**THE MOMBASA POLYTECHNIC UNIVERSITY COLLEGE**
**UNIVERSITY EXAMINATIONS**
**DEPARTMENT OF MATHEMATICS AND PHYSICS**
**EXAMINATION FOR THE DEGREE OF B. Sc/ B. Eng/ B. Tech IN ELECTRICAL AND ELECTRONICS, MECHANICAL AND AUTOMOTIVE, BUILDING AND CIVIL ENGINEERING, AND INFORMATION TECHNOLOGY**
**SPH 2171/APS 4102: PHYSICS II EXAM**
**DATE: DECEMBER, 2011**
**TIME: 2HOURS**

**Instructions to Candidates**

Answer Question **ONE** and any other **TWO** questions.

Take:

Electronic charge= $1.6\times10^{-19}$C

Permittivity of free space=$8.854\times10^{-12}$ C/(Nm$^2$)

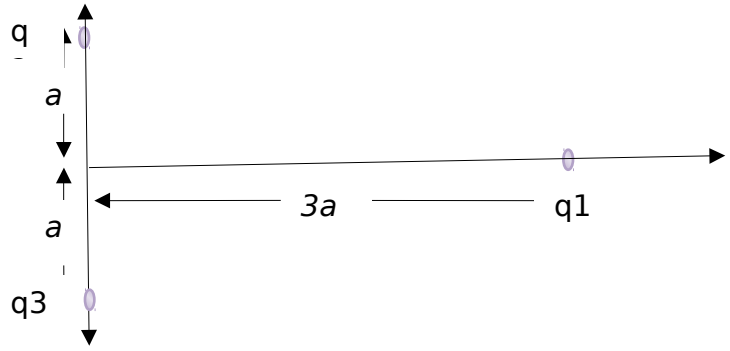
Permeability of free space= $4\pi\times10^{-7}\ NA^{-2}$

Mass of electron, Me =9.11 x 10-31 kg

**Question One (30 Marks)**

a) State Coulomb's law (2 marks)

b) A positive charge $q_1$ interacts with another positive charge $q_2$ and a negative charge $q_3$ as shown in the diagram below.



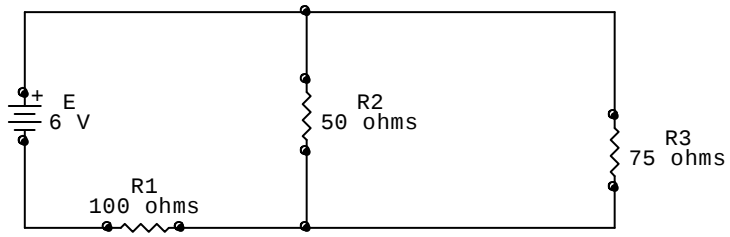

If $q_1$=2.0 μC, $q_2$=5.0 μC, $q_3$=-3.5 μC and a=30 cm, find the magnitude and direction of the resultant force exerted on $q_1$. (5 marks)

**c)** Draw a Wheatstone bridge and explain how it can be used for measuring an unknown resistance. (6 marks)

**d)** Derive the expression of capacitance of a cylindrical capacitor. (6 marks)

**e)** State Ampere's law. (2 marks)

**f)** The figure below shows a resistive circuit. Given that $R_1$=100 Ω, $R_2$=50 Ω, $R_3$=75 Ω, and E=6 V




Find:

**i)** the effective resistance of the circuit (2 marks)

**ii)** the current flowing through R3 resistor (2 marks)

**iii)** the potential difference (pd) across R2 (2 marks)

**g)** Define "half-life" of a radionuclide and express it in terms of the decay constant, λ. (3 marks)

**QUESTION 2 (20 Marks)**

a) State the principle of superposition of electric fields (2 marks)

b) An electric dipole has a distance of separation between the charges as 2a. Find an expression for electric field at a point P, which is at a distance y>>a, on the central axis perpendicular to the dipole orientation (5 marks)

c) If a third charge +q is introduced at point P in (b) above, calculate the total electric potential energy of the system of charges. Take q=10 μC, a= 2 cm and y= 4a. (4 marks)

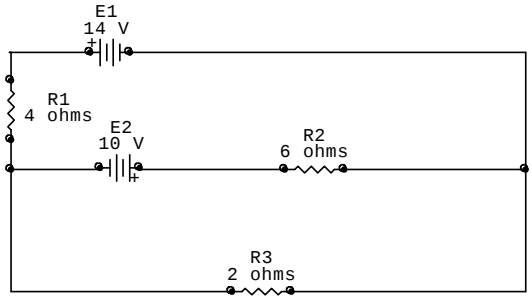
d) A rod of length $l$ has a uniform positive charge per unit length $\lambda$ and a total charge Q. Calculate the electric field and potential at a point P that is located along the axis of the rod at a distance a from one end. (9 marks)

**QUESTION 3 (20 Marks)**

**a)** Define electric current and state its SI unit (2 marks)

**b)** Show that the average current flowing through a conductor of uniform cross-sectional area A is given by $I_{av} = nqv_d A$. Define each term used in your working. (5 marks)

**c)** Use the circuit diagram below to determine the magnitude and direction of the current through the 4Ω, 6 Ω, and the 2 Ω resistors respectively




(10 marks)

**d)** State the factors affecting the magnitude of the induced e.m.f in electromagnetic induction

(3 marks)

**QUESTION 4 (20 Marks)**

**a)** State Lenz's law
(2 marks)

**b)** Explain self induction and outline the factors affecting the inductance of an inductor

(5 marks)

**c)** A 30 mH inductor is connected in series with a 6 Ω resistor and a switch S. If the Emf source across the circuit is 12 V, find:

- **i)** the time constant of the circuit
(2 marks)
- **ii)** the current in the circuit at 2.00 ms
(3 marks)
- **iii)** the p.d. across the resistor at 2.00 ms
(3 marks)
- **iv)** the total energy stored by the inductor when it is fully charged
(3 marks)

**d)** State the significance of Ampere's law
(2 marks)

**QUESTION 5 (20 Marks)**

**a)** Explain the effect of a dielectric placed between the plates of a capacitor
(4 marks)

**b)** Three capacitors are connected in series, find the expression for the effective capacitance in the circuit
(3 marks)

**c)** An electron is released from rest in a uniform electric field that has magnitude of $5.6 \times 10^4$ V/m. The electron undergoes a displacement of 0.50 m in the direction opposite to the electric field. Find:

- **i)** the change in electric potential between the two points
(2 marks)
- **ii)** the change in P.E of the electron-field system for this displacement
(2 marks)
- **iii)** the final speed of the electron
(2 marks)

**d)** Briefly discuss how radiations (x-rays and gamma rays) can be used in measuring thickness of metal sheets
(4 marks)

**e)** Describe the 'causes' of radioactivity
(3 marks)