P510/2
PHYSICS
(Theory)
Paper 2
Nov./Dec. 2020
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS
(THEORY)

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

Answer* five** *questions, taking at least* **one** *from each of the sections;* **A, B, C** *and* **D,** ***but not *more than* **one** *question should be chosen from either* **A** *or* **B.***

Any additional question(s) answered will **not** *be marked.*

Mathematical tables and graph paper are provided.

Non-programmable scientific calculatiors may be used.

Assume where necessary:

Speed of light in a vacuum, C	$= 3.0 \times 10^{8}\,\text{ms}^{-1}$.
Acceleration due to gravity, g	$= 9.81\ \text{ms}^{-2}$.
Electron charge, e	$= 1.6 \times 10^{-19}\,\text{C}$.
Electron mass	$= 9.11 \times 10^{-31}$ kg.
Planck's constant, h	$= 6.6 \times 10^{-34}$ Js.
Permeability of free space, μ_0	$= 4.0\pi \times 10^{-7}\ \text{Hm}^{-1}$.
Permittivity of free space, ε_0	$= 8.85 \times 10^{-1}\ \text{Fm}^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\,\text{F}^{-1}\,\text{m}$.
One election volt (eV)	$= 1.6 \times 10^{-19}$ J.
Avogadro's number, N_A	$= 6.02 \times 10^{23}\,\text{mol}^{-1}$.
Resistivity of Nichrome wire at 25 ^{o}C	$= 1.2 \times 10^{-6}\,\Omega\text{m}$.
Specific heat capacity of water	$= 4.2 \times 10^{3}\ \text{Jkg}^{-1}\,\text{K}^{-1}$.

SECTION A

1. (a) State the **laws of refraction of light**. (*02 marks*)

(b) (i) The deviation, d, by a prism of small angle A and refractive index, n, is $d = (n - 1)A$. Use this to show that the focal length of a thin converging lens of refractive index, n, is given by

$$\frac{1}{f} = (n - 1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

where r_1 and r_2 are the radii of curvature of the lens surfaces. (*05 marks*)

(ii) The radii of curvature of the surface of a converging meniscus are 25 cm and 20 cm. Find its focal length if the refractive index of the lens is 1.5. (*02 marks*)

(c) Describe an experiment to determine the refractive index of a liquid using a biconvex lens of known radius of curvature and a plane mirror. (*06 marks*)

(d) The focal length of a projector lens is 3.0 cm. If a magnification of 300 is required, find the;

(i) distance of the screen from the lens. (*03 marks*)
(ii) distance between the slide and the lens. (*02 marks*)

2. (a) (i) State the **laws of reflection of light**. (*02 marks*)
(ii) With the aid of a diagram, describe the operation of an optical lever in a mirror galvanometer. (*04 marks*)

(b) Describe an experiment to determine the focal length of a concave lens using a convex lens and a plane mirror. (*04 marks*)

(c) Figure 1 shows a ray of monochromatic light incident on a triangular glass prism at an angle of incidance θ. Light just emerges from the face AB of the prism. The speed of light in the prism is $2.0 \times 10^8 ms^{-1}$.

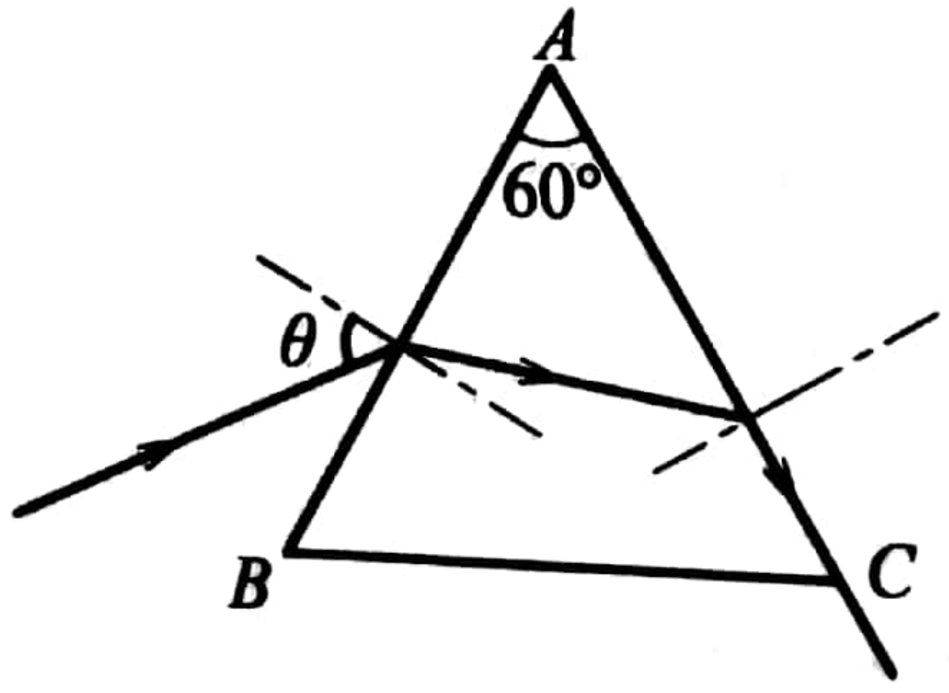

Fig. 1

(i) Calculate the refractive index of the glass. (*02 marks*)

(ii) Find the value of θ. (*03 marks*)

(iii) Explain what happens when the angle of incidance is greater than θ. (*02 marks*)

(d) Describe adjustments of the telescope, and the collimator of a spectrometer before making measurements. (*03 marks*)

SECTION B

3. (a) State **two** differences between **mechanical** and **electromagnetic** waves. (*02 marks*)

(b) Describe an experiment to demonstrate that sound obeys the laws of reflection. (*04 marks*)

(c) (i) Explain what is meant by **beats**. (*03 marks*)

(ii) Explain how beats are used to determine the frequency of a given note. (*04 marks*)

(d) A car, P, moving at a speed of 108 kmh^{-1} towards a stationary observer and another observer in car, Q, moving in the opposite direction with the same speed as, P, sounds a horn of frequency 256 Hz. Find the frequency of sound heard by the;

(i) stationary observer. (*03 marks*)

(ii) observer in car, Q. (*03 marks*)

(*Speed of sound in air = 340 ms^{-1}*)

(e) State **two** applications of the Doppler effect. (*01 mark*)

4. (a) What is meant by the following:

(i) Ordinary light, (*01 mark*)

(ii) Plane polarised light? (*01 mark*)

(b) (i) Describe how plane polarised light can be produced by reflection. (*04 marks*)

(ii) The refractive index of a polaroid is 2.417. Find the polarising angle of the polaroid. (*02 marks*)

(c) (i) State **Huygen's** principle. (*01 mark*)

(ii) Use Huygen's construction to verify the laws of reflection of light. (*04 marks*)

(d) (i) What is a **diffraction grating**? (*01 mark*)

(ii) Describe an experiment to determine the wave length of monochromatic light using a diffraction grating and a spectrometer. *(06 marks)*

SECTION C

5. (a) Define the following as applied to the earth magnetic field:

(i) Magnetic meridian. *(01 mark)*

(ii) Angle of dip at a location. *(01 mark)*

(b) Describe an experiment to compare the magnetic flux density at the centre of a coil carrying current with the horizontal component of the earth's magnetic flux density. *(05 marks)*

(c) A rectangular coil of a wire of N turns and area, A, is suspended at the mid point of one side by a fibre of torsional constant K. The plane of the coil is initially set parallel to a horizontal uniform magnetic field of flux density B.

(i) Derive an expression for the angle of rotation of the coil when a current I flows through it. *(04 marks)*

(ii) State the modification that would be required to turn the arrangement in (c) (i) into a moving coil galvanometer. *(02 marks)*

(d) Figure 2 shows two parallel conductors A and B, each carrying current of 2 A into the plane of the page.

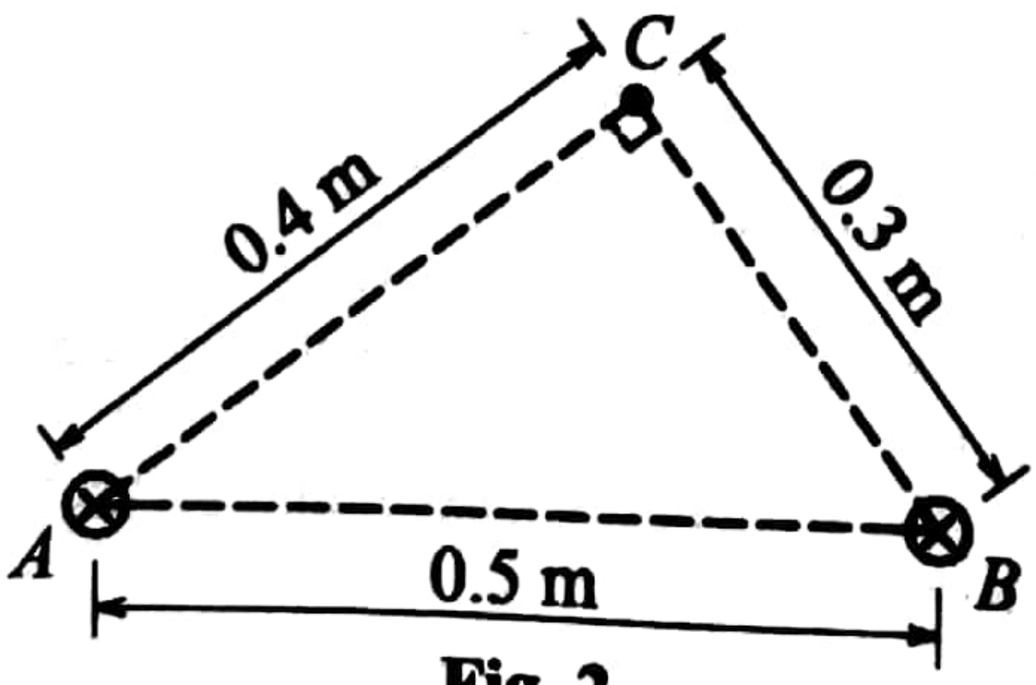

Fig. 2

(i) Find the resultant magnetic flux density at C. *(06 marks)*

(ii) Draw the magnetic field pattern due to currents throught A and B. *(01 mark)*

6. (a) (i) Define **self induction**. *(01 mark)*

(ii) Derive the expression, $E = -L\frac{dI}{dt}$ where L is the inductance of a coil and I is the value of the alternating current flowing in the coil. *(03 marks)*

(b) Figure **3** shows two coils **A** and **B**. Coil **B** is connected to an ammeter $\mathbf{A_2}$ while coil **A** is connected to an alternating voltage source and an ammeter $\mathbf{A_1}$.

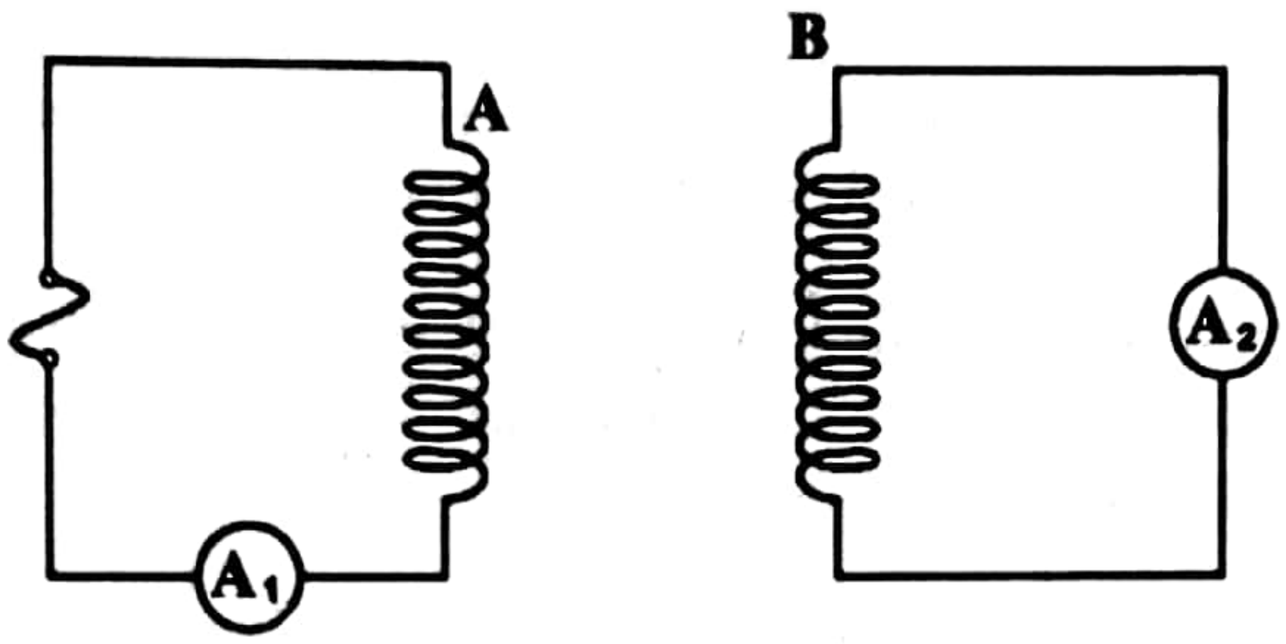

Fig. 3

(i) Explain why current flowing through $\mathbf{A_1}$, in circuit **A** is less than current that would flow through a straight wire of equal resistance when connected across the same voltage source. *(03 marks)*

(ii) Explain what will be observed on the ammeters when the coils are brought closer to each other. *(03 marks)*

(c) A motor consists of a rectangular coil of area 20 cm^2 having 50 turns. A current of 2.5 A is passed through the coil.

(i) Calculate the flux density of the field in which the coil is placed if a torque of 0.30 Nm acts on the coil. *(03 marks)*

(ii) Calculate the back e.m.f in the coil if the coil is rotating at 2400 revolutions per minute. *(03 marks)*

(d) (i) Explain how Eddy currents are produced in a motor. *(03 marks)*

(ii) How are effects of Eddy currents minimised in a motor? *(01 mark)*

7. (a) Define the **root mean square value** of an alternating current. (*01 mark*)

(b) With the aid of a diagram, describe the structure and action of a moving iron meter. (*05 marks*)

(c) An 8.0 μF capacitor is placed across a 200 V (rms) supply.

(i) Calculate the amplitude of the current which flows if the frequency of the a.c is 50 Hz. (*04 marks*)

(ii) Explain what happens to the value of the current in the circuit if the frequency of the a.c is increased. (*02 marks*)

(d) Explain the phase relationship between the applied alternating voltage across an inductor and the current that flows. (*04 marks*)

(e) A sinusoidal alternating voltage, $V = V_o \sin \omega t$ is applied to a resistor of resistance, R. Derive an expression for the mean power dissipated in the resistor. (*02 marks*)

(f) Find the amplitude of the a.c which dissipates energy in a resistor equal to three times that produced by a d.c of 2 A passed through the resistor under the same condition. (*02 marks*)

SECTION D

8. (a) What is meant by **potential difference**? (*01 mark*)

(b) (i) Describe an experiment to verify Ohm's law. (*04 marks*)

(ii) A 12 V battery is connected across a potential divider of resistance 600 Ω. If a bulb with a filament resistance of 100 Ω is connected across one third of the potential divider, determine the amount of electrical energy consumed by the bulb in 10 s. (*04 marks*)

(c) Describe the mechanism of heat generation in a current carrying conductor. (*04 marks*)

(d) Describe an experiment to determine internal resistance of a cell using a potentiometer. (*07 marks*)

9. (a) Define the following:

(i) Electric field intensity. *(01 mark)*
(ii) Electric potential. *(01 mark)*

(b) Sketch **two** graphs on the same axes to show the variation of electric field intensity and electric potential with distance from an isolated point charge. *(02 marks)*

(c) Describe an experiment to show that the potential over the surface of a pear-shaped charged conductor is constant. *(04 marks)*

(d) Figure **4** shows two parallel metal plates placed 10 mm apart in a vacuum with a potential difference of 100 V between them. A point charge of +2 μC is transfered from *A* to *C* following the path shown.

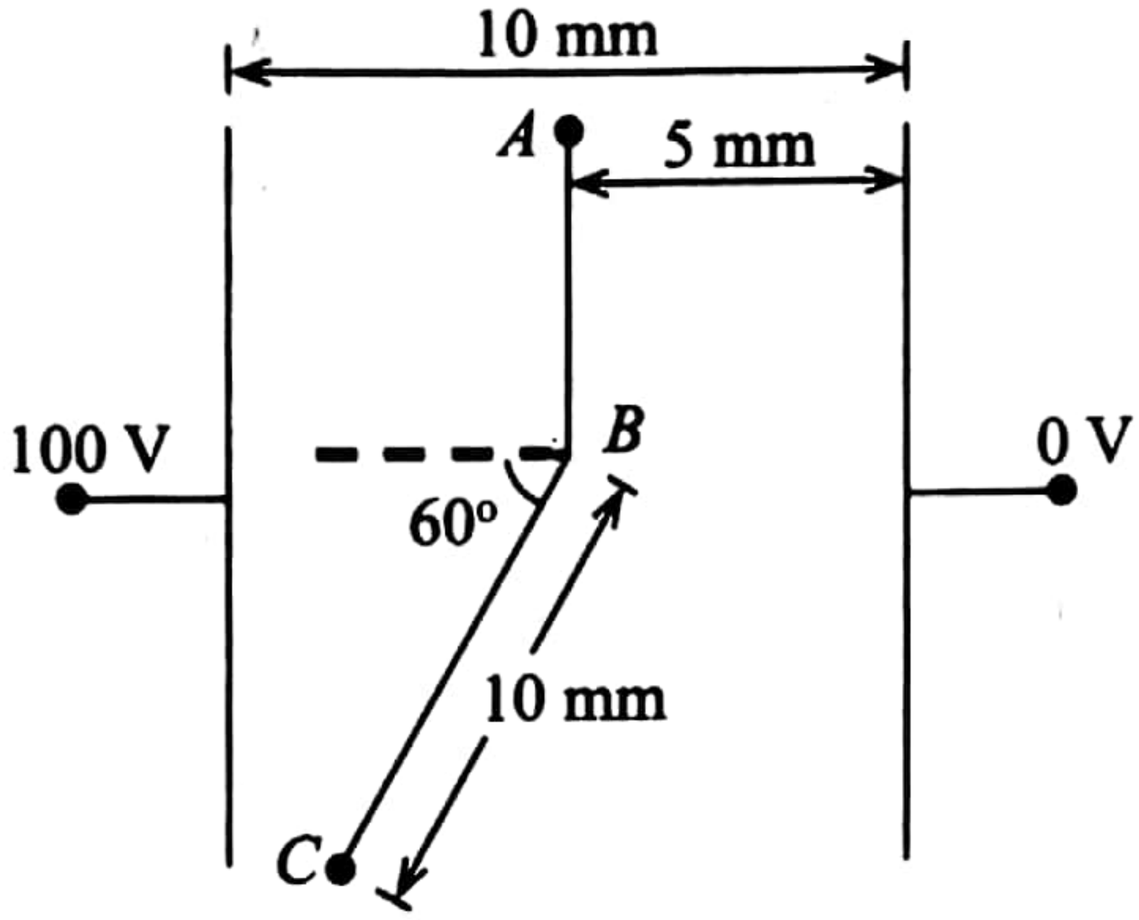

Fig. 4

If *AB* is parallel to the metal plates, and *BC* is 10 mm long, find the work done in moving the point charge from:

(i) *A* to *B* and explain your answer. *(02 marks)*
(ii) *B* to *C*. *(04 marks)*

(e) An alpha particle of charge $+3.2 \times 10^{-19}$ C and mass 6.8×10^{-27} kg travels with a velocity *V* directly towards a nitrogen nucleus which has a charge of $+11.2 \times 10^{-19}$ C. The alpha particle reverses direction at a distance of 9.4×10^{-15} m from the nitrogen nucleus.

(i) Explain why the alpha particle reverses direction. *(02 marks)*
(ii) Find the initial velocity *V* of the alpha particle. *(04 marks)*

Turn Over

10. (a) (i) Define **capacitance** of a capacitor. *(01 mark)*

(ii) A conducting sphere of radius 7.5 cm is maintained at an electric potential of 9 kV. Calculate the charge on the sphere. *(03 marks)*

(b) Describe an experiment to determine the effect of the separation of the plates on capacitance of a capacitor. *(04 marks)*

(c) The plates of a parallel plate capacitor are separated by a distance of 2 mm in air. If the surface area of each plate is 5.0 cm^2, and a p.d of 6 V is applied across the plates, find the magnitude of the charge on each plate. *(03 marks)*

(d) Explain the effect of replacing a dielectric by filling the space between the plates of a charged capacitor with a conductor. *(03 marks)*

(e) (i) What is meant by **relative permittivity** of an insulating material? *(01 mark)*

(ii) Describe how the relative permittivity of an insulating material is determined by using a ballistic galvanometer. *(05 marks)*

END