MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR DEGREE IN BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING BACHELOR OF SCIENCE IN CIVIL AND BUILDING ENGINEERING BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

ECU 103: PHYSICS FOR ENGINEERS

DATE: 12/6/2017 **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 x 10^{-31} kg and -1.6021917 x 10^{-19} C respectively, mass and charge of a proton 1.67261 x 10^{-27} kg and +1.6021917 x 10^{-19} respectively, permittivity of free space ε_o = 8.8542 x 10^{-12} $C^2/N.m^2$

a) Charles Coulomb in 1736-1806 measured magnitude of electric forces between charged objects.

   i) State FOUR findings that he made (4 marks)

   ii) Hence derive Coulomb's law (3 marks)

b) The force between an electron and a proton in a hydrogen atom is 6.9 x 10^{-9} N. Find

   i) Distance between them (3 marks)

   ii) Gravitational force between them (3 marks)

   iii) Compare gravitational and electrical force between them (1 mark)

c) Three point charges lie along the y-axis. The positive charge $q_1 = 12\ \mu C$ is at the co-ordinate A (0, y), the positive charge $q_2 = 8\ \mu C$ is located at origin. The resultant force on charge q_3 located at B (0, 0.865) m is zero.

i) Represent the information diagrammatically (2 marks)

ii) Find the co-ordinate A (0, y). (4 marks)

d) Three point charges are located at the corners of an equilateral triangle OAB of side 20 cm as shown in **figure 1**. The charges $q_1 = 7\mu c\ q_2 = 4\mu C\ and\ q_3 = -3\mu C$ are located at O , A and B. Calculate

i) Electric field at O due to A (3 marks)

ii) Electric field at O due to B (3 marks)

iii) Calculate the net electric field at O. (4 marks)

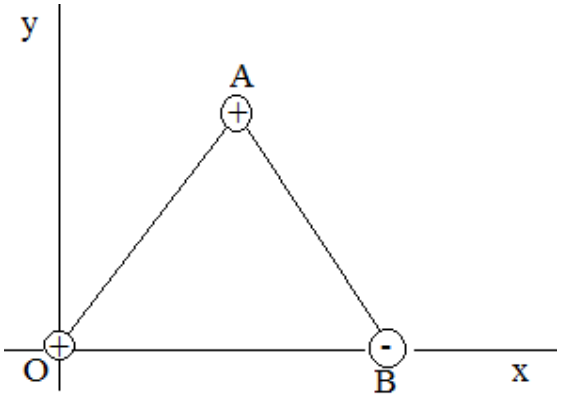

Figure 1

SECTION B: ANSWER ANY OTHER TWO QUESTIONS

QUESTION TWO (20 MARKS)

a) Two identical pith balls hang in equilibrium as shown in **figure 2**. The mass of each ball is 4.0 x 10^{-3} kg and the length of each string is 0.45 m.

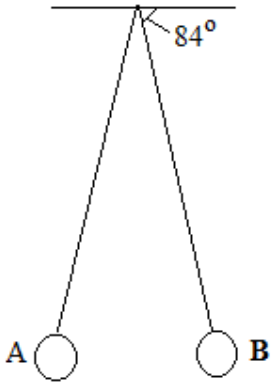

Figure 2

i) Draw a well labelled Free Body Diagram about ball B (1 mark)
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)

b) The Bio-Savart law can be used to evaluate a magnetic field B at a point P
i) State the law giving its statement and mathematical expression (2 marks)
ii) A wire is bent into a square loop of side L and carries current I. Find an expression for the magnetic field at the centre of the square and its direction (4 marks)
iii) If L = 18 cm and I = 3.4 A compute the magnetic field. (3 marks)

QUESTION THREE (20 MARKS)

a) Consider the charging process of a capacitor
i) Draw well labelled circuit that can be used to charge a capacitor (2 marks)
ii) Show that initial value of current at t= 0 is $I_o = \frac{\in}{R}$ (1 marks)
iii) Show that maximum charge reached is $Q = c \in$ (1 marks)
iv) Determine analytical expression for the time dependence of charge (include the calculus) (6 marks)
v) Sketch a graph showing variation of charge with time (1 mark)
vi) Determine analytical expression for the time dependence of current (3 marks)
vii) Sketch a graph showing variation of current with time (1 mark)

b) i) State Ampere's law (give statement and its math expression) (2 marks)
ii) Hence calculate the strength of magnetic field just outside the wire, when the wire 0.3 cm in diameter carry current 2000 A. (3 marks)

QUESTION FOUR (20 MARKS)

a) Show that
i) gravitational potential energy between a body of mass *m* at a distance *r* from a body of mass *M* is given by $U_g = -\frac{GMm}{r}$ (3 marks)
ii) Hence show that electric potential energy between a test charge q_o at a distance *r* from a fixed charge Q will be given by $U_e = \frac{Qq_o}{4\pi\varepsilon_o r}$ (3 marks)
iii) Thus find an expression for electric potential *V* (2 marks)

b) A thunder cloud just before a lightning bolt has positive charge + 500 C accumulated at the top and negative charge – 100 C accumulated at the bottom as shown in **figure 3.** Electric potential energy of the charge accumulations is – 8.0 x 10^9 J. Treating this charge accumulations as point charges

i) Estimate the thickness of the thunder cloud (3 marks)

ii) Find electric potential difference (or simply potential (V)) between positive and negative charge accumulations (3 marks)

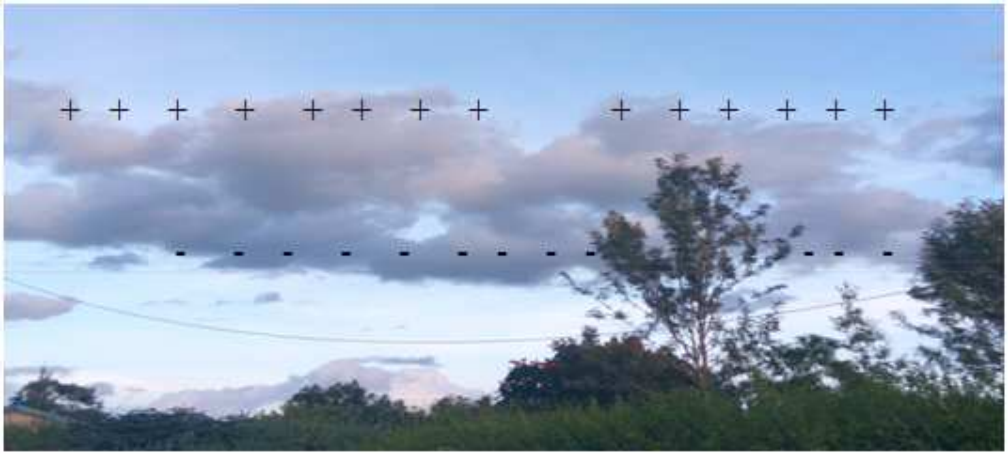

Figure 3

c) State two advantages of dielectric in a capacitor (2 marks)

d) A 400 μF capacitor is made of two strips of metal foil with plate area 64.0 cm^2. The plates are separated by Plexiglas material of thickness 4.0 x 10^{-4} m. Find the dielectric constant? (4 marks)

QUESTION FIVE (20 MARKS)

a) A charge $q_1 = 3\ \mu C$ is located at A (0, 4) and $q_2 = -6\ \mu C$ at B (3, 0). Find

i) potential at origin V_{01} due to q_1 (3 marks)

ii) potential at origin V_{02} due to q_1 (3 marks)

iii) the total electric potential due to these charges at origin (3 marks)

iv) change in potential energy of a $q_3 = 4\mu C$ charge as it moves from minus infinity towards origin. (3 marks)

b) State Kirchoff's rule (2 marks)

c) Calculate current through each resistor in the circuit **Figure 4.** Given the emfs and resistors as $\in_1$ =16 V, $\in_2$ =19 V, $R_1 = 6\ \Omega$, $R_2 = 4\ \Omega$, $R_3 = 3\ \Omega$. (6 marks)

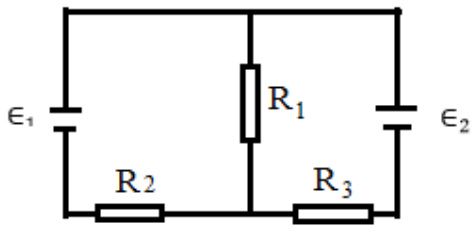

Figure 4