



TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Applied & Health Sciences

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR DEGREE OF:

BACHELOR OF SCIENCE IN MATHEMATICS & COMPUTER SCIENCE
BACHELOR OF SCIENCE IN CIVIL ENGINEERING (A & B)
BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING
BACHELOR OF SCIENCE IN MECHANICAL & AUTOMOTIVE ENGINEERING
BACHELOR OF SCIENCE IN STATISTICS & COMPUTER SCIENCE

APS 4201/SPH 2171/SPH 2174: PHYSICS II/PHYSICS FOR ENGINEERS II

END OF SEMESTER EXAMINATION

SERIES: APRIL 2015

TIME ALLOWED: 2 HOURS

Instructions to Candidates:

You should have the following for this examination

- *Mathematical tables*
- *Scientific Calculator*

This paper consist of **FIVE** questions

Answer question **ONE (COMPULSORY)** and any other **TWO** questions

Maximum marks for each part of a question are as shown

This paper consists of **FOUR** printed pages

Question One (Compulsory)

- a) (i) State Coulomb's Law **(2 marks)**
- (ii) An electron and a proton are separated by a distance of 5.5×10^{-11} m. Find the magnitude of the electrostatic force between them **(3 marks)**
- b) Use the super position principle for forces between multiple charges to show that given charges q_1, q_2, \dots, q_n , the force experienced by q_1 due to the other multiple charges is given by:

$$F_1 = \sum_{i=2}^n \frac{1}{4\pi\epsilon_0} \frac{q_1 q_i}{r_i^2} \vec{r}_i$$

where r_{11} is the displacement between charge q_1 and q_i (3 marks)

c) In the classical model of the hydrogen atom the electron revolves around the proton with a radius of $r = 0.53 \times 10^{-10} \text{ m}$. The magnitude of the electron charge and the proton charge is $e = 1.6 \times 10^{-19} \text{ C}$

(i) What is the magnitude of the electrostatic force between the proton and the electron (2 marks)

(ii) What is the magnitude of the electric field due to the proton at r ? (2 marks)

(iii) What is the ratio of magnitudes of the electric (electrostatic) and gravitational force between electron and proton. Does the result depend on the distance between the proton and electron?

(4 marks)

d) (i) What is an electric dipole? (1 mark)

(ii) Show that the electric field strength due to a dipole is given by:

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{2\vec{P}}{r^3}$$

(4 marks)

e) Two capacitors C_1 and C_2 are connected in series with a voltage V across the combination. Show that the voltages across the individual capacitors are:

$$V_1 = \frac{C_2 V}{C_1 + C_2} \quad V_2 = \frac{C_1 V}{C_1 + C_2}$$

and

(4 marks)

f) (i) Differentiate between self and mutual inductance (2 marks)

(ii) Give THREE differences between electric and magnetic forces (3 marks)

(iii) State Ampere's Law (2 marks)

Question Two

a) An electron $q = -e$ placed near a charged body experiences a force in the $+y$ direction of magnitude $3.6 \times 10^{-8} \text{ N}$:

(i) What is the electric field at that location (3 marks)

$(q = +2e)$

(ii) What would be the force exerted by the same body on the alpha particle placed at the location formerly occupied by the electron? Take $e = +1.602 \times 10^{-19} \text{ C}$ (3 marks)

b) Two point charges q_1 and q_2 of $8 \times 10^{-9} \text{ C}$ and $-8 \times 10^{-9} \text{ C}$ respectively shown in figure 1

0.1m

Find the electric fields at points a, b and c

(8 marks)

c) Electric dipole consists of two charges $q_1 = 6\text{mC}$ and $q_2 = -6\text{mC}$ separated by 0.04m. Find the electric field at a point 1.5m away from the centre of the dipole:

(i) On the side of the charge q_1

(3 marks)

(ii) On the line perpendicular to the axis

(3 marks)

Question Three

a) A potential difference of 300V is applied to a $2\mu\text{F}$ capacitor and a $8\mu\text{F}$ connected in series:

(i) Calculate the potential difference across each capacitor

(3 marks)

(ii) The charged capacitors are reconnected with their positive plates together and then negative plates together with no external voltage being applied. Calculate the charge and the potential difference across capacitor

(4 marks)

(iii) The charged capacitor in (a) are connected together with plates of opposite sign. Calculate the charge and the potential difference across each capacitor

(2 marks)

b) A camera flash gets its energy from $150\mu\text{F}$ capacitor and requires 170V to fire. If the capacitor is charged by a 200V source through an $18\text{K}\Omega$ resistor how long must the photographer wait between the flashes

(4 marks)

c) Show that the capacitance for a spherical capacitor consisting of conducting sheet of radius b and charge Q concentric with a smaller conducting sphere of radius a and charge Q is given by:

$$C = \frac{ab}{k(b-a)}$$

(5 marks)

Question Four

a) (i) A certain meter has a resistance of 5Ω and deflect full scale for a voltage of 20mV across its terminal. how can it be converted into a 3A ammeter

(4 marks)

(ii) Calculate the magnetic field of a long straight wire carrying a current of 10A at a distance 8cm from the wire

(3 marks)

(iii) A wire loop of radius 10cm has resistance of 2Ω . The plane the loop is perpendicular to a uniform magnetic field that is increasing at 0.10T/s . Find the magnitude of the induced current in the loop
(5 marks)

b) (i) State and explain the factors that affect capacitance **(4 marks)**

(ii) A parallel plate capacitor with air between the plates has a area of 2cm^2 and plate separation of 1mm. Find its capacitance **(4 marks)**

Question Five

a) State Kirchoff's Laws **(2 marks)**

b) A steady uniform current of 5mA flows axially along a metal cylinder of cross-section area 0.2mm^2 , length 5m and resistivity $3 \times 10^{-5}\Omega\text{m}$. Find:

(i) The potential difference between the ends of the cylinder **(3 marks)**

(ii) The rate of heat production **(3 marks)**

c) Consider the circuit in figure 3

If $R_1 = R_2 = R_4 = R_5 = 1.7\Omega$, $R_3 = 3.5\Omega$ and $E_1 = 2.1\text{V}$ $E_2 = E_3 = 6.3\text{V}$, find the currents i_1, i_2, i_3
(7 marks)



d) Consider the formation of Helium nucleus whose atomic number is 2 and mass number is 4 using 2 protons and 2 neutrons. Determine mass defect and the binding energy of helium nucleus.

$m_n = 1.008666\text{a.m.u}$

The $m_p = 1.007277\text{ a.m.u}$, and mass of helium = 4.001509 a.m.u where 1 a.m.u = $1.66 \times 10^{-27}\text{kg}$ **(5 marks)**

e) e Kirchoff's current and voltage laws **(2 marks)**

f) Explain what is meant by wheat stone bridge network, and derive a relation between the resistances when the bridge is balanced **(5 marks)**

g) A capacitor is charged through a resistor using a battery of constant e.m.f. Draw a sketch graph on some axis showing how the current through the circuit vary with time. Qualitatively explain the shapes **(4 marks)**