KABARAK UNIVERSITY

UNIVERSITY EXAMINATIONS
2010/2011 ACADEMIC YEAR
FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHYS 211

COURSE TITLE: ELECTRICITY AND MAGNETISM

STREAM: SESSION II

DAY: SATURDAY

TIME: 9.00 – 11.00 A.M

DATE: 27/11/2010

Instructions

- *Answer Question **ONE** and any other **TWO** Questions. Question One carries **30marks** while each of the other Two Questions carry **20marks**.*
- ***The following constants may be useful***
  - Permeability of free space $\mu_0 = 4\pi \times 10^{-7} Wb/A$
  - Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12} C^2/NM^2$
  - Resistivity of Iron $\rho = 9.68 \times 10^{-8} \Omega m$
  - Acceleration due to gravity $g = 9.8 m/s^2$

PLEASE TURN OVER

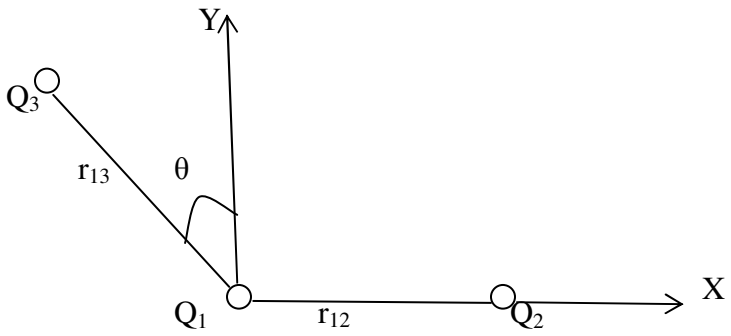
QUESTION 1 (30 marks)

a) i) Name two types of electric charges **(1mark)**

ii) Explain why conductors cannot be charged by friction. **1mark)**

b) i) State the superposition principle **(1mark)**

ii) The diagram below shows three charged particles held in place.



Given that $Q_1 = -1.2\mu C$, $Q_2 = +3.6\mu C$, $Q_3 = -2.4\mu C$, $r_{12} = 25cm$, $r_{13} = 10cm$ and $\theta = 30^0$ Calculate;

I) the resultant force on Q_1 due to the other two charges **(4marks)**

II) The direction of this resultant force **(2marks)**

c) Calculate the electric field at a point 1.5cm from a $2\mu C$ point charge **(2marks)**

d) i) Define electric dipole **(1mark)**

ii) Consider two opposite charges of equal magnitudes placed at a distance (d). Derive the expression of finding the electric field at a point (p) a distance (X) from the line joining the two charges along its bisector **(5marks)**

e) Sketch a diagram to show how a.c. rectification can be achieved using a bridge rectifier **(2marks)**

f) i) State two effects of dielectrics on capacitors **(2marks)**

ii) Consider a capacitor of capacitance (C) without dielectric and capacitance (C') with dielectric of dielectric constant (k). If (q) is the original charge, show that the induced surface charge (q') on the surface of the dielectric is given by

$$q' = q\left(1 - \frac{1}{k}\right)$$ **(5marks)**

g) i) Define r.m.s. value of alternating current **(1mark)**

ii) A bulb is rated 60W, 240V; calculate its maximum value of current and the resistance of the filament **(3marks)**

QUESTION 2 (20 marks)

a) Define flux of a vector field and give circumstances under which flux is positive or negative. **(2marks)**

b) i) State Gauss' law in words and give its mathematical expression **(2marks)**

ii) Consider a cylindrical capacitor of length (L) formed by two coaxial cylinders of radii (a) and (b) and enclosing a charge (q). Derive the expression of finding the capacitance (C) of this capacitor. **(5marks)**

c) i) Define Gaussian surface **(1mark)**

ii) The volume between two concentric spherical conducting shells is filled with an insulating oil of dielectric constant (k). The inner shell has a total charge q^+ and radius (a) and the outer shell has a total charge q^- and radius (b). Find the capacitance of the geometry. **(5marks)**

d) A parallel plate capacitor of capacitance 3.55μF has cross sectional area $2000cm^2$ and plate separation of $10^{-2}m$. If this capacitor is charged to a potential difference $V_0 = 15V$, using a battery, calculate;

i). the energy stored in the capacitor **(2marks)**

ii). the energy density of the capacitor **(3marks)**

QUESTION 3 (20 marks)

a) i) Derive Poisson's equation **(4marks)**

ii) Find the electrostatic potential (V) inside a coaxial cable filled with a dielectric having no net charge **(6marks)**

b) A transformer has primary voltage $V_p = 7.5KV$, secondary voltage $Vs = 150V$ and output power $P_{out} = 80KW$, calculate,

i). the turns ratio **(3marks)**

ii). primary current (I_P) and secondary current (I_S) **(4marks)**

iii). the equivalent load resistance in the primary circuit **(3marks)**

QUESTION 4 (20 marks)

a) Define the following terms **(2marks)**

i). reactance

ii). admittance

b) A series RLC circuit has the following elements: $R = 250\Omega$, $L = 0.8H$, $C = 1.5\mu F$ and $\varpi = 200s^{-1}$. If this circuit is connected to a mains source of 240V, calculate,

i). inductive reactance **(2marks)**

ii). capacitive reactance **(2marks)**

iii). impedance of the circuit **(2marks)**

iv). maximum amplitude current **(2marks)**

v). the phase angle **(2marks)**

c) Define resonance frequency of series RLC circuit and show that it is given by

$$f = \frac{1}{2\pi\sqrt{LC}}$$ **(3marks)**

d) A series RLC circuit is driven by an a.c. source of the form

$$V = V_0 Sin\varpi t$$

Where: $V_0 = 110V$, $f = 50Hz$, $R = 20\Omega$, $L = 5.0\times10^{-2}H$ and $C = 50\mu F$. Find the potential difference across the inductor at $t = 0$ **(5marks)**

QUESTION 5 (20 marks)

a) i) What are electromagnetic waves? **(1mark)**

ii) Consider a varying electromagnetic radiation in space with the vectors $\vec{E}$, $\vec{D}$, $\vec{B}$ and $\vec{H}$ defined by

$$\vec{D} = \varepsilon_0 \vec{E}, \vec{H} = \frac{\vec{B}}{\mu_0} \ ;$$

Show that the magnetic field obeys the equation

$$\nabla^2 \vec{B} = \frac{\varepsilon_0 \mu_0 \partial^2 \vec{B}}{\partial^2 t}$$

Where the symbols have there usual meanings. **(5marks)**

iii) State three properties of electromagnetic waves **(3marks)**

b) i) State Laplace's equation **(1mark)**

ii) Find the electrostatic potential (V) inside a coaxial cable filled with a dielectric having no net charge. **(6marks)**

c) i) What is a filter? **(1mark)**

ii) Sketch a filter implemented using a capacitor which allows direct current at the output. **(3marks)**