



MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR DEGREE IN
BACHELOR OF SCIENCE(MATHEMATICS)
BACHELOR OF EDUCATION (SCIENCE)

SPH 101: ELECTRICITY AND MAGNETISM 1

DATE: 31/5/2017

TIME: 2:00 – 4:00 PM

INSTRUCTIONS

Answer Question One and Any Other Two Questions

The following constants may be useful- mass and charge of an electron 9.1095×10^{-31} kg and $-1.6021917 \times 10^{-19}$ C respectively, mass and charge of a proton 1.67261×10^{-27} kg and $+1.6021917 \times 10^{-19}$ respectively, permittivity of free space $\epsilon_0 = 8.8542 \times 10^{-12}$ C²/N.m², dielectric constant of nylon is 3.5

SECTION A (COMPULSORY)

QUESTION ONE (30 MARKS)

- Define the term “electrostatic equilibrium” (2 marks)
 - State FOUR properties of a conductor in electrostatic equilibrium (4 marks)
- Explain how a dielectric in a capacitor prevents electric breakdown and increases capacitance (2 marks)
- A battery has an emf of 12 v and an internal resistance of 0.04Ω . Its terminals are connected to a load resistance $R = 6.0 \Omega$. Calculate current in the circuit (4 marks)
- Calculate the conductance per unit length of a 26 gauge tungsten wire, which has a radius of 0.13 mm (4 marks)
- Two identical pith balls hang in equilibrium as shown in **figure 2**. The mass of each ball is 2.0×10^{-3} Kg and the length of each string is 0.45 m.

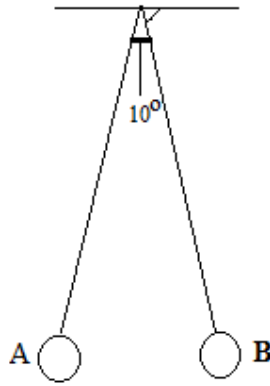


Figure 2

- i) Draw a well labelled Free Body Diagram about ball B (2 marks)
- ii) Find the distance between the spheres (3 marks)
- iii) Calculate electric force between the pith balls (3 marks)
- iv) Find the quantity of charge on each pith ball (2 marks)
- v) Determine the number of electrons in each pith ball (2 marks)
- f) State Lenz's law (2 marks)

SECTION B: ANSWER ANY OTHER TWO QUESTIONS

QUESTION TWO (20 MARKS)

- a) Three point charges q_1, q_2 and q_3 are located at the corners of a right triangle ΔABC in that order, where $\angle ABC = 90^\circ$ and point B is at origin. $q_1 = -3 \mu C$, $q_2 = 4.0 \mu C$ and $q_3 = -2 \mu C$, $AB = 2$ cm and $BC = 3$ cm.
 - i) Represent the above information in a well labelled diagram (3 marks)
 - ii) Show the direction of forces exerted by q_1 and q_2 on q_3 (2 marks)
 - iii) Find the magnitude of forces in part (ii) above (6 marks)
 - iv) Calculate resultant force exerted on q_3 (6 marks)
- b) Find capacitance of a parallel plate capacitor of area 4.0 cm^2 and distance between plates 1.6 mm filled with nylon as a dielectric. (3 marks)

QUESTION THREE (20 MARKS)

- a) A test charge q_o of mass m is located at a distance r from a fixed large positively charged body Q of mass M as shown in figure 2.
 - i) Derive an expression for gravitational field between the two bodies, hence determine its SI units (3 marks)
 - ii) Derive an expression for electric field between the two bodies, hence determine its SI units (3 marks)
 - iii) Compare and contrast part i and ii above (2 marks)
 - iv) Show that electric field E at q_o is given by $E = \frac{Q}{4\pi\epsilon_o r^2}$ (4 marks)

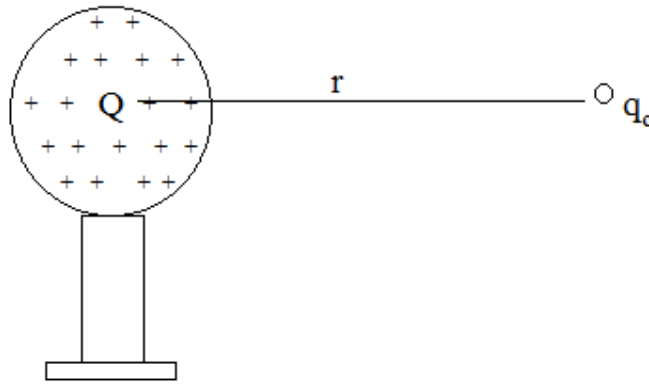
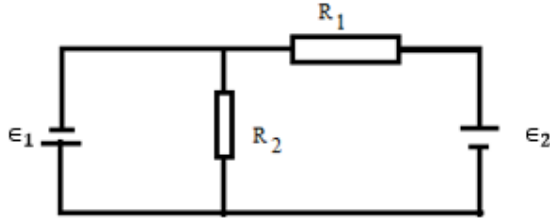


Figure 2

- b) State Ampere's Law (2 marks)
- c) Calculate magnetic field of a solenoid that is infinitely long with tightly wound coils. (6 marks)

QUESTION FOUR (20 MARKS)

- a) A charge $q_1 = 6 \mu\text{C}$ is located at origin and second charge $q_2 = -3 \mu\text{C}$ is located at $(0, 0.4)$ along y- axis. A point P is located at $(0.3, 0)$. Find
- represent the information schematically (2 marks)
 - direction and magnitude of electric field E_1 at P due to q_1 (3 marks)
 - direction and magnitude of electric field E_2 at P due to q_2 (3 marks)
 - resultant electric field at P (4 marks)
- b) State kirchoff's law (2 marks)
- c) Find the current through each of the resistors shown in the circuit **Figure 3**. Given that $\epsilon_1 = 8.0 \text{ V}$, $\epsilon_2 = 5 \text{ V}$, $R_1 = 4 \Omega$, $R_2 = 5 \Omega$ (6 marks)



QUESTION FIVE (20 MARKS)

- a) Consider a capacitor discharge process.
- Draw the circuit that can be used in this process (1 mark)
 - Find an analytical expression for the time dependent of charge (include calculus) (6 marks)
 - Find an analytical expression for the time dependent of current (4 marks)
 - Represent part ii) and iii) graphically (4 marks)
- b) A capacitor of capacitance c is being discharged. After how many time constants is the charge on the capacitor 25 % of its initial value? (3 marks)
- c) Show that time constant has units of time using dimensional analysis (2 marks)