



**STRATHMORE UNIVERSITY**  
**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES**  
**Bachelor of Science in Electrical and Electronics Engineering**  
**Final Examination**  
**PHY 1201: PHYSICS 2**

**DATE: 18<sup>th</sup> March 2022**

**TIME: 2 hours**

**Instruction:**

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

***Important constants***

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  $m_p = 1.67261 \times 10^{-27} kg$

Coulomb constant  $k_e = 8.9875 \times 10^9 N.m^2/C^2$

Permittivity of free space  $\epsilon_0 = 8.9852 \times 10^{-12} C^2/N.m^2$

Gravitational acceleration,  $g = 9.8 m/s$

Permeability of free space,  $\mu_0 = 1.257 \times 10^{-7} T.m/A$

**QUESTION 1 (20 MARKS)**

- a) A sinusoidally varying voltage of frequency  $3.00 kHz$  and voltage amplitude of  $30.0V$  is applied across an  $8.00 \mu F$  capacitor. Determine the displacement current in the capacitor (4 marks)
- b) Calculate magnitude of the electric field at a point  $(3.00\hat{i} - 2.00\hat{j} + 4.00\hat{k})m$  given that the electric potential in space is  $V = 4xz - 3x^2y + 2yz^3$ , where V is in volts, x, y, and z are in meters. (3 marks)

- c) Figure 1 shows five charged lumps of plastic and an electrically neutral coin. The cross section of a Gaussian surface  $S$  is indicated. Calculate the net electric flux through this surface given that  $q_1 = q_4 = +3.1 \text{ nC}$ ,  $q_2 = q_5 = -5.9 \text{ nC}$ , and  $q_3 = -3.1 \text{ nC}$  (3 marks)



Figure 1

- d) A glass prism of angle  $72^\circ$  and index of refraction 1.66 is immersed in a liquid of refractive index 1.33. Calculate the angle of minimum deviation for a parallel beam passing through the prism (3 marks)
- e) An electron is shot at an initial speed of  $v_0 = 2.00 \times 10^6 \text{ m/s}$  at an angle  $\theta_0 = 40.0^\circ$  as shown in Figure 2. It then moves through uniform electric field of  $\vec{E} = (5.00 \text{ N/C})\hat{j}$ . A screen for detecting the electrons is positioned parallel to the  $y$ -axis at a distance  $x = 3.00 \text{ m}$ . In unit-vector notation, determine the velocity at which the electron strikes the screen. (4 marks)

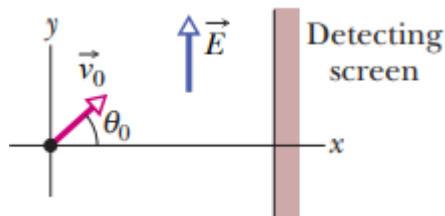


Figure 2

- f) An incandescent lamp connected to a 120-V source with a short extension cord provides more illumination than the same lamp connected to the same source with a very long extension cord. Explain (1 mark)

- g) A solenoid of length 1.23 m and inner diameter 3.55 cm carries a current of 5.57 A. The solenoid consists of five closely packed layers each with 850 turns along its length, calculate the magnetic field at the center of the solenoid. (2 marks)

**QUESTION 2 (20 MARKS)**

- a) An isolated conducting sphere whose radius is 6.85 cm has a charge of  $q = 1.25 \text{ nC}$ .
- Show that the capacitance of the isolated sphere is given as  $4\pi\epsilon_0 R$  and hence calculate (4 marks)
  - The potential energy stored in the electric field of the charged sphere (3 marks)
  - The energy density of the surface of the sphere (3 marks)
- b) A conducting bar moves on two frictionless parallel rails in present of a uniform magnetic field directed into the page as shown in Figure 3. Suppose the bar has a mass  $m$  and length is  $l$  and it is given an initial velocity of  $v_i$  to the right at released at  $t = 0$ , find the velocity of find the velocity of the bar as a function of time (10 marks)

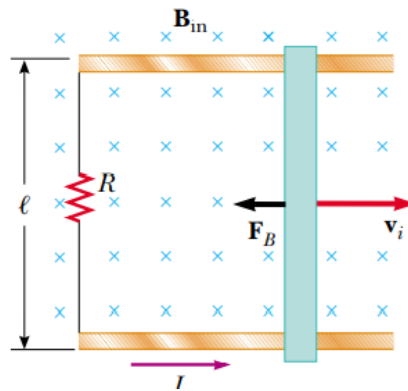


Figure 3

**QUESTION 3 (20 MARKS)**

- a) In an experiment designed to measure the magnitude of a uniform magnetic field, electrons are accelerated from rest through a potential difference of 1.5kV. The electrons travel along a curved path and covers a radius of 9 cm resulting from a magnetic field is perpendicular to the beam of the electrons. Calculate
- the magnitude of the magnetic field. (4 marks)

ii. the angular speed of the electron (2 marks)

b) A dead battery is charged by connecting it to a live battery of another car with jumper cables as shown in Figure 4. Determine the current needed by the starter (7 marks)

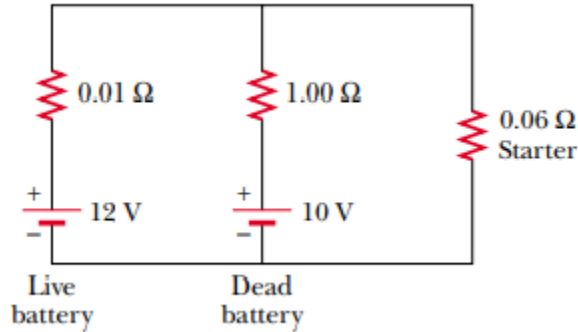


Figure 4

c) Two identical small-charged spheres  $q_1$  and  $q_2$ , each having a mass of  $3.0 \times 10^{-2} kg$ , hang in equilibrium as shown in Figure 5. The length of each string is 0.15 m and the angle  $\theta$  is  $5.0^\circ$ . Find the magnitude of the charge on each sphere. (7 marks)

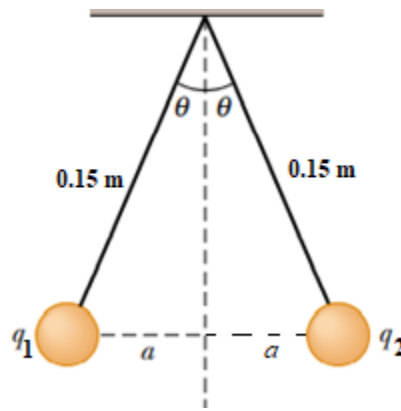


Figure 5

### QUESTION 4 (20 MARKS)

a) In a certain particle accelerator, electrons emerge with an energy of 40.0 MeV. The electrons emerge as pulses at a rate of 250 pulses/s as shown in Figure 6 and not as a steady current. The time interval between pulses is 4.00ms. Each pulse has a duration of 200 ns, and the electrons in pulse have a current of 250 mA. The current is zero between pulses.

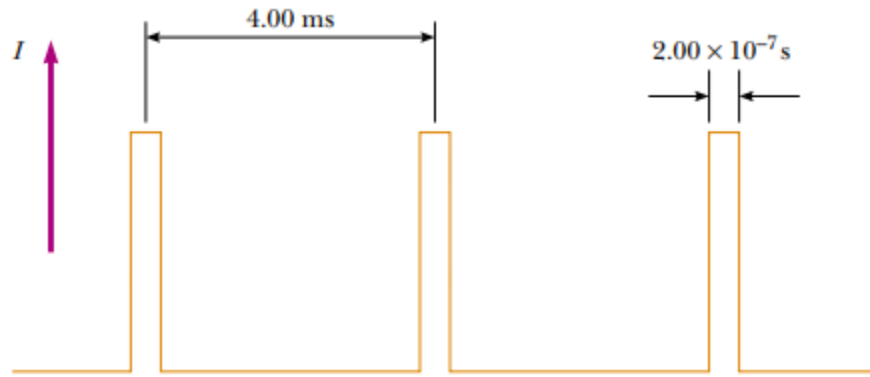


Figure 6

Calculate

- i. The number of electrons delivered by the accelerator per pulse (3 marks)
  - ii. The average current per pulse delivered by the accelerator (2 marks)
  - iii. The peak power delivered by the electron beam (2 marks)
  - iv. The average power delivered the electron beam (2 marks)
- b) Light of wavelength 589 nm is used to view an object under a microscope. If the aperture of the object has a diameter of 0.900 cm
- a. Determine the limiting angle of resolution (2 marks)
  - b. Suppose that water ( $n=1.33$ ) fills the space between the object and the objective, what effect does this have on the resolving power when 589 nm light is used? (3 marks)
- c) Two long parallel wires 5.0 cm apart carry current  $i_1 = 15\text{ A}$  and  $i_2 = 32\text{ A}$  in opposite directions as shown in Figure 7. Determine the magnitude and direction of the net magnetic field at point P shown in the Figure. (6 marks)

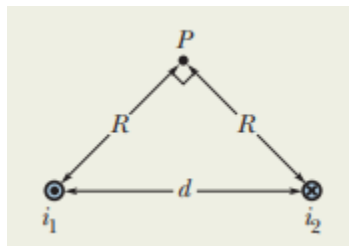


Figure 7

**QUESTION 5 (20 MARKS)**

- a) A negatively charged inkjet drop of mass  $1.3 \times 10^{-10} \text{ kg}$  and charge  $Q = 1.5 \times 10^{-13} \text{ C}$  initially moving along the x-axis with a speed of  $v_x = 15 \text{ m/s}$  enters a region between charged deflecting plates of length  $L = 1.6 \text{ cm}$  as shown in Figure. 8. Suppose the electric field  $\vec{E}$  on the deflecting plates is directed downwards and it is uniform with a magnitude of  $1.4 \times 10^6 \text{ N/C}$ , find the vertical deflection of the charged inkjet drop at  $x = L$ . (4 marks)

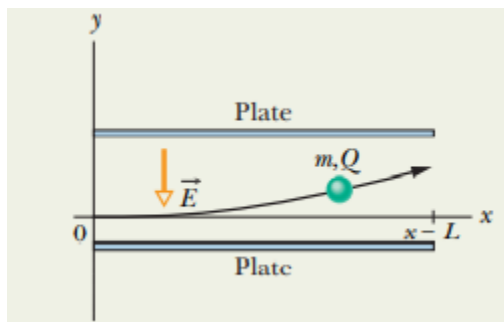


Figure 8

- b) A point charge  $q = 250 \text{ nC}$  is placed at  $(0, 2.00) \text{ m}$  from the center of a spherical shell of radius  $3.00 \text{ m}$  and surface density  $(3.00 \times 10^{-9}) \text{ C/m}^2$ . Determine the electric field at point P placed  $(3.00, 0) \text{ m}$  from the center of the spherical shell (5 marks)
- c) Three-point charges are aligned along the x axis such that  $Q_1 = -4.00 \text{ nC}$  is at  $(-0.500, 0) \text{ m}$ ,  $Q_2 = 5.00 \text{ nC}$  is at  $(0, 0) \text{ m}$  and  $Q_3 = 3.00 \text{ nC}$  is at  $(0.800, 0) \text{ m}$ . Determine the magnitude and position of the electric field at  $(0, 0.200) \text{ m}$ . (11 marks)