P510/2
PHYSICS
(Theory)
Paper 2
Nov./Dec. 2022
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 calculators 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	$= 9.11 \times 10^{-31}\ \text{kg}$
Plank's constant, h	$= 6.6 \times 10^{-34}\ \text{Js}$
Permeability of free space, μ_0	$= 4.0\,\pi \times 10^{-7}\ \text{Hm}^{-1}$
Permittivity of free space, ε_0	$= 8.85 \times 10^{-12}\ \text{Fm}^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ \text{m F}^{-1}$
One electron volt (eV)	$= 1.6 \times 10^{-19}\ \text{J}$
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ \text{mol}^{-1}$
Resistivity of Nichrome wire at 25 °C	$= 1.2 \times 10^{-6}\ \Omega\text{m}$
Specific heat capacity of water	$= 4.2 \times 10^{3}\ \text{Jkg}^{-1}\ \text{K}^{-1}$

Turn Over

SECTION A

1. (a) With the aid of a diagram explain **diffuse reflection**. (*02 marks*)

(b) Show that for small angles of incidence, the deviation of a ray of light by a small angle prism depends on only the angle of the prism and refractive index of the material. (*05 marks*)

(c) Describe an experiment to determine the angle of minimum deviation by a prism, using optical pins and a plain sheet of paper. (*05 marks*)

(d) Explain why a fish in water has a wide field of view. (*04 marks*)

(e) A layer of transparent oil of thickness 5 cm floats on water in a beaker. The bottom of the beaker appears to be 9.5 cm below the top surface of the oil when viewed directly from above. Find the refractive index of the oil if the depth of the water is 8 cm.
[*Refractive index of water = 1.33*] (*04 marks*)

2. (a) Define **focal length** of a lens. (*01 mark*)

(b) (i) When an object is placed at O, infront of the lens at A, a sharp image is formed at I, as shown in Figure **1**.

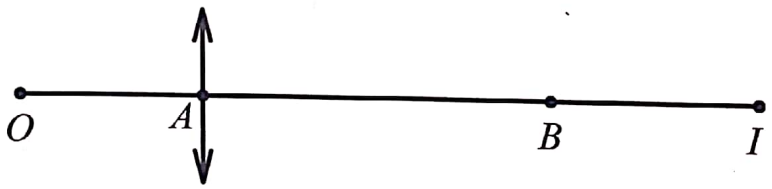


Fig. 1

A sharp image is also formed at I when the lens is moved to B. If $OI = l$ and $AB = d$, show that $l^2 - d^2 = 4lf$, where f is the focal length of the lens. (*05 marks*)

(ii) Using a ray diagram, construct and locate the image position of an object placed at a distance less than the focal length of a converging lens. (*02 marks*)

(iii) State the characteristics of the image formed. (*02 marks*)

(c) A Plano convex lens is placed on a plane mirror on a table with its flat side up. A pin held horizontally above the lens coincides with its image at a point 20.0 cm above the lens. When the lens is placed in the same way on mercury in a trough, the pin coincides with its image at a point 7.0 cm above the lens. Find the radius of curvature of the lens. (*04 marks*)

(d) With respect to the human eye, define the following:

(i) The near point, *(01 mark)*

(ii) Accommodation. *(01 mark)*

(e) Two lenses of focal length 1.2 cm and 4.0 cm are arranged to form a microscope in normal adjustment. If the object is placed 1.5 cm infront of the objective lens, find the distance between the two lenses. *(04 marks)*

SECTION B

3. (a) (i) What is a **progressive wave**? *(01 mark)*

(ii) State the properties of progressive waves. *(03 marks)*

(b) A progressive wave is given by the equation $y = 20\sin\left(300\pi t - \frac{\pi x}{15}\right)$,

where t is time in seconds and x is the displacement in cm.

(i) Write down the equation of a progressive wave that superimposes the above to form a stationary wave. *(01 mark)*

(ii) Using the given progressive wave equation and the equation written in (b)(i) determine the equation of the resulting stationary wave and state its amplitude. *(04 marks)*

(iii) Calculate the wavelength of the stationary wave in (b)(ii). *(02 marks)*

(iv) Determine the phase difference between two points on the progressive wave separated by 25 cm. *(02 marks)*

(c) Show that the frequency of the second harmonic is $3f_0$, where f_0 is the frequency of the fundamental note in a closed pipe. *(04 marks)*

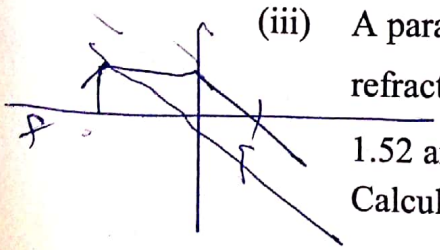
(d) Explain how the unknown frequency of a note can be obtained using beats. *(03 marks)*

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

(ii) Using Huygen's principle of secondary wavelets, explain how refracted wavefront is formed when a beam of light travelling in glass medium, traverses the air-glass boundary. *(03 marks)*

(iii) A parallel beam of unpolarised light travelling in liquid of refractive index $\frac{4}{3}$ is incident on a glass block of refractive index 1.52 and is reflected as plane polarised light.

Calculate the angle of refraction in the glass block. *(04 marks)*



(b) (i) Define **interference** as applied to light waves. (*01 mark*)

(ii) What is meant by path difference in reference to interference of two wave motions? (*01 mark*)

(iii) With the aid of a diagram, explain how Newton's rings are formed. (*06 marks*)

(c) In Loyd's mirror experiment, the source slit S_0 and its virtual image lie in a plane 15 cm beyond the left edge of the mirror. The mirror is 36 cm long and the screen is placed vertically at the right edge of the mirror. Calculate the distance from the right edge of the mirror to the position of the first maximum, if the perpendicular distance from S_0 to its image is 6.0 mm and the wavelength of light is 600 nm. (*03 marks*)

(d) State **one** application of interference. (*01 mark*)

SECTION C

5. (a) Define the following terms:

(i) Magnetic flux density. (*01 mark*)

(ii) The tesla. (*01 mark*)

(b) A coil having N turns of the same radius is made from a wire of length x. If a steady current I flows in the coil in a clock wise direction,

(i) show that the magnitude of the magnetic flux density at the centre of the coil is

$$B = \frac{\mu_0 \pi N^2 I}{x}.$$ (*03 marks*)

(ii) determine the direction of the magnetic field at the centre of the coil. (*01 mark*)

(c) A square coil ABCD of length 1.0 m and 100 turns is balanced by a 500 g mass as shown in Figure **2**.

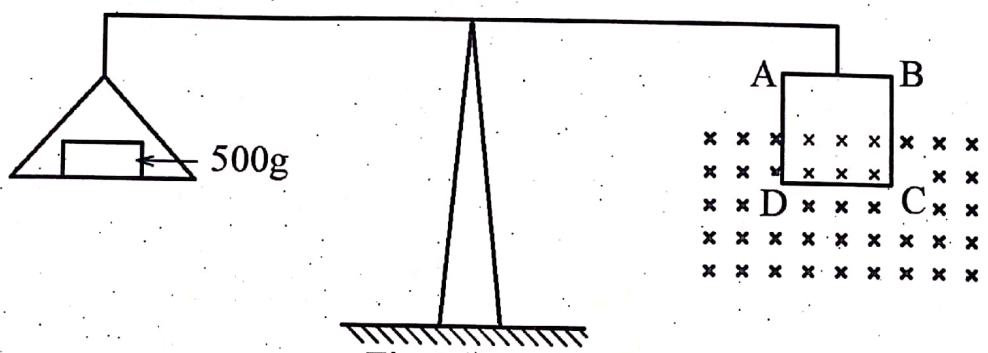


Fig. 2

Find the mass to be added to the 500 g in order to restore balance when a current of 9.8 A is passed through the coil whose side CD is maintained in a constant magnetic field of 0.2 T. (*02 marks*)

(d) Describe an experiment to investigate the variation of magnetic field strength at the centre of a circular coil when current passes through the coil. (*06 marks*)

(e) (i) A square coil of area A and N turns is pivoted between the poles of a magnet as shown in Figure **3**. The magnetic field of flux density B is uniform and a current I is passed through the coil pivoted above the axis of rotation XY perpendicular to the magnetic field.

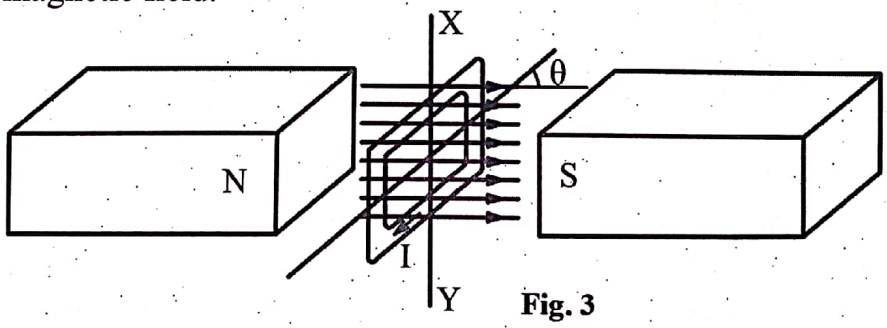


Fig. 3

Derive an expression for the torque on the coil when its plane is at an angle θ to the magnetic field. (*04 marks*)

(ii) An electron moving at 10^7 ms^{-1} is 2 cm from a straight wire carrying a current of 10 A. Find the force acting on the electron. (*02 marks*)

6. (a) (i) What is meant by **mutual induction**? *(01 mark)*

(ii) Describe an experiment to demonstrate mutual induction. *(02 marks)*

(b) Explain how the heat loss in the core of a transformer is reduced. *(02 marks)*

(c) Figure **4** shows a conducting disc of radius r rotating with angular velocity, ω in a uniform magnetic field of flux density, B .

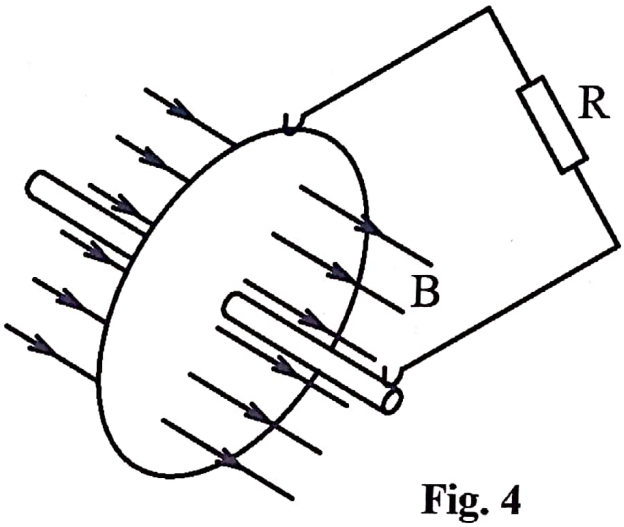


Fig. 4

If the rim and axle are joined by a wire of total resistance R, find the expression for the e.m.f induced in the circuit. *(03 marks)*

(d) A conducting rod 0.5 m long, of resistance 0.04 Ω and mass 0.03 kg falls through a horizontal magnetic field of flux density 0.2 T, with its ends sliding smoothly down two thick vertical rails. The top ends of the rails are joined by a wire of negligible resistance.

(i) Explain why the rod attains steady velocity after a short time. *(03 marks)*

(ii) Calculate the steady velocity attained. *(04 marks)*

(e) Describe the structure and mode of operation of a moving coil loud speaker. *(05 marks)*

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

(i) alternating current, *(01 mark)*

(ii) reactance? *(01 mark)*

(b) An a.c source of frequency, f, is connected across a pure inductor of inductance L. If the current $I = I_0 \sin 2\pi ft$ flows through the inductor,

(i) derive the expression for the reactance of the inductor. (*04 marks*)

(ii) sketch graphs on the same axes, for the variations of current through an inductor and voltage across it with time. (*02 marks*)

(iii) Explain why there is a phase difference between current through the inductor and voltage across it. (*02 marks*)

(c) A lamp is rated at 120 V, 2 A. In order to operate the bulb at its full voltage from the 240 V, 50 Hz mains, a pure inductor is connected in series with the lamp.

Calculate the;

(i) reactance of the inductor, (*03 marks*)

(ii) inductance of the inductor. (*02 marks*)

(d) Describe how a hot wire meter is used to measure alternating current. (*05 marks*)

SECTION D

8. (a) (i) Define **resistance** of a conductor. (*01 mark*)

(ii) An electric hot plate has a coil of manganin wire of length 20 m, diameter 0.54 mm and resistivity $4.6 \times 10^{-7}\ \Omega$ m. The coil is to be replaced with one made of nichrome of diameter 0.5 mm and resistivity $10.0 \times 10^{-7}\ \Omega$ m. Find the length of nichrome required if the power rating is to remain the same. (*03 marks*)

(b) (i) Explain why resistors connected in parallel carry larger current than when they are connected in series. (*03 marks*)

(ii) A milliameter of coil resistance 10 Ω deflects fully when a current of 3 mA flows through it. Calculate the value of the shunt that must be connected to milliameter so that it can measure a maximum current of 1.5 A. (*03 marks*)

(c) (i) Describe with the aid of a diagram how an ammeter may be calibrated using a potentiometer. (*06 marks*)

(ii) Explain the main causes of errors in measurement when using a potentiometer. (*02 marks*)

(iii) State **two** likely causes for failure to get balance point when using a potentiometer. (*02 marks*)

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

(i) electric field, *(01 mark)*

(ii) electric field strength? *(01 mark)*

(b) Sketch a graph showing variation of electric field strength with distance from the centre of a positively charged conducting sphere. *(02 marks)*

(c) (i) Define **electric potential energy**. *(01 mark)*

(ii) Derive an expression for the electric potential energy of two point charges Q_1 and Q_2, x metres apart in a vacuum. *(04 marks)*

(d) A charged sphere X of mass 80 g is suspended using an inelastic thread of length 20 cm. When a uniform electric field **E** of magnitude 1.5×10^6 N C^{-1} is applied at an angle of 30° to the horizontal, the sphere is deflected through a distance of 5 cm horizontally, as shown in Figure **5**.

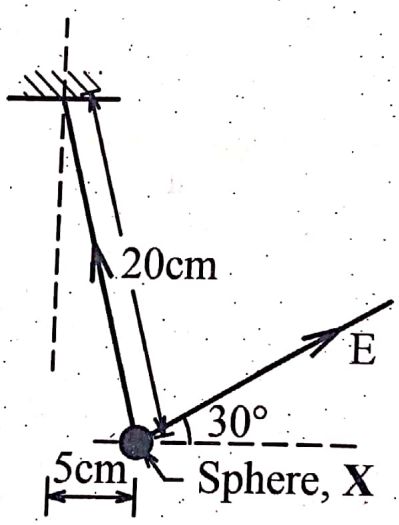


Fig. 5

Determine the:

(i) Tension in the thread. *(02 marks)*

(ii) Magnitude of charge on the sphere. *(03 marks)*

(e) Explain the mechanism of charging a body by friction. *(03 marks)*

(f) Explain what is observed when a body that has a large amount of negative charge is brought slowly from far until it is very close to the cap of the electroscope with a small positive charge. *(03 marks)*

10. (a) Define the following:

(i) The farad. *(01 mark)*

(ii) Dielectric strength. *(01 mark)*

(b) State:

(i) **two** uses of dielectrics in capacitors. *(02 marks)*

(ii) the energy changes that take place when a capacitor is charging from a battery. *(02 marks)*

(c) Two capacitors C_1 and C_2 are connected in series across a battery of e.m.f, E. Show that the p.d, V_1, across the capacitor of capacitance C_1 is given by the expression:

$$V_1 = \left(\frac{C_2}{C_1 + C_2}\right)E.$$ *(03 marks)*

(d) A rectangular piece of wood of dielectric constant 4 is placed between parallel plates of a capacitor of capacitance 16 μF. If a p.d of 6000 V is connected across the plates:

(i) Find the capacitance of the capacitor when the piece of wood is withdrawn. *(02 marks)*

(ii) Calculate the difference in energy before and after withdrawing the piece of wood from the capacitor. *(04 marks)*

(iii) Account for the difference in the energy in (d) (ii). *(01 mark)*

(e) Describe how the capacitance, C of a capacitor can be determined using a standard capacitor and a ballistic galvanometer. *(04 marks)*

END