P510/2
PHYSICS
(Theory)
Paper 2
Nov./Dec.2019
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 section* **A** *or* **B.**

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

Mathematical tables and squared paper are provided.

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ m\ s^{-1}$
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}\ m\ s^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ C$
Electron mass,	=	$9.11 \times 10^{-31}\ kg$
Planck's constant, h	=	$6.6 \times 10^{-34}\ J\ s$
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7}\ H\ m^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ F\ m^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}m$
One electron volt (eV)	=	$1.6 \times 10^{-19}\ J$
Avogadro's number, N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1}\ K^{-1}$

Turn Over

SECTION A

1. (a) (i) Derive the relationship $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ for a convex lens, where u is the object distance, v is the image distance, and f is the focal length of the lens. *(04 marks)*

(ii) State **three** possible reasons under which an image of a real object may not be formed by a convex lens on a screen. *(03 marks)*

(b) Describe an experiment to determine the focal length of a convex lens fixed inside a short cylindrical tube. *(05 marks)*

(c) A convex lens of focal length 10 cm is arranged coaxially with a concave lens of focal length 18 cm. The lens system is used to focus an object placed 24 cm from the convex lens on the side remote from the concave lens. The final image is formed on a screen placed 18.6 cm from the concave lens.
Calculate the;

(i) separation between the lenses. *(05 marks)*

(ii) magnification. *(03 marks)*

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

(ii) A small object is placed at a distance of 30. 0 cm from a converging lens of focal length 10.0 cm. Calculate the distance from the first lens where a second converging lens of focal length 40.0 cm must be placed in order to produce an erect image of the same size as the object. *(05 marks)*

(b) (i) Draw a diagram to show the formation of an image by a compound microscope in normal adjustment and use it to derive an expression for the magnifying power. *(06 marks)*

(ii) A microscope has an objective of focal length 10.0 cm and an eye piece of focal length 20.0 cm. If the distance between the objective and eye piece is 20.0 cm, calculate the magnifying power of the microscope. *(03 marks)*

(c) What is meant by the following:

(i) Total internal reflection, *(01 mark)*

(ii) Critical angle. *(01 mark)*

(d) Briefly explain why an observer sees a spectrum of colours through rain drops when it is raining on a sunny day. *(02 marks)*

SECTION B

3. (a) Explain what is meant by an **interference pattern** as applied to light waves. (*03 marks*)

(b) Explain why it is necessary to use a common source when demonstrating interference in light. (*03 marks*)

(c) In an experiment to determine wavelength of light using Young's method, two slits, at a separation of 1.2 mm were used.

When the screen was placed 18.0 cm from the slits, 30 bright fringes occupying a distance 2.5 mm were obtained.

(i) Find the wavelength of the light used. (*04 marks*)

(ii) List the changes that would be observed if the distance of the screen from the slits were increased. (*02 marks*)

(d) (i) Derive the expression for the angular position of the n^{th} order principal maximum produced by a transmission diffraction grating. (*04 marks*)

(ii) Light of two wavelengths 5.4×10^{-7} m and 5.7×10^{-7} m is incident normally on a transmission grating with spacing 2.00×10^{6} m. Find the angular separation of the second order principal maxima. (*03 marks*)

(iii) Suppose white light is used in (d) (ii), describe the positions of red and violet lights in the first order principal maximum relative to the central maximum. (*01 mark*)

4. (a) Define the following:

(i) Transverse waves. (*01 mark*)

(ii) Longitudinal waves. (*01 mark*)

(b) When a plane wave traverses a medium, the displacement of the particles is given by, $y = 0.01 \sin 2\pi (2t - 0.01x)$, where y and x are in metres and t in seconds.

Calculate the;

(i) frequency of the wave. (*02 marks*)

(ii) wave velocity. (*03 marks*)

(iii) phase difference at a given instant of time, between two particles 50 m apart. (*02 marks*)

(c) Describe an experiment to determine the velocity of sound in air by an interference method. (*06 marks*)

(d) (i) State **two** applications of the **Doppler effect.** (*02 marks*)

(ii) Derive an expression for the frequency f, of sound as heard by a stationary observer when the source of sound of frequency f approaches with uniform speed u_s. (*03 marks*)

SECTION C

5. (a) (i) Write down the expression for the force on a charge, q coulombs moving with velocity, u, at an angle, α, to a uniform magnetic field of flux density B. (*01 mark*)

(ii) Use the expression in (a) (i), to deduce the force on a conductor carrying a current in a magnetic field. (*03 marks*)

(b) Figure **1** shows an aluminium bar ***AB*** resting on two horizontal aluminium rails connected to a battery through switch K. A magnetic field of flux density 0.10 T, acts perpendicularly into the paper.

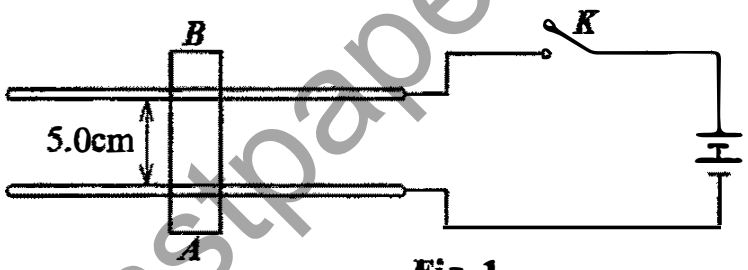

Fig. 1

(i) Explain what happens to ***AB*** when switch K is closed. (*03 marks*)

(ii) Calculate the angle to the horizontal to which the rails must be tilted to keep ***AB*** stationary if its mass is 5.0 g, current in it is 4.0 A and the direction of the field remains unchanged. (*04 marks*)

(c) (i) With the aid of a labelled diagram, describe the structure and mode of operation of a moving coil galvanometer. (*06 marks*)

(ii) Discuss the factors which affect the current sensitivity of a moving coil galvanometer. (*03 marks*)

6. (a) State the **laws of electromagnetic induction**. (*02 marks*)

(b) (i) With the aid of a diagram, describe how a simple a.c generator works. (*04 marks*)

(ii) What are the main energy losses in a practical a.c generator and how are they minimised? (*02 marks*)

(c) A circular coil having 20 turns each of radius 8.0 cm is rotated about its vertical diameter with angular speed of 50 radians per second in a uniform horizontal magnetic field of magnitude 30 mT.

(i) Calculate the r.m.s value of the e.m.f induced in the coil. (*03 marks*)

(ii) If the coil forms a closed loop of resistance 10 Ω , how much power is dissipated as heat in it? (*02 marks*)

(d) Figure 2 shows a capacitor and a bulb connected to a.c supply.

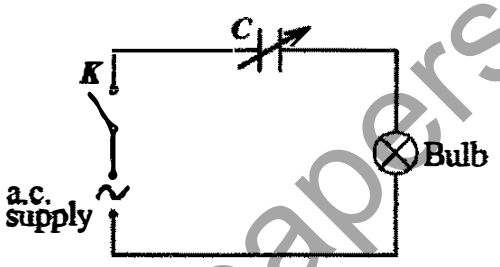

Fig. 2

Explain;

(i) why the bulb lights when switch K, is closed. (*01 mark*)

(ii) what would happen if the capacitance were reduced. (*02 marks*)

(e) Explain the following observations:

(i) A spark is seen at the switch when the circuit of a current carrying coil is broken. (*02 marks*)

(ii) A magnetised iron bar dropped vertically through a hollow region of a thick cylindrical shell made of copper experiences a retarding force. (*02 marks*)

7. (a) Define the following;

(i) peak value, (*01 mark*)

(ii) root mean square (r.m.s) value of an alternating current. (*01 mark*)

(b) Derive an equation relating peak value and r.m.s value of an alternating current. (*03 marks*)

(c) An electric current flows through a coil of 4 Ω immersed in 200 g of water placed in a container. If the temperature of the water rises by 1K per minute, calculate the peak value of current supplied. (*03 marks*)

(d) What is meant by **resonance** in a circuit? (*01 mark*)

(e) A lamp of resistance 10 Ω, a capacitor of capacitance 0.4 μ F and an inductor of inductance 0.4 H are connected in series to an alternating voltage source of 0.01 V(r.m.s). The frequency f, is varied from low to high value while maintaining the amplitude of the applied voltage constant.

(i) Explain how the brightness of the lamp varies. (*03 marks*)
(ii) Calculate the resonant frequency. (*03 marks*)
(iii) Find the voltage across the capacitor. (*03 marks*)

(f) Explain why in an R - C circuit, power is only absorbed by the resistive part of the circuit. (*02 marks*)

SECTION D

8. (a) State **Coulomb's law** of electrostatics. (*01 mark*)

(b) (i) Describe how a conductor may be positively charged but remains at zero potential. (*03 marks*)
(ii) Explain how the presence of a neutral conductor near a charged conducting sphere may reduce the potential of the sphere. (*03 marks*)

(c) In figure 3, points P and Q are at distances 30.0 cm and 20.0 cm from a point charge of 4.0 μC, respectively.

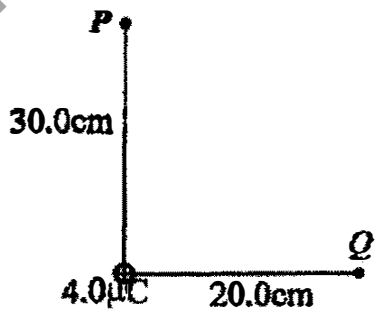

Fig. 3

Calculate the;

(i) electric potential difference between P and Q. (*05 marks*)
(ii) energy required to bring a charge at + 1.0 μC from infinity to point Q. (*03 marks*)

(d) Describe with the aid of a diagram an experiment to show that excess charge resides only on the outside of a hollow conductor. *(05 marks)*

9. (a) (i) Define **e.m.f** of a battery. *(01 mark)*

(ii) Explain why the e.m.f of a battery left standing in a room for long decreases. *(02 marks)*

(b) Figure **4** shows a network of resistors connected to two identical cells of e.m.f 1.5 V and internal resistance 0.8 Ω.

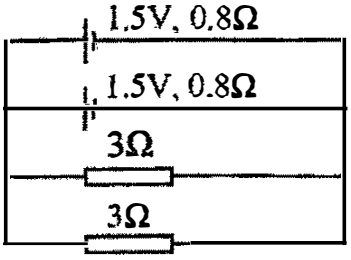

Fig. 4

Calculate the current supplied by the cells. *(04 marks)*

(c) Describe an experiment which can be carried out to determine the resistance of a wire using a potentiometer. *(06 marks)*

(d) Figure **5** shows a uniform resistance wire AB, 100 cm long and of resistance 4.0 Ω connected in series with a 2.0 Ω resistor to a driver cell of e.m.f 3.4 V and negligible internal resistance. Cell X is connected to a 5.0 Ω resistor through switch K_2. When K_1 is closed and K_2 is open, the balance length is 53.0 cm.

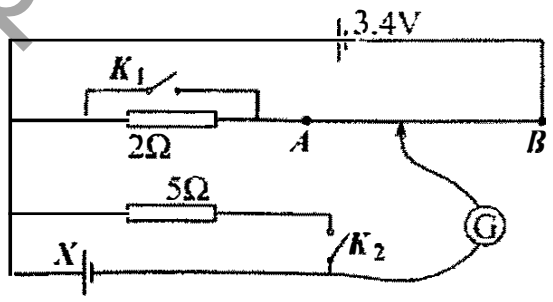

Fig. 5

Find the;

(i) balance length when K_1 and K_2 are both open. *(03 marks)*

(ii) internal resistance of cell X if the balance length is 44.1 cm when both K_1 and K_2 are closed. *(04 marks)*

10. (a) (i) Define a **Farad**. *(01 mark)*

(ii) Describe briefly the energy transformations that take place when charging a capacitor using a dry cell. *(02 marks)*

(b) (i) What is meant by **dielectric constant**? *(01 mark)*

(ii) A parallel plate capacitor is charged to 100 V and then isolated. When a sheet of a dielectric is inserted between the plates, the p.d decreased to 30 V. Calculate the dielectric constant of the dielectric. *(03 marks)*

(c) A 60 μF capacitor is charged from a 120 V supply. It is then connected across the terminals of a 20 μF capacitor. Calculate the;

(i) final p.d across the combination. *(03 marks)*

(ii) difference in the initial and final energies stored in the capacitors and comment on the difference. *(05 marks)*

(d) Explain the principle of operation of a lightning conductor. *(05 marks)*