P510/2
PHYSICS
(Theory)
Paper 2
12th June, 2023
2½ hours

MATIGO EXAMINATIONS BOARD

PRE MOCK 2023

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

*Answer **five** questions, taking at least **one** from each sections* **A, B, C** *and D, but not more than one question should be chosen from either A or B.*
*Any additional questions(s) answered will **not** be marked.*
Mathematical tables and graph paper are provided.
Non- programmable scientific calculators may be used
Assume where necessary:

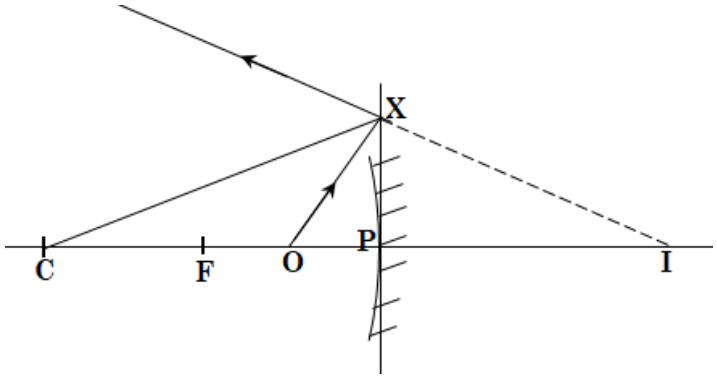
Acceleration due to gravity, g	$= 9.81\text{ms}^{-2}$
Speed of light in vacuum, C	$= 3.0 \times 10^{8}\text{ms}^{-1}$
Speed of sound in air, v	$= 340\text{ms}^{-1}$
Electronic Charge, e	$= 1.6 \times 10^{-19}\text{C}$
Electronic mass,	$= 9.11 \times 10^{-31}\text{kg}$
$Permeability\ of\ free\ space, \mu_0$	$= 4.0\pi \times 10^{-7}\text{H}m^{-1}$
$Permittivity\ of\ free\ space, \varepsilon_0$	$= 8.85 \times 10^{-12}\ \text{F}m^{-1}$
$The\ Constant\ \frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}F^{-1}\text{m}$
$Resistivity\ of\ Nichrome\ wire\ at\ 25°C$	$= 1.2 \times 10^{-6}\Omega m$
$Specific\ heat\ capacity\ of\ water$	$= 4.2 \times 10^{3}Jkg^{-1}K^{-1}$
$Avogadro's\ number, N_A$	$= 6.02 \times 10^{23}\text{mol}^{-1}$
$One\ election\ volt\ (eV)$	$= 1.6 \times 10^{-19}\text{J}$

Turn Over

SECTION A

1. (a) Define **principal focus** and **centre of curvature** of a concave mirror. (02 marks)

(b)



In the diagram above, a ray from object point O is reflected from the mirror and appears to come from I. Derive the relation between u, v, and, f, for the mirror, where u, and v are the object and image distances, and, f, is the focal length of the mirror. (04 marks)

(c)(i) With the aid of a diagram explain how thick mirrors form multiple images of an object. (03 marks)

(ii) Describe the factors determining the distances between the images formed in c(i) above. (03 marks)

(d) Describe an experiment to determine the refractive index of a transparent liquid using a travelling microscope. (05 marks)

(e) When an optical pin held above a concave mirror containing a thin layer of water, it is found to coincide with its image at a height of 6.0cm. When the water is replaced with a transparent oil, the coincidence occurs at a height of 5.6cm. Find the refractive index of the oil, given that the refractive index of water is 1.33. (03 marks)

2. (a) State two properties of a real image. (02 marks)

(b)

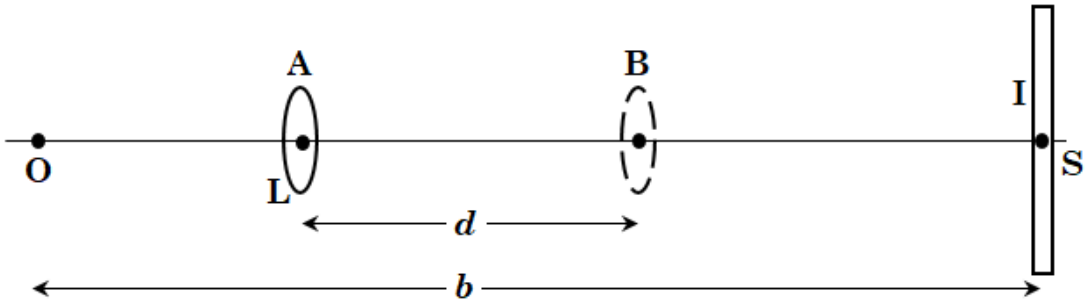


Figure above shows a convex lens L and a screen. When an object is placed at O, an image is formed on S. Keeping O and S fixed while moving L, the image is formed on the screen again when L is at B. Show that $f = \frac{b^2 - d^2}{4b}$ where f is the focal length of the lens. (05 marks)

(c) Describe an experiment to determine the focal length of a convex lens using the relation in (b) above, and involving a graph. (05 marks)

(d)(i) Define magnifying power of a microscope. (01 mark)

(ii) Draw a ray diagram to show image formation by a compound microscope in normal adjustment. (02 marks)

(e) An astronomical telescope is made of two lenses of focal lengths 120cm and 20cm. The telescope is used to focus a distant object such that the final image is formed 300cm away. Find the:

(i) lens separation (03 marks)

(ii) magnifying power. (02 marks)

SECTION B

3. (a) (i) State the principle of superposition of waves. (01 mark)

(ii) A progressive wave given by $y = 80\sin 2\pi\left(ft - \frac{x}{\lambda}\right)$ is reflected and superposed to form a stationary wave, where x and t are in cm and seconds respectively. Show that the separation of two successive nodes in the stationary wave is $\frac{\lambda}{2}$. (04 marks)

(iii) Find the amplitude of the stationary wave at a point distance 20cm to the right of any node, where λ = 80cm. (02 marks)

(b) What are **longitudinal** and **transverse** waves, giving an example of each. (03 marks)

(c) With the aid of a relevant equation explain why two closed pipes of equal length may produce different fundamental frequencies. (03 marks)

(d) (i) Explain how sound is produced when stretched wire is plucked in the middle. (02 marks)

(ii) Describe an experiment to determine the relationship between the length of the wire in d(i) and the fundamental frequency. (05 marks)

4. (a)(i) With reference to light, define **interference**. (01 mark)

(ii) Explain how Newton's rings are produced in an air film between a convex lens and glass plate when monochromatic light is used. (06 marks)

(iii) State the change in appearance of the fringes that occur when the air film is replaced with a transparent liquid. (01 mark)

(b)(i) Briefly explain what is meant by division of wave front. (02 marks)

(ii) Derive the expression for fringe separation in Young's interference pattern, in terms of slit separation, a, the distance, D of the screen from the double slits, and the wavelength, λ, of the light. (05 marks)

(c) A diffraction grating has 560 lines per mm. When it is illuminated normally by monochromatic light, the angular deviation of the first order image is 19.3^0. Find the

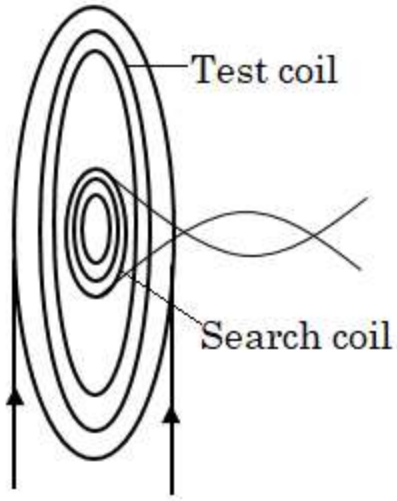
(i) wavelength of the light. (03 marks)

(ii) maximum number of diffraction images obtainable. (02 marks)

SECTION C

5. (a) Define **magnetic field** and **magnetic flux**. (02 marks)

(b)



A wire of length 90.4m is wound into a coil of radius 32.0cm, and arranged with a search coil of 20 turns and radius 15.0cm. Find the magnetic flux linking the search coil when a current of 3A is passed through the test coil. (04 marks)

(c)(i) Describe how the angle of dip varies from the equator to the North Pole. (02 marks)

(ii) Describe how the angle of dip in a given place may be determined using an earth inductor. (05 marks)

(d)(i) With the aid of an illustrative diagram explain why a current carrying conductor in a magnetic field experiences a force. (03 marks)

(ii) A straight horizontal wire carries current of 3A in the North – South direction. If the angle of dip at the location is 67^0 and the earth's horizontal component of magnetic flux density is $1.4x10^{-5}T$, find the force per m acting on the wire. (04 marks)

6. (a)

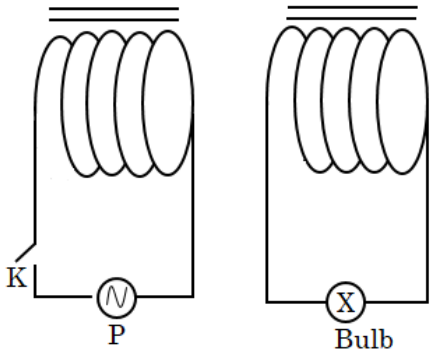


Figure above shows two circuits containing iron cored coils placed close to each other. Explain what is observed when:

(i) Switch K is closed. (03 marks)

(ii) P is replaced with d.c source and K is closed. (02 marks)

(b) Describe an experiment to investigate the relationship between direction of the induced emf and change in magnetic flux linkage. (06 marks)

(c)

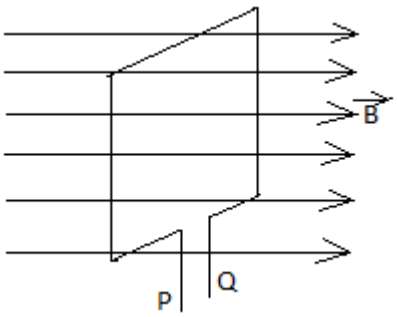


Figure above shows a rectangular coil of $a \times b$ and N turns in a uniform horizontal magnetic field of flux density B. Derive the expression for the peak value of the emf induced between the terminals P and Q, when the coil is rotated about a vertical axis with uniform angular frequency, *f*.

(04 marks)

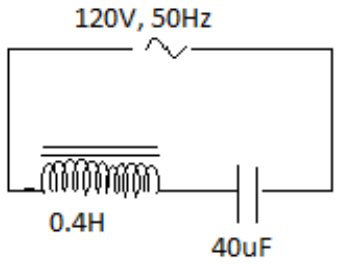
(d) A metal rod of mass 0.4kg, length 0.5m and negligible resistance rolls down frictionless rails inclined at 20^0 to the horizontal. The rails lie in a uniform vertical magnetic field of flux density 0.6T, and their ends on one side, are joined through a resister of resistance 3Ω. Find the constant speed attained by the rod. (05 marks)

7. (a)(i) What is meant by **peak value** of a sinusoidal alternating current? (01 mark)

(ii) A source of sinusoidal alternating voltage of $V = V_0 \sin 2\pi ft$, is connected across a coil of inductance, L. Derive an expression for the peak value of the current which flows. (03 marks)

(iii) Sketch using the same axes, graphs to show the variation of voltage and current in a (ii) above, with time. (02 marks)

(b)



An inductor of inductance 0.4H and a capacitor of capacitance 40μF are connected in series across a voltage source of 120V and frequency 50Hz as in figure above.

(i) Show that the circuit is net inductive. (04 marks)

(ii) Find the peak value of the current which flows in the circuit. (03 marks)

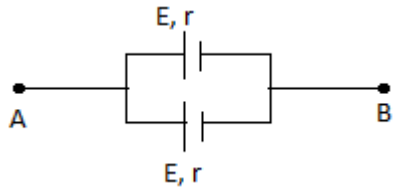
(c) (i) With the aid of a labelled diagram, describe how a repulsive type of moving iron ammeter works. (05 marks)

(ii) Explain why a moving iron ammeter is not suitable for measuring alternating current of high frequencies. (02 marks)

SECTION D

8. (a) Define **electromagnetic force** and **internal resistance** of a battery. (02 marks)

(b)



Two identical cells of emf, E and internal resistance, r, are connected as above. When two resistors of resistances 2Ω and 3Ω are joined in series and connected to the terminals A and B, a current of 0.29A flows in the circuit. When arranged in parallel and connected to A and B, the current supplied is 1.03A. Find the values of E and r. (04 marks)

(c) A variable resistance, R, is connected across a d.c voltage source of internal resistance, r.

(i) Draw a graph showing the variation of terminal p.d, V, with resistance, R. (01 ark)

(ii) Explain the graph in c(i) above.

(02 marks)

(d)(i) Outline the principles of operation of a potentiometer. (03 marks)

(ii) Describe an experiment to determine the emf of a thermocouple, using a potentiometer. (05 marks)

(iii) Explain any additional features in the experimental set up and procedure involved in the experiment in d(ii) above compared to one in which emf of an ordinary battery is being determined. (03 marks)

9. (a) (i) What is an **equipotential surface**? (01 mark)

(ii) Describe an experiment to show that the surface of a metal is an equipotential surface. (04 marks)

(b) Define **electric field intensity** at a point and **electric potential energy** of a charge. (02 marks)

(c)

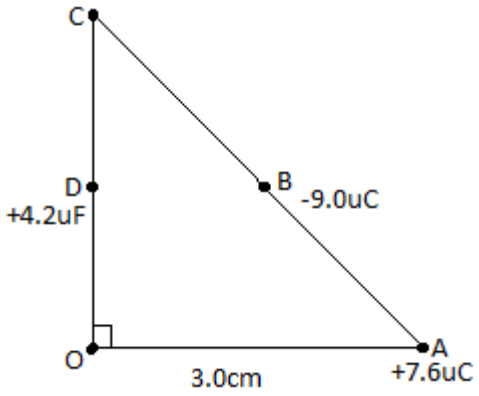


Figure above shows an isosceles right angle triangle OAC with side $\overline{OA}$ =3.0cm. Charges of +7.6μC, -9.0μC and +4.2μC, are placed at points A, B and D respectively, where B and D are the mid points of AC and OC respectively. Find the:

(i) Electric field intensity at O. (06 marks)

(ii) Electric potential energy of the +4.2μC charge. (04 marks)

(d) Describe how electrostatics may be used to remove dust particles from industrial waste gases. (03 marks)

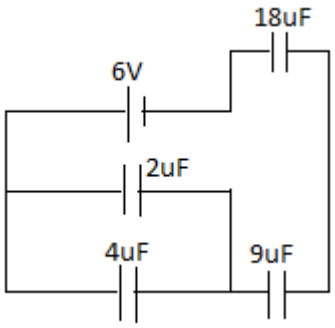
10. (a) (i) What is a dielectric material? (01 mark)

(ii) Explain how placing a dielectric in a capacitor changes the capacitance. (04 marks)

(b) Two identical capacitors of capacitance, C, are connected in series. Show that when the effective area of one of them is reduced to half the original value and a material of dielectric constant, ε_r, is inserted in the other, the net capacitance reduces by $\frac{C}{2(1+2\varepsilon_r)}$. (04 marks)

(c) Describe how you can determine capacitance of a capacitor using a vibrating reed switch circuit. (04 marks)

(d)



The circuit above shows a network of four capacitors of 2μF, 4μF, 9μF and 18μF, connected across a battery of 6V. Find the:

(i) P.d across the 9μF capacitor. (04 marks)

(ii) Energy stored in the 18μF capacitor. (03 marks)

END