P510/2

Physics

Paper 2

July-August 2023

2 ½ Hours

UGANDA MUSLIM TEACHERS' ASSOCIATION

UMTA JOINT MOCK EXAMINATIONS 2023

UGANDA ADVANCED CERTIFICATE OF EDUCATION

Physics

Paper 2

2 Hours 30 Minutes

INSTRUCTIONS TO CANDIDATES:

Answer only five questions, including at least one question from each of the sections A, B, C and D but not more than one question from either section A or B.
Any additional question(s) answered will not be marked.
Mathematical tables and squared paper will be provided where need be.
Non-programmable scientific calculators may be used.
Begin each question on a fresh page of the answer sheets / booklet provided.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ m\,s^{-2}$
Speed of light in Vacuum, c	=	$3.0 \times 10^{8}\ m\,s^{-1}$
Speed of sound in air,	=	$340\ ms^{-1}$
Electronic charge, e	=	$1.6 \times 10^{-19}\ C$
Electronic mass, m_e	=	$9.11 \times 10^{-31}\ kg$
Permeability of free space, μ_o	=	$4.0\pi \times 10^{-7}\ H\,m^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The Constant, $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}\,m$
Planck's constant, h	=	$6.6 \times 10^{-34}\ Js$
Avogadro's number, NA	=	$6.02 \times 10^{23}\ mol^{-1}$
One electrons volt (eV)	=	$1.6\,X\,10^{-19}$
Specific heat capacity of water	=	$4.2\,X\,10^{3}\ Jkg^{-1}\,k^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2\,X\,10^{-6}\Omega m$

SECTION A:

1. (a) (i) State the laws of reflection of light. (02 marks)

(ii) Derive an expression relating the focal length, f, and radius of curvature r, of a convex mirror. (04 marks)

(b) (i) Define **critical angle** as applied to light. (01 mark)

(ii) Explain how total internal reflection is applied in rear reflectors. (03 marks)

(c) (i) Describe an experiment in which the refractive index of a liquid can be determined using an air cell. (05 marks)

(ii) Monochromatic light is made incident at an angle of 43^0 on a glass prism of refracting angle 65^0 in air. If the emergent light just grazes the other refracting surface of the prism, find the refractive index of the glass material. (05 marks)

2. (a) (i) Define **refractive index** of a material. (01 mark)

(ii) A ray of monochromatic light moving in air is incident on a parallel - sided glass block of width, h as shown in figure1. The glass block is made out of a material of refractive index, n.

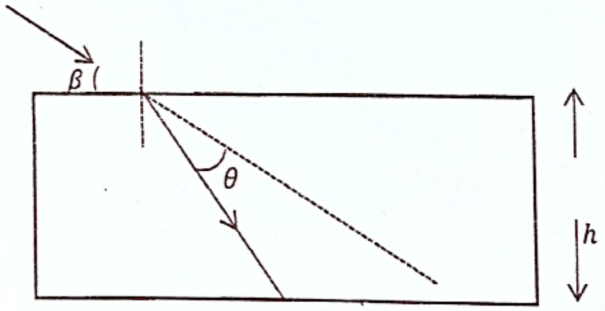

Fig.1

If the ray suffers a deviation, θ, on first face of the block, show that the ray will take time, t, to emerge from the opposite face of the block given by;

$$t = \frac{nhcosec(\theta+\beta)}{c}$$

Where c is speed of light in vacuum. (03 marks)

(b) Define the following as applied to lenses and optical instruments;

(i) **focal length** (01 mark)

(ii) **angular magnification** (01 mark)

(c) A thin liquid lens is formed between a bi-convex lens of focal length 10 cm and a plane mirror. The focal length of the combination is found to be 16.0cm; when the lens is turned over the focal length of the combination is 16.5cm. Calculate the refractive index of the liquid if the refractive index of the glass is 1.5.

(05 marks)

(d) (i) With the aid of a labeled diagram, describe how a Galilean telescope works in normal adjustment. (05 marks)

(ii) Explain the limitation of the telescope in (c)(i) above. (02 marks)

(c) State **two** differences between Microscopes and telescopes. (02 marks)

SECTION B

3. (a) What is meant by the following;

(i) **Beats?** (01 mark)

(ii) **Doppler effect?** (01 mark)

(b) A radar speed gun emitting radio waves of frequency f is pointed at an approaching car moving at speed, v.

(i) Derive the expression for frequency, f_b of the beats registered by the speed gun. (03 marks)

(ii) Calculate speed of the car if $f = 6.0MHz$ and f_b=1.8Hz. (02 marks)

(c) (i) Define **fundamental note** and a **harmonic** in sound. (02 marks)

(ii) Explain why a note emitted by a string can easily be distinguished from that of a turning fork with which it is in unison. (03 marks)

(d) A string of length **1m** and mass **0.5g** is fixed at both ends and kept under tension of 20N. The string is plucked at a point 25cm from one end. Find the frequency of the note emitted by the string. (03 marks)

(e) Describe how the effect of increasing tension in a stretched string on its fundamental frequency may be investigated. (05 marks)

4. (a) (i) State Huygen's principle. (01 mark)

(i) Use Huygen's principle to show that the angle of incident is equal to the angle of reflection of light. (05 marks)

(b) (i) Define the term diffraction as applied to a light wave. (01 marks)

(ii) Describe an experiment in which the wavelength of light can be determined using a diffraction grating and a spectrometer. (06 marks)

(c) (i) What is meant by interference of light waves? (01 marks)

(ii) Explain why a series of bright and dark lines are observed in an air wedge when irradiated normally with a monochromatic light. (03 marks)

(d) Two plane glass plates which are in contact at one edge are separated by a piece of metal foil **12.5cm** from that edge. Interference fringes parallel to the line of contact are observed in reflected light of wavelength 5.46×10^{-7}m and are found to be 1.50mm apart. Find the thickness of the foil. (04 marks)

SECTION C

5. (a) (i) Define **magnetic flux density** and **a magnetic moment.** (02 marks)

(ii) Write down the expression for magnetic flux density at the centre of a plane circular coil of **N** turns, radius **R**, and carrying a current **I** in a vacuum. (01 mark)

(b) A short wire forming part of a current balance of length 2.5cm is at the centre of a coil of radius 8.0cm of 40 turns each carrying a current of 10.0A. Calculate the magnetic force experienced by the wire if a current through it is 3.0A. (04 marks)

(c) With the aid of a diagram, describe an experiment to show how the force acting on a conductor carrying current in a magnetic field depends on the magnitude of the current in the conductor. (05 marks)

(d) (i) Explain with the aid of a sketch diagram and relevant equations why a large voltage builds up across opposite faces of a conductor when a current is passed through it. (04 marks)

(ii) State the effect of increasing temperature on voltage developed in d(i). (01 mark)

(c) A slice of a semi-conductor is 2.0mm thick and carries a current of 50mA. A magnetic field flux density 0.49T correctly applied, produces a maximum hall voltage of 420mV between the edges of the slice. Calculate the number of free charge carriers per unit volume. (03 marks)

8. (a) (i) State the **laws** of electromagnetic induction. (02 marks)

(ii) Describe an experiment to verify Faraday's law of electromagnetic induction. (05 marks)

(b) Figure 2 shows a loop of wire has its shape bent into a semi-circle of radius 20cm. The normal to the plane of the loop is parallel to a uniform magnetic fieldof flux density 0.85T .

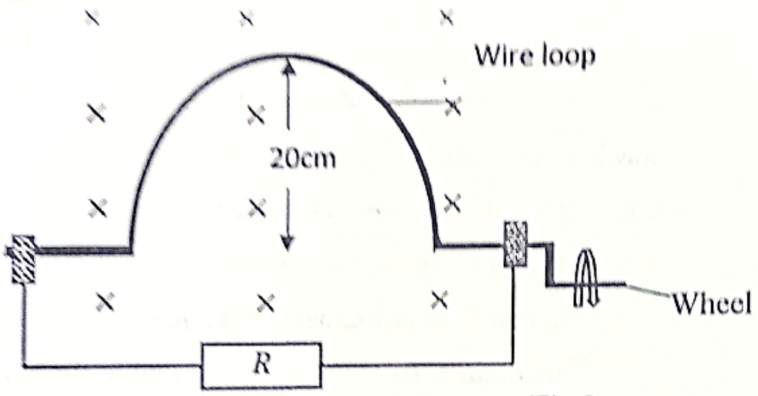

Fig.2

Starting with the position shown in diagram, the loop is rotated through half a revolution,

(i) find the change in magnetic flux linking the loop. (03 marks)

(ii) if the change in (i) takes **0.28s**, and $R = 15\Omega$, calculate the current that flows through R. (03 marks)

(c) (i) What is meant by **back emf** in a dc motor? (01 mark)

(ii) Show that the *emf* induced in a motor rotating at ω radians per second in a radial magnetic field of flux density B is $E = \omega NBA$, where N is the number of turns and A is the area of the coil. (04 marks)

(b) **Figure 2** shows a small disc of copper lying on top of a vertical solenoid of 300 turns of wire per metre and of radius 3.0cm.

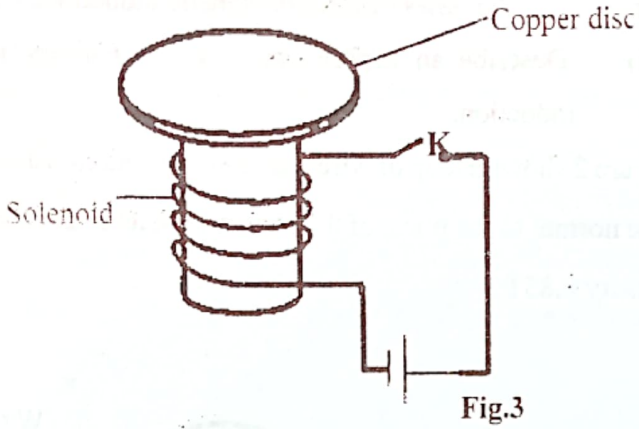

Fig.3

When current in solenoid is suddenly switched on, the disc flies up and very quickly falls back

(i) Explain the observation made. (03 marks)

(ii) If current in solenoid is increasing at a rate of **50A** per second, and the solenoid is surrounded by a small coil of 120 turns wound tightly round its middle, find the emf generated in the small coil while the current in solenoid is increasing. (04 marks)

(c) (i) Define the term **root mean square** value of alternating current. (01 mark)

(ii) With aid of a diagram, describe how a hot – wire ammeter is used to measure alternating current. (04 marks)

(d) A capacitor of **16.0 *F*** and an inductive coil of **300Ω** resistance are connected in series across a **20V, 50Hz** ac supply to form part of a radio circuit. The current obtained is **40mA**.

(i) Calculate the inductance of the coil. (04 marks)

(ii) find the resonant frequency of the circuit. (02 marks)

SECTION D

8. (a) (i) What is meant by the term **electrostatic induction**? (01 mark)

(ii) With aid of diagrams, describe how a metal sphere can be charged positively at zero potential. (04 marks)

(b) (i) Define electric field intensity and electric potential energy. (02 marks)

(ii) Derive an expression for electric field intensity perpendicular to a charged conductor of surface charge density δ in air. (03 marks)

(c) Charges Q_1, Q_2 and Q_3 of magnitude **-3μC**, **+2μC** and **-5μC** respectively are situated vertices of an equilateral triangle of side 10cm in a vacuum as shown in the figure 4.

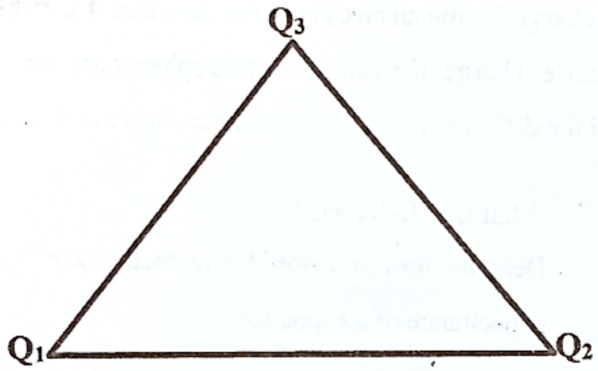

Fig.4

Calculate;

(i) the net force on Q_1 (04 marks)

(ii) the potential energy Q_3 (03 marks)

(d) Explain how electrostatics is applied in oil spray gun. (03 marks)

9. (a) (i) Define **capacitance** and a **farad** as applied to a capacitor. (02 marks)

(ii) Derive the expression for the effective capacitance of three capacitances of capacitances C_1, C_2 and C_3 connected in series. (04 marks)

(b) A capacitor is connected a dc supply of emf, **E** as shown in figure 5.

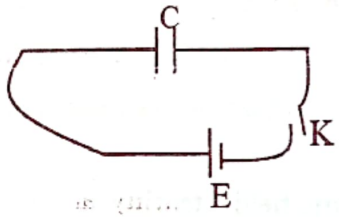

fig.5

(i) On same axes, sketch graphs showing variation of voltage and current from the time switch, **K** is closed. (02 marks)

(ii) Explain why the capacitor stores energy on charging. (02 marks)

(c) Two isolated metal spheres **A** and **B** of radius 80mm and 50mm respectively are charged using an electrophorus such that **A** carries charge of $+10\mu C$ while **B** carries charge of $+4\mu C$. If the two spheres are later connected using a wire, find the difference in energy before and after connection. (05 marks)

(d) (i) What is a **dielectric**? (01 mark)

(ii) Describe how you would investigate the effect of a dielectric on capacitance of a capacitor. (04 marks)

10. (a) Define the following as applied to a battery

(i) **Electromotive force** (01 mark)

(ii) **Internal resistance.** (01 mark)

(b) Explain why it is easier to start a car engine on a hot day than on a cold day. (03 marks)

(c) (i) Explain the principle of a potentiometer. (03 marks)

(ii) Describe how you would adapt the potentiometer in (i) to determine the emf of a thermocouple. (05 marks)

(d) In figure 6, **AB** is a uniform slide wire of length **100cm** and resistance **15Ω**. **Y** is a driver cell of ***e.m.f*** **3.0V** and negligible internal resistance.

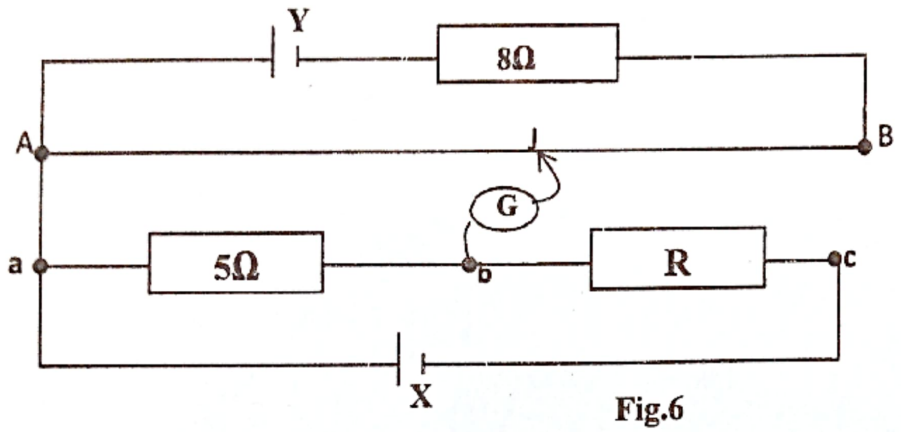

Fig.6

When the galvanometer, **G**, is connected in turn to points ***b*** and ***c***, the balance lengths are 62.0cm and 75.0cm respectively. Calculate the

(i) current flowing through the resistor, **R**. (04 marks)

(ii) e.m.f of cell **X** given that the cell has negligible internal resistance. (03 marks)

END