



**STRATHMORE UNIVERSITY**  
**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES**  
**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC**  
**ENGINEERING**  
**PHY1201: PHYSICS II**

**DATE: 23<sup>rd</sup> July 2024**

**TIME: 15:30-17:30 Hours**

**Instructions**

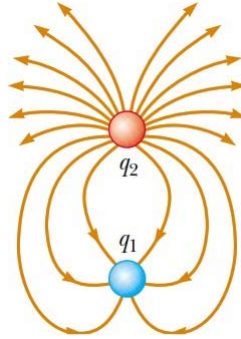
1. *This paper consists of FIVE questions.*
2. *Answer question 1 (Compulsory) and ANY other TWO questions*

<b>Important constants</b>	
Charge of an electron or proton, $q_{e^-}$ or $q_{e^+}$	$1.6 \times 10^{-19}C$
Mass of an electron $m_e$	$9.1095 \times 10^{-31}kg$
Mass of a proton, $m_p$	$1.673 \times 10^{-27} kg$
Mass of deuterons, $m_d$	$2m_p$
Coulomb constant $k_e$	$8.9875 \times 10^9 N \cdot m^2 / C^2$
Permittivity of free space $\epsilon_0$	$8.8542 \times 10^{-12} C^2 / N \cdot m^2$
Permeability constant, $\mu_0$	$1.26 \times 10^{-6} T \cdot m / A$
Gravitational acceleration, $g$	$9.81 m/s^2$
1 MeV	$1.60 \times 10^{-13} J$

### **QUESTION 1**

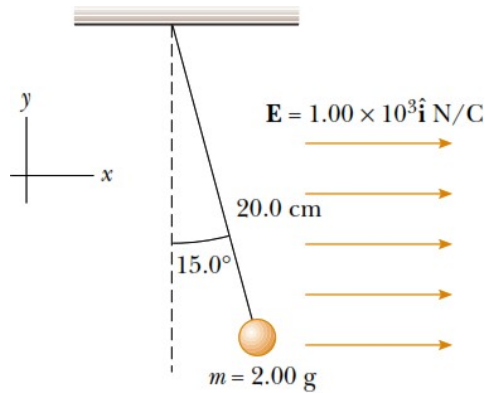
a)

- i) **Figure 1** shows the electric field lines for two-point charges separated by a small distance. Determine the ratio  $q_1/q_2$ . (b) What are the signs of  $q_1$  and  $q_2$ ? **(3 marks)**



*Figure 1*

- ii) A small, 2.00-g plastic ball is suspended by a 20.0-cm-long string in a uniform electric field as shown in **Figure 2**. If the ball is in equilibrium when the string makes a  $15.0^\circ$  angle with the vertical, what is the net charge on the ball? **(5 marks)**



*Figure 2*

b)

- i) What is the difference between hard and soft ferromagnetic materials? Give two examples of hard and soft ferromagnetic materials. **(3 marks)**
- ii) In an experiment that is designed to measure the Earth's magnetic field using the Hall effect, a copper bar 0.500 cm thick is positioned along an east–west direction. If a current of 8.00 A in the conductor results in a Hall voltage of  $5.10 \times 10^{-12}$  V, what is the magnitude of the Earth's magnetic field? (Assume that  $n = 8.49 \times 10^{28}$  electrons/m<sup>3</sup> and that the plane

of the bar is rotated to be perpendicular to the direction of B.) (3 marks)

c)

- i) Describe the dual nature of light. (2 marks)
- ii) An anti-shoplifting mirror shown in **Figure 3**, shows an image of a woman who is located 3.0 m from the mirror. The focal length of the mirror is - 0.25 m. Find the position of her image and the magnification of the image. (4 marks)



Figure 3

- d) An ink drop with a mass  $m$  of  $1.3 \times 10^{-10}$  kg and a negative charge of magnitude  $Q = 1.5 \times 10^{-13}$  C enters the region between the deflecting plates of an ink-jet printer, initially moving along the  $x$  axis with speed of  $V_x = 18$  m/s as shown in **Figure 4**. The length  $L$  of each plate is 1.6 cm. The plates are charged and thus produce an electric field at all points between them. Assuming that field  $E$  is downward directed, is uniform, and has a magnitude of  $1.4 \times 10^6$  N/C. What is the vertical deflection of the drop at the far edge of the plates? (The gravitational force on the drop is small relative to the electrostatic force acting on the drop and can be neglected.) (5 marks)

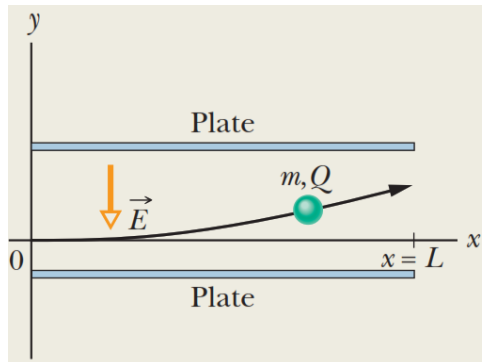


Figure 4

- e) A parallel-plate capacitor with a plate separation  $d$  has a capacitance  $C_0$  in the absence of a dielectric. What is the capacitance when a slab of dielectric material of dielectric constant  $\kappa$  and thickness  $1/3 d$  is inserted between the plates? (5 Marks)

## QUESTION 2

- a) A light, uncharged metallic sphere suspended from a thread is attracted to a charged rubber rod. After it touches the rod, the sphere is repelled by the rod. Explain. (2 marks)
- b) Using equations, state the following laws. (2 Marks)

- i) Gauss Law
- ii) Coulomb's law
- c) An electric dipole consists of two charges of equal magnitude and opposite sign separated by a distance  $2a$ , as shown **Figure 5** and **Figure 6**.

i) Show that the electric field  $E$  at  $P$  due to the electric dipole in **Figure 5** is, **(5 Marks)**

$$E = k_e \frac{2qa}{y^3}$$

where  $P$  is a distance  $y \gg a$  from the origin.

For the **Figure 6** below:

- ii) Calculate  $V$  and  $E_x$  at a point far from the dipole. **(3 Marks)**
- iii) Calculate  $V$  and  $E_x$  if point  $P$  is located anywhere between the two charges. **(3 Marks)**

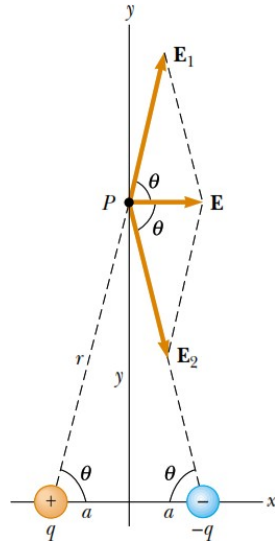


Figure 5

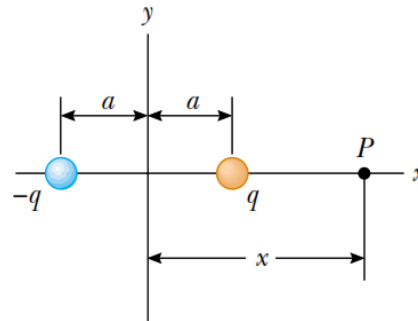


Figure 6

### QUESTION 3

- a) With the aid of a diagram, describe how electrostatic precipitator works. **(5 Marks)**
- b) Three-point charges are located at the corners of an equilateral triangle as shown in **Figure 7**. Calculate the resultant electric force on the  $7.00\mu\text{C}$  charge. **(5 Marks)**

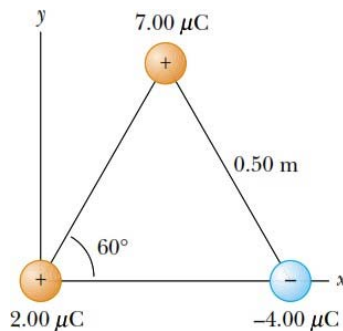
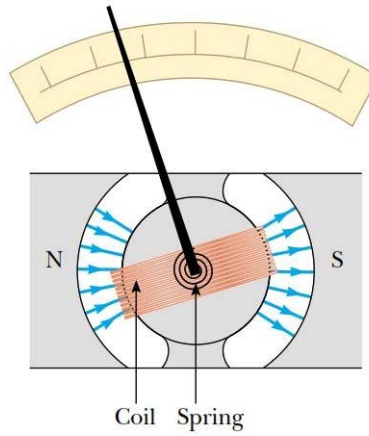


Figure 7

- c) An end view of a D'Arsonval galvanometer is shown in **Figure 8**. When the turns of wire making up the coil carry a current, the magnetic field created by the magnet exerts on the coil a torque that turns it (along with its attached pointer) against the spring. Show that the angle of deflection of the pointer is directly proportional to the current in the coil. **(5 Marks)**



**Figure 8**

**QUESTION 4**

- a) A telescope is a device used to form magnified images of distant objects. Using clear illustration, describe how telescopes operate. **(5 Marks)**
- b) A rectangular copper strip 1.5 cm wide and 0.10 cm thick carries a current of 5.0 A. Find the Hall voltage for a 1.2-T magnetic field applied in a direction perpendicular to the strip. **(4 Marks)**
- c)
- i) Calculate the drift speed of the electrons in a copper wire with cross-sectional area of  $3.31 \times 10^{-6} \text{ m}^2$  and carries a current of 10.0 A. Assume that each copper atom contributes one free electron to the current. The density of copper is  $8.95 \text{ g/cm}^3$ . **(3 Marks)**
  - ii) Using the classical model of electron conduction, estimate the average time interval between collisions for electrons in copper wire in (i) above. **(3 Marks)**

**QUESTION 5**

- a) How would you shield an electronic circuit or laboratory from stray electric fields? Why does this work? **(2 Marks)**
- b) Differentiate Snell's law of refraction and Huygen's principle applied to refraction **(2 Marks)**
- c) Over a certain region of space, the electric potential is:
- i) Find the expressions for the x, y, and z components of the electric field over this region.
 
$$V = 5x - 3x^2y + 2yz^2$$
**(2 Marks)**
  - ii) What is the magnitude of the field at point P that has coordinates (1, 0, -2) m? **(1 Marks)**
- d) A converging lens of focal length 10.0 cm forms images of objects placed: (a) 30.0 cm, (b) 10.0 cm, and (c) 5.00 cm from the lens.
- i) Construct a ray diagram for each object position. **(3 Marks)**
  - ii) Find the image distance and describe the image for each object position. **(5 Marks)**