END OF TERM I 2023 EXAM
S.5 PHYSICS
P510/2
TIME: 2 HOURS 30 MINUTES
INSTRUCTIONS

- *Answer any FOUR questions choosing atleast one question from each of the sections A, B, C and D.*
- *All questions carry equal marks.*

Where necessary assume the following constants;

Acceleration due 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	=	$330 m s^{-1}$
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, $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9} F^{-1} m$
Resistivity of Nichrome wire at 25°C	=	$1.2 \times 10^{-6} \Omega m$
Specific heat capacity of water	=	$4.2 \times 10^{3} J kg^{-1} K^{-1}$

SECTION A

1. (a) (i) State the **laws of reflection** of light. (2 marks)
   (ii) When a plane mirror is turned through an angle α, the reflected ray rotates through an angle Φ. Derive the relationship between α and Φ. (4marks)
   (b) (i) Describe how an optical lever in a mirror galvanometer is used to measure small electric currents. (4 marks)
   (ii) State two advantages of optical lever to a metallic pointer. (2 marks)
   (c) Describe an experiment to verify the laws of reflection of light. (6 marks)
   (d) State two applications of plane mirrors (2 marks)

2. (a) With the aid diagrams distinguish between regular and irregular reflection. (4 marks)

(b) The diagram in figure 1 below shows a ray of light undergoing two successive reflections at points X and Y in two mirrors $M_1 and M_2$ inclined at an angle θ

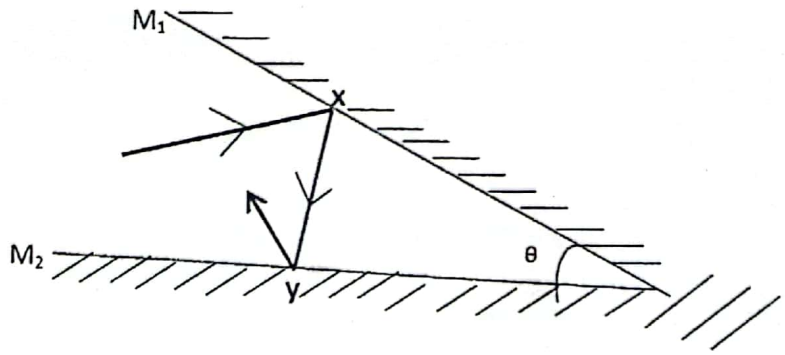


Fig 1.

Show that the ray is deviated through an angle 2θ. (3marks)

(c) Show that the image formed in a plane mirror is as far behind the mirror as the object is in front. (4 marks)

(d) (i) State the principle of operation of a sextant. (1 mark)

(ii) Describe how a sextant is used to determine the angle of elevation of a star (4 marks)

(e) Prove that the minimum size of a plane mirror fixed on the wall of a room in which the observer at the centre of a room can see the full image of wall behind him is one third the height of the wall. (4 marks)

SECTION B

3. (a) Define the following terms;

i) A wave (01 mark)

ii) Frequency (01 mark)

iii) Wave length (01 mark)

(b) Derive a relationship between the speed, V, frequency. f and wavelength λ of a progressive wave. (02 marks)

(c) Differentiate between;

i) mechanical and electromagnetic waves. (03 marks)

(d) (i) With the aid of suitable diagrams, where possible, explain the following;

a) free oscillation (1 ½ marks)

b) damped oscillation (1 ½ marks)

c) forced oscillation (01 mark)

(ii) Differentiate between free and damped oscillation. (02 marks)

(e) A plane progressive wave in a medium a long $x - direction$ is described by the equation.

$y = 2.0\,x\,10^{-3} \sin\left(100\pi t - \frac{1.03}{12}\pi x\right)$ *where y is* displacement in metres, t the time in seconds and x the distance from the origin in metres. Calculate;

i) Frequency (02 marks)

ii) Wavelength (01 mark)

iii) Speed of the wave (01 mark)

iv) Phase difference between points 0.25cm and 0.32cm from the origin. (02 marks)

4. (a) (i) What is meant by the term wave front and a progressive wave. (02 marks)

(ii) Derive the relation $f = \frac{1}{T}$, where f is frequency of the wave and T is the periodic time. (02 marks)

(b) Differentiate between:

(i) Transverse waves and longitudinal waves. (03 marks)

(ii) Light and sound waves. (02 marks)

(c) Describe how the amplitude of a forced oscillation builds up to a constant value. (03 marks)

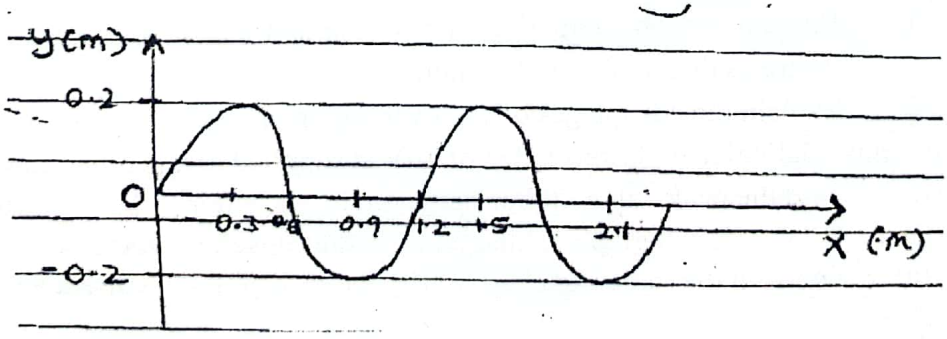
(d) A plane progressive wave travelling in the positive $x - direction$ is represented by the equation.

$y = 0.36 \sin 7\pi \left(40t - \frac{t}{25}\right)$ *where* t is the time in seconds, y is the displacement in metres. Determine:

i) Periodic time (02 marks)

ii) Speed of the wave (02 marks)

(e) The sketch shows a wave propagating in the positive $x - direction$ with a velocity of $9ms^{-1}$.



Show that displacement at any time t is given by $y = 0.2 \sin \frac{5\pi}{3} (9t - x)m$ (04 marks)

SECTION C

(a) (i) What is meant by sinusoidal alternating current. (01 mark)

(ii) Define peak value, root mean square value and frequency of alternating sinusoidal current. (05 marks)

(iii) Show that the r.m.s value of an alternating voltage is;

$V_{r.m.s} = \frac{V_o}{\sqrt{2}}$ where V_o is the peak voltage. (04 marks)

(b) A sinusoidal voltage, $V = 339\sin 100\pi t$ is connected across a 40Ω resister. Find the;

(i) Amplitude of the current through the resistor. (02 marks)

(ii) Average power developed in the resistor. (03 marks)

(c) Explain why a moving coil ammeter is unsuitable for measuring alternating current. (03 marks)

(d) (i) What is a phasor diagram? (01 mark)

(ii) Draw a phasor diagram showing variation of alternating current, I and alternating voltage across a resistor. (01 mark)

(iii) Sketch on the same axis the graphs showing variation of alternating current, I and alternating voltage, V, with time across a resistor. (02 marks)

graphical way of representing the magnitude and directional relationship between two or more alternating quantities.

(a) (i) Define the following terms;

- Reactance
- Capacitance reactance (02 marks)

(b) (i) A source of sinusoidal voltage of amplitude V_o and frequency f, is connected across a capacitor of capacitance C. Derive an expression for the instantaneous current which flows. (03 marks)

(ii) With reference to the circuit in b(i) above, sketch using the same axes, graphs to show the variation of voltage V and current I, with time. (02 marks)

(c) (i) Explain why an alternating current apparently flows through a capacitor where as direct current does not. (03 marks)

(ii) Explain the advantages of a.c. over d.c. in power transmission. (02 marks)

(d) A sinusoidal voltage of r.m.s value of 10V is supplied across $50\mu F$ capacitor.

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

(ii) Draw a sketch graph of charge, Q on the capacitor against time. (01 mark)

(iii) Draw on the same sketch in (c) (ii) above, a graph of current against time. (01 mark)

(iv) If the a.c. supply has a frequency of 50Hz, calculate the r.m.s value of the current through the capacitor. (04 marks)

$|m| = |a^3$

SECTION D

7. (a) (i) Define the following:
   - Electrostatistics
   - Electrostatic induction. (01 mark)

   (ii) State the law of electrostatics. (01 mark)

   (b) (i) Explain how two different insulators rubbed together acquire equal but opposite charge. (03 marks)

   (ii) Distinguish between conductors and insulators. Give two examples of each. (04 marks)

   (c) (i) What is an electrophorus? (01 mark)

   (ii) Describe how corona discharge occurs. (03 marks)

   (d) (i) With the aid of labeled diagrams, explain how a conductor can be charged positively by induction. (04 marks)

   (ii) State any two precautions put into consideration while charging a body by induction. (02 marks)

8. (a) (i) Describe the structure and mode of operation of a gold leaf electroscope. (04 marks)

   (ii) State two reasons why the cap of a G.L.E is made circular and smooth. (02 marks)

   (iii) Explain how a gold leaf electroscope can be used to test for sign of charge on a body. (03 marks)

   (b) Define the following terms;
   i) surface charge density
   ii) corona discharge (02 marks)

   (c) (i) Explain how a neutral body gets attracted when placed near a charged body. (03 marks)

   (ii) State any two applications of corona discharge. (02 marks)

   (d) Describe an experiment to investigate charge distribution of a pear shaped conductor. (05 marks)

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