P510/2
PHYSICS
Paper 2
NOVEMBER, 2024
2½ hours

UGANDA ADVANCED CERTIFICATE OF EDUCATION

PHYSICS

(Principal Subject)
PAPER 2

TIME: 2½ HOURS

INSTRUCTIONS TO CANDIDATES:

Answer only **five** questions, taking at least **one** question from each of the sections **A**, **B**, **C** and **D**, but **not** more than **one** question should be chosen from **either** section **A** or section **B**.
Any additional question(s) answered will **not** be marked.
Mathematical tables and squared paper will be provided.
Non-programmable Silent Scientific Calculators may be used.

Assume where necessary:

Acceleration due to gravity,	g	=	9.81m s^{-2}
Speed of light in Vacuum,	c	=	$3.0 \times 10^{8} \text{ m s}^{-1}$
Speed of sound in air,	v	=	$3.40 \times 10^{2} \text{ m s}^{-1}$
Electronic charge,	e	=	$1.60 \times 10^{-19} \text{C}$
Electronic mass,	m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Permeability of free space,	μ_o	=	$4\pi \times 10^{-7} \text{ H m}^{-1}$
Permittivity of free space,	ε_0	=	$8.85 \times 10^{-12} \text{ F m}^{-1}$
The Constant,	$\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9} \text{ F}^{-1} \text{ m}$

SECTION A

1. (a) (i) In a plane mirror show that the reflected ray suffers a deviation of twice the glancing angle. (03 marks)

(ii) Two plane mirrors M_1 and M_2 are inclined at 65° to each other. Incident ray OP is parallel to mirror M_2, but ray QR is not parallel to mirror M_1.

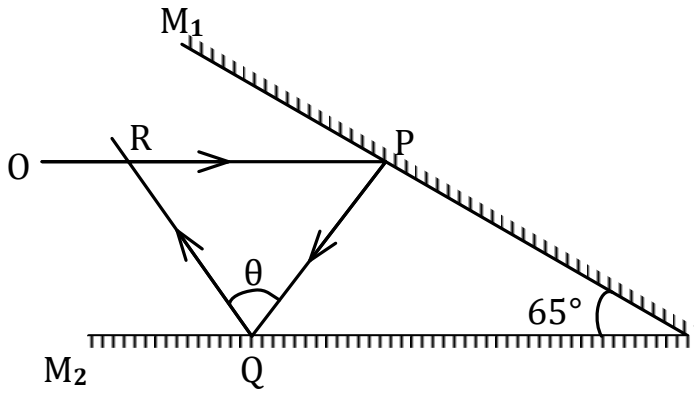


Fig. 1

Determine the value of θ. (03 marks)

(b) Define the following terms as applied to concave mirrors.

(i) Radius of curvature. (01 mark)

(ii) Aperture. (01 mark)

(c) A small quantity of liquid L_1 of refractive index 1.32 is poured into a concave mirror placed on a flat horizontal surface. An optical pin clamped horizontally above it coincides with its own image at 15.0cm above the mirror. When liquid 1 is replaced by liquid 2 and the procedure repeated, coincidence is established at a height h_2. If the ratio of the refractive index of liquid 1 to that of liquid 2 is 1.20. Determine;

(i) The position of coincidence between the pin and its image, when liquid 2 is in the mirror. (03 marks)

(ii) Refractive index of the liquid 2. (02 marks)

(d) (i) Draw a ray diagram to show how a converging mirror acts as a magnifying glass. (02 marks)

(ii) Derive the mirror formula for a diverging mirror for a point object. (05 marks)

2. (a) (i) Draw a ray diagram to show how a concave mirror forms a real image of a finite size object. (02 marks)

(ii) From the diagram in (i) above, derive the relation, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ where u, v and f are object distance, image distance and focal length of the mirror respectively. (04 marks)

(b) Describe an experiment to determine focal length of a convex mirror using a plane mirror. (05 marks)

(c) (i) Define the term refractive index of a material (01 mark)

(ii) Explain with the help of a diagram, why a pond of clear water looks shallower than it actually is. (04 marks)

(d). Monochromatic light is incident from air into a glass slab of refractive index 1.50 at 48.6°. Given that the thickness of the slab is 9.0 cm. Determine the time taken by the light to move across the slab. ($speed\ of\ light\ in\ air = 3.0 \times 10^8 ms^{-1}$). (04 marks)

SECTION B

3. (a) Distinguish between free and damped oscillations. (03 marks)

(b) (i) Define the terms **harmonics** and **overtones**. (02 marks)

(ii) A narrow tube of length 0.300 m is closed at one end. A tuning fork of frequency 825 Hz is set into vibration just above the open end of the tube causes the air in the tube to resonate with the tuning fork. If the speed of sound in air is $330 ms^{-1}$, determine the mode of vibration of air in the tube. (04 marks)

(c) (i) What is meant by the terms **beats** and **Doppler effect**? (03 marks)

(ii) A pedestrian moving in a straight line between two stationary sources of sound each of frequency 680 Hz, hears beats at a rate of 5.0 s^{-1}. Using well defined symbols, derive an expression for the speed of the pedestrian. Hence calculate the pedestrian's speed. (05 marks)

(d) State three differences between sound waves and light waves. (03 marks)

4. (a) (i) Define the term **interference** of light waves. (01 mark)

(ii) Explain with the aid of a diagram how interference occurs in an air-wedge. (03 marks)

(b) An air-wedge film formed by placing an aluminium foil between two glass slides at a distance of 75 mm from the line of contact of the slides. When the air wedge is illuminated normally, by light of wave length 5.60×10^{-7} m, parallel interference fringes of separation 1.20 mm are produced.
Calculate the;

(i) angle between the slides. (02 marks)
(ii) thickness of the aluminium foil. (02 marks)

(c) (i) What is **plane polarized light?** (01 mark)
(ii) Describe with the aid of a labelled diagram, one application of plane polarized light. (04 marks)

(d) (i) Describe an experiment to determine the wavelength of light waves used in a diffraction grating. (05 marks)
(ii) A parallel beam of sodium light of wavelength 5.89×10^{-7} m is incident normally on a diffraction grating having 6000 lines per cm. Find the angle for which the second order image will be seen. (02 marks)

SECTION C

5. (a) Define the following terms:

(i) Angle of declination. (01 mark)
(ii) Magnetic meridian. (01 mark)

(b) Describe an experiment to determine the horizontal component of the Earth's magnetic field using a tangent galvanometer. (06 marks)

(c) (i) Define the term **ampere** and use this definition to show that the Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ H m^{-1} (03 marks)

(ii) The diagram in figure 3 shows three straight parallel wires P, Q and R of the same length L, carrying currents of 2A, 1A and 8A respectively. The distance between P and Q is x, while that between Q and R is d. The separation between wires P and R is 0.100 m.

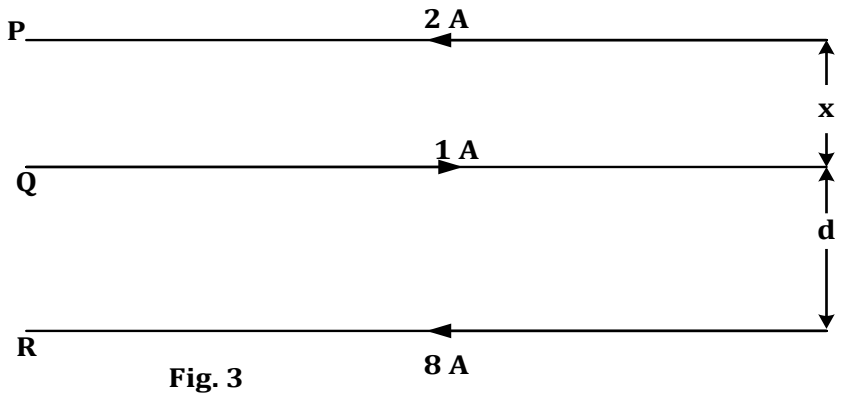


Fig. 3

Find the value of d, for which the net force per metre on wire Q is zero. (04 marks)

(d) Explain with the aid of a labelled diagram how a moving coil galvanometer works. (05 marks)

6. (a) i) What is meant by eddy current . (03 marks)

(ii) Explain one practical application of eddy currents. (04 marks)

(b) (i) Explain why a pure inductor is wattles component . (03 marks)

(ii) Given that an alternating current $V=V_0 \sin 2\pi ft$ is connected across an inductor. Show that voltage leads current by $\frac{\pi}{2}$. (04 marks)

(c) (i) describe the structure and mode of operation of moving iron meter repulsive type.

(05 marks)

(ii) State two advantages of the A.C meter in (c) (i) over ordinary moving coil ammeter.

(01 marks)

7. (a) (i) Define the terms **amplitude** and **root mean square value** of an alternating current. (02 marks)

(ii) Show that the r.m.s value of alternating current of amplitude I_0 is given by $I_{rms} = 0.7071\ I_0$ (03 marks)

(b) (i) Define the term **inductive reactance**. (01 mark)

(ii) Derive an expression for the inductive reactance of a pure inductor of self inductance L, connected to an alternating current, $I = I_0 \sin 2\pi ft$.

(03 marks)

(c) A sinusoidal voltage of r.m.s value 10V is applied across a 50 μF capacitor.

(i) Find the maximum value of charge on the capacitor. (02 marks)

(ii) Draw a sketch graph of charge Q on the capacitor against time and explain the features of the graph. (03 marks)

(d) (i) Define the term **rectification**. (01 mark)

(ii) Describe how full-wave rectification can be achieved using only two rectifiers. (05 marks)

SECTION D

8. (a) (i) Define the term **electric field line**. (01 mark)

(ii) Sketch electric field pattern due to an isolated positively charged metal sphere of radius r, placed in air. (02 marks)

(b) (i) What is meant by the term electric field intensity. (01 mark)

(ii) A neutral polythene ball of 120 mg is hanged at one end of a light uniform wooden beam at the 30.0 cm mark from the knife edge while a charged parallel plate air capacitor is at 20.0cm from the knife edge; as shown in figure 6.

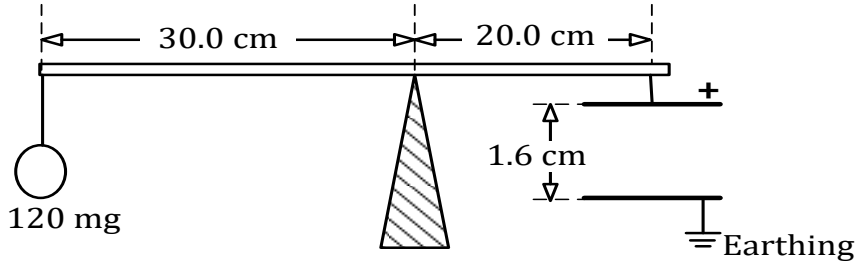


Fig. 6

Given that, the charge on capacitor is 0.24 μC and the plates separation is 1.6 cm, determine the p.d. across the plates of the capacitor.

(04 marks)

(c) (i) What is meant by the term corona discharge? (01 mark)

(ii) Explain why the metal caps of Gold leaf electroscopes are always smooth and circular. (03 marks)

(d) (i) Describe an experiment to measure the dielectric constant of a material placed between the plates of a parallel plate capacitor. (06 marks)

(ii) State two characteristics of a good dielectric material. (02 marks)

9. (a) (i) What is a capacitor? (01 mark)

(ii) Derive an expression for the effective capacitance of two capacitors arranged in series and connected to a d.c. supply. (04 marks)

(b) Explain the effect of a dielectric on the capacitance of a capacitor. (04 marks)

(c) The figure 7 shows 6 capacitors of capacitances 1.5μF, 2.5μF, 4.0μF, 5.0μF, 14.0μF and 28.0μF connected to a 12 V d.c. source.

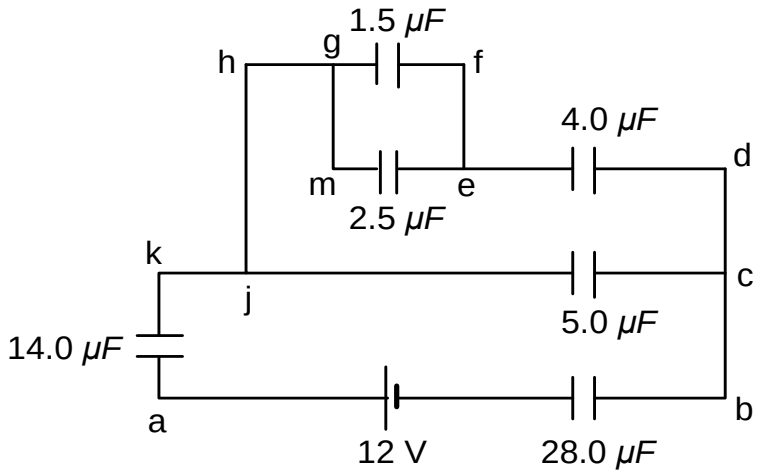


Fig. 7

Determine;

(i) The effective capacitance of the network. (04 marks)

(ii) The energy stored in the 14μF capacitor. (03 marks)

(d) An electron is liberated from the lower surface of two large parallel metal plates separated by a distance of 2.0 cm. The upper plate has a potential of +2400 V with respect to the lower plate. Given that the charge to mass ratio of an electron is 1.76×10^{11} C kg^{-1}, determine the time taken by the electron just

to reach the upper plate. (04 marks)

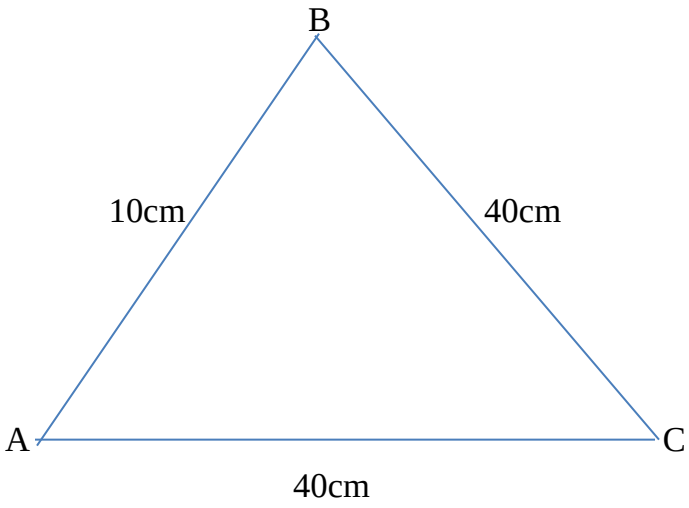
10. (a) (i) Explain what is meant by action at point . (03 marks)
(ii) State two practical applications of action at a point. (01 mark)

(b)(i) Draw a graph showing variation of electric field intensity due isolates point charge . (02 marks)

(ii) Prove that $\emptyset = \frac{Q}{\varepsilon_o}$ where
$\emptyset$ *is electric flux* Q *is charge and* ε_o *is permittivity of free space*. (04 marks)

(c) Explain what is observed when positively charged body is slowly brought near the cap of negatively changed gold leaf electro scope. Assume the body has a large charge than gold leaf electroscope. (03 marks)

d) Charges of -20μC and + **20 μ**C are placed at points A and B as shown in figure below.



Find electric field intensity at C hence find the magnitude of force acting on charge of 60pC when placed at C. (06 marks)

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