface as shown in Figure 5. Find the electric field at points

i. Outside the shell **(3 marks)**

ii. Inside the shell **(2 marks)**

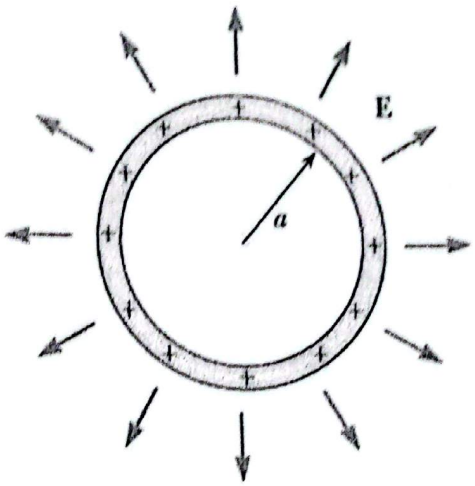

Figure 5

Question 4 (10 Marks)

a) i.If the potential difference across a capacitor is doubled, by what factor does the energy stored change? **(1 mark)**

ii. Determine the capacitance and the maximum potential difference that can be applied to a teflon-filled parallel-plate capacitor having a plate area of 1.75 cm^2 and plate separation of 0.0400 mm. Take the dielectric constant and dielectric strength of teflon to be 2.1 and 60 $\times 10^6$ V/m, respectively. **(4 marks)**

b). Calculate the electric potential at point P on the axis of the annulus shown in Figure 6, which has a uniform charge density σ. **(5 marks)**

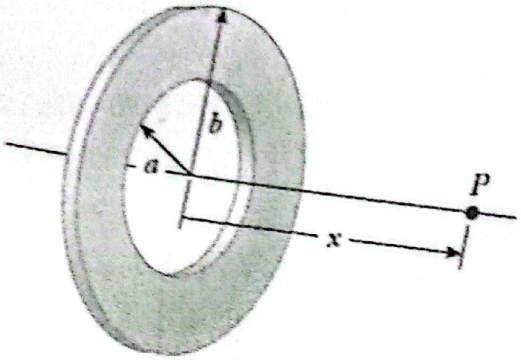

Figure 6

Question 5 (10 Marks)

a). i. Explain why it possible for a bird to sit on a high-voltage wire without being electrocuted.

(2 marks)

ii. Are the two headlights of a car wired in series or in parallel? How can you tell?

(1 mark)

b). Consider a series *RC* circuit in Figure 7 for which $R = 1.00\ \text{M}\Omega$, $C = 5.00\ \mu\text{F}$, and $\varepsilon = 30.0$ V. Find:

i. The time constant of the circuit **(2 marks)**

ii. The maximum charge on the capacitor after the switch is closed. **(2 marks)**

iii Find the current in the resistor 10.0 s after the switch is closed. **(3 marks)**

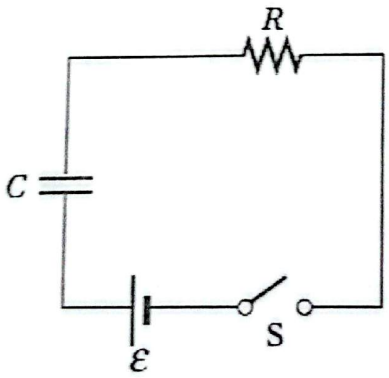

Figure 7