P510/2
PHYSICS
Paper 2
July / Aug. 2022
2 ½ hours

UGANDA TEACHERS' EDUCATION CONSULT (UTEC)

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

*Attempt only **Five** questions with at least one question from each of the four sections A, B, C and D. Do not attempt more than one question from each of the sections A and B.*

Silent Non – programmable electronic scientific calculators may be used.

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, $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}\,m$

SECTION A

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

(ii) State the conditions under which total internal reflection occurs. (02 marks)

(b) A ray of light is refracted through a spherical glass marble, whose refractive index is n in such a way that it passes through the extremeties of two radii which make an angle, θ, with each other. If γ is the deviation of the ray caused by its passage through the sphere.

(i) Draw a ray diagram to show the path of the ray of light through the marble. (02 marks)

(ii) Derive an expression for the refractive index in terms of θ and γ. (04 marks)

(c) (i) Explain the meaning of critical angle and total internal reflection. (03 marks)

(ii) Describe one natural phenomenon due to total internal reflection. (04 marks)

(d) Light from luminous point on the lower face of a rectangular glass, 2.0cm thick, strikes the upper face and the totally internally reflected rays outline a circle of 3.2cm radius on the lower face. Calculate the refractive index of the glass material. (03 marks)

2. (a) (i) What is meant by **magnifying power** of an optical instrument. (01 mark)

(ii) Draw a ray diagram to show the path of light through a compound microscope in normal adjustment. (03 marks)

(iii) Use the diagram above to obtain an expression for the magnifying power of the compound microscope in terms of the focal length of the objective and the eye – piece lens.

(b) A compound microscope has an eye – piece of focal length 2.50cm and an objective of focal length 1.60cm. If the distance between the objective and the eye piece is 22.1cm. Calculate the magnifying power produced when the final image is at infinity. (03 marks)

(c) Describe with the aid of a diagram, the functions of the essential parts of a photographic camera. (04 marks)

(d) A telephoto lens in a camera consists of a convex lens of focal length 10.0cm with a concave lens of focal length 5.0cm placed 7.0cm behind it. The object to be photographed is 5.0cm in front of the convex lens. Calculate;

(i) the total length of the camera from the convex lens to the film when the image is in focus on the film. (03 marks)

(ii) the magnification produced. (02 marks)

SECTION B

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

(ii) Derive a relationship between the speed , v, frequency , f, and were length λ of a progressive wave. (02 marks)

(b) A plane progressive wave in a medium along x – direction is described by the equation;

$y = 2.0\ x\ 10^{-3} \sin\left(100\pi t - \frac{1.03\pi x}{12}\right)$ 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) Wave length (01 mark)

(iii) Speed of the wave (01 mark)

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

(c) (i) Explain how beets are formed. (02 marks)

(ii) Derive an expression for the beat frequency. (03 marks)

(d) Explain why the amplitude of a wave goes on decreasing as the distance from the source increases. (05 marks)

4. (a) (i) What is meant by **interference**. (01 mark)

(ii) State two conditions for observable interference effects to be obtained. (02 marks)

(b) In a young double slit experiment, the two yellow slit sources have a wavelength 600nm, a separation of 0.6mm and they are 0.8m from a white screen. Calculate the separation of bright bands on the screen. (03 marks)

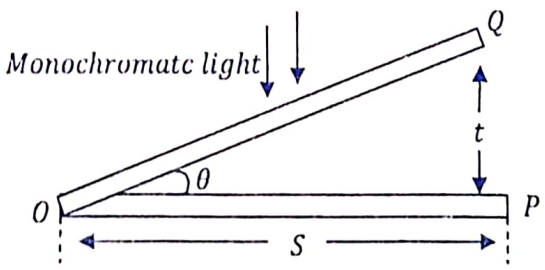
(c) Describe the appearance of the screen in (b) above if the;

(i) yellow sources are replaced by blue sources? (03 marks)

(ii) screen is moved farther from the sources. (02 marks)

(iii) slits are made slightly narrower. (02 marks)

(d) The figure below shows a wedge shaped air film illuminated by monochromatic light of wave length, λ, normally incident on the top surface of the wedge.



(i) Explain the formation of interference fridges. (04 marks)

(ii) Show that $\tan\theta = \frac{\lambda}{2a}$ where a is the fringe separation. (04 marks)

SECTION C

5. (a) (i) Derive an expression for the force per unit length between two long straight wires in a vacuum carrying currents I_1 and I_2 and are a distance x apart. (04 marks)

(ii) Define the ampere using the expression above. (07 marks)

(b) Two long parallel wires P and Q are in a vacuum and are 10cm apart. The wires carry currents 15A and 2A respectively in the same direction.

(i) Sketch the resultant magnetic field pattern due to the two currents, clearly indicating the directions of the field and force on the two wires. (02 marks)

(ii) At what point from wire, P, is the magnetic flux density zero? (03 mark)

(c) (i) What is meant by current sensitivity of a moving coil galvanometer? (01 mark)

(ii) Describe, with the aid of a diagram, the structure and mode of action of a moving – coil galvanometer. (05 marks)

(d) The coil of a moving coil galvanometer has resistance 100Ω and 200 turns of mean area $2cm^2$. The coil is situated in a radial magnetic field of flux density $3.0 \times 10^{-2}T$. If the coil suspension exerts a restoring torgue of 6.0×10^{-7} $Nmrad^{-1}$, find the voltage sensitivity of the galvanometer. (03 marks)

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

(b) (i) With the aid of a labeled diagram, describe how a simple a.c generator works. (05 marks)

(ii) What are the main energy loses in practical a.c. generator and how are they minimized? (03 marks)

(c) (i) Explain how the design of a moving coil galvanometer can be modified to produce a ballistic galvanometer. (02 marks)

(ii) Describe how a ballistic galvanometeri s used to measure the magnetic flux density in a region between the poles of a magnet. (04 marks)

(iii) State one possible source of error in (c) (ii) above. (01 mark)

(d) A circular coil of 50 turns of mean radius 0.50m is arranged so that its plane is perpendicular to the magnetic meridian. The coil is connected to a ballistic galvanometer of sensitivity 5.0×10^4 rad C^{-1}. The total resistance of the coil and the galvanometer is 100Ω. If the coil is rotated through 180° about a

vertical axis, the ballistic galvanometer deflects through 0.8 radius. Calculate the horizontal component of the earth's magnetic flux density. (03 marks)

7. (a) (i) Define root mean square value of an alternating current. (01 mark)

(ii) Distinguish between impedence and reactance as applied to a.c. (02 marks)

(b) (i) Show that an alternating current passing through an inductor lags on the applied p.d. by $\frac{\pi}{2}$ radians.

(ii) Sketch the variation of the current and voltage with time. (02 marks)

(iii) Derive the expression for the inductive reactance X_L in terms of the frequency $, f,$ *and inductance* $, L,$ for b(i) above. (02 marks)

(c) (i) What is meant by the term **full wave refraction**. (01 mark)

(ii) Explain how a bridge rectifier works to provide full wave rectification. (04 marks)

(d) A flat circular coil with 200 turns and each of radius 40cm is rotated at a uniform rate of 480 rev/min about its diameter at right angles to a uniform magnetic field of flux density 5.0×10^{-4}T. Calculate;

(i) the r.m.s of the induced e.m.f. (02 marks)

(ii) instantaneous value of induced e.m.f when the plane of the coil makes an angle of 60° with the field direction. (03 marks)

(e) Explain why a capacitor allows the flow of alternating current but not direct current yet it conducts direct current.

SECTION D

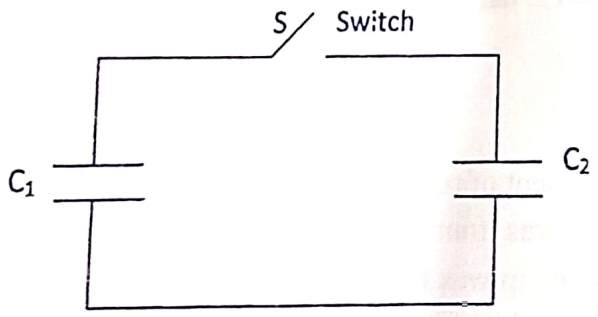
8. (a) Define the following:

(i) The farad (01 mark)

(ii) Relative permittivity (01 mark)

(b) A capacitor is labeled "$3000\mu F, 25V$". Explain the meaning of the labeling. (02 marks)

(c) A capacitor C_1 is charged to a p.d. V_o with the aid of a battery. The battery is then removed and the capacitor is connected to an uncharged capacitor C_2 as shown below.



Find the expression for;

(i) The final p.d. V across the combination on closing switch S. (03 marks)

(ii) The energy stored before and after the switch S is closed. (03 marks)

(iii) The final energy if $C_1 = C_2$. (02 marks)

(d) A parallel plain air capacitor is charged to a p.d of 300V. It is then connected in parallel with another uncharged capacitor of equal dimensions with rubber as a dielectric between its plates. The p.d of the combination is found to be 75V. Calculate;

(i) the dielectric constant of the rubber. (04 marks)

(ii) the total energy stored in the two capacitors. (03 marks)

(iii) Account for the difference in the initial and final energy stored. (01 mark)

9. (a) What is meant by the following terms?

(i) Electrostatic induction? (01 mark)

(ii) Electric point discharge? (01 mark)

(b) (i) Describe, with the aid of a labeled diagram a Van de Graaf generator. (05 marks)

(ii) The high voltage terminal of such a generator consists of a spherical conducting shell of radius 50cm.

Calculate the maximum potential to which it can be raised in air for which electrical break down occurs when the electric intensity exceeds $3.0 \times 10^4 Vcm^{-1}$. (03 marks)

(c) A needle is mounted vertically, point upwards on the cap of a gold leaf electroscope, the blunt end being in contact with the cap. Explain what is observed.

(i) When a negatively charged body is brought close to the needle point without touching it, and is then quickly withdrawn. (03 marks)

(ii) When the negatively charged body is again brought near the needle point and left there for sometime and is withdrawn. (03 marks)

(d) Three charges $-1\mu C, 2\mu C,$ and $3\mu C$ are placed respectively at the corners A, B and C of an equilateral triangle of side 2m. Calculate the electric field intensity at a point X which is half way along BC. (04 marks)

10. (a) Define the terms;

(i) Resistivity (01 mark)

(ii) Temperature coefficient of resistance. (01 mark)

(b) A carbon lamp filament was found to have a resistance of 375Ω at the temperature of 20oc. The lamp was then connected in series with an ammeter and a d.c. supply, and a voltmeter of resistance 1050Ω was connected in

parallel with the lamp. The ammeter and voltmeter indicated 0.76A and 100V respectively. The temperature of the carbon filament was estimated to be 1200°C.

(i) Find the mean value of the temperature coefficient of resistance of carbon between 20°C and 1200°C. (04 marks)

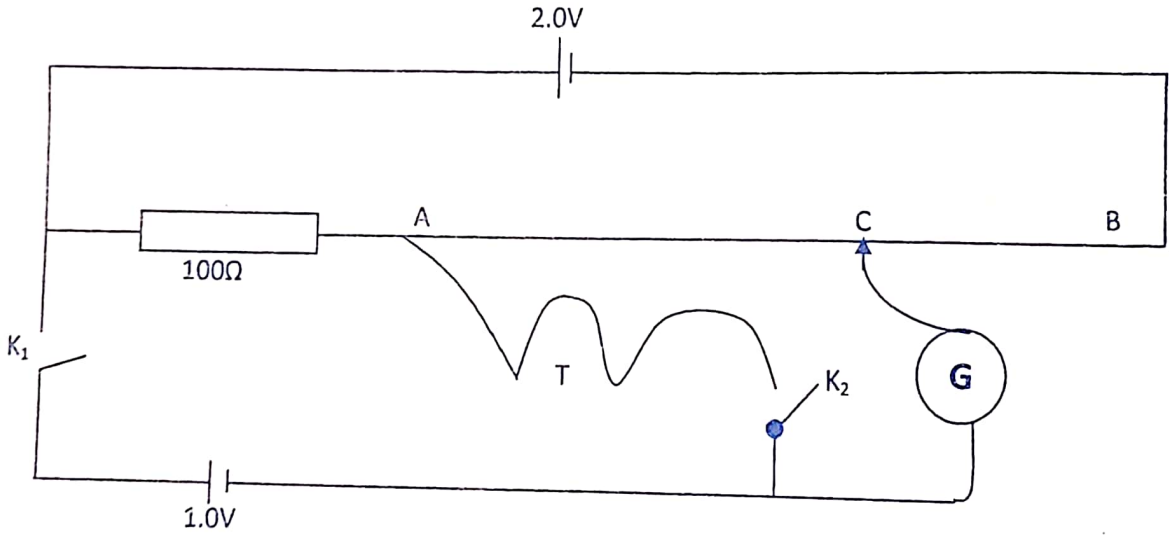
(ii) Comment on the result obtained in (b) (i) above. (01 mark)

(c) (i) Describe how the potentiometer can be calibrated. (03 marks)

(ii) Describe how the potentiometer can be used to compare two resistances. (04 marks)

(d) (i) In the measurement of thermoelectric e.m.f a high resistance is connected in series with the resistance wire of the potentiometer. Explain why this is so. (02 marks)

(ii)



The circuit above is used to measure the e.m.f of a thermo couple T. AB is a uniform wire of length 1.0m and resistance 2.0Ω. With K_1, open and K_2 closed, the balance length is 45cm. What is the e.m.f of the thermocouple? (04 marks)

END