P510/1
PHYSICS
(Theory)
Paper 1
Nov./Dec. 2020
2½ hours

# UGANDA NATIONAL EXAMINATIONS BOARD

## Uganda Advanced Certificate of Education

PHYSICS
(Theory)
**Paper 1**
2 hours 30 minutes

**INSTRUCTIONS TO CANDIDATES:**

*Answer* **five** *questions, including at least* **one**, *but* **not** *more than* **two** *from each of the sections;* **A**, **B** *and* **C**.
*Any additional question(s) answered will* **not** *be marked.*
*Non-programmable scientific calculators may be used.*
*Assume where necessary:*

| | |
|---|---|
| *Acceleration due to gravity, g* | $= 9.81\ ms^{-2}$. |
| *Electron charge, e* | $= 1.6 \times 10^{-19}$ C. |
| *Electron mass* | $= 9.11 \times 10^{-31}$ kg. |
| *Mass of the earth* | $= 5.97 \times 10^{24}$ kg. |
| *Plank's constant, h* | $= 6.6 \times 10^{-34}$ Js. |
| *Stefan's Boltzmann's constant, σ* | $= 5.67 \times 10^{-8}\ Wm^{-2}\ K^{-4}$. |
| *Radius of the Earth* | $= 6.4 \times 10^{6}$ m. |
| *Radius of the Sun* | $= 7 \times 10^{8}$ m. |
| *Radius of earth's orbit about the sun* | $= 1.5 \times 10^{11}$m. |
| *Speed of light in a vacuum, c* | $= 3.0 \times 10^{8}\ ms^{-1}$. |
| *Thermal conductivity of copper* | $= 390\ Wm^{-1}\ K^{-1}$. |
| *Thermal conductivity of aluminium* | $= 210\ Wm^{-1}K^{-1}$. |
| *Specific heat capacity of water* | $= 4200\ J\ Kg^{-1}\ K^{-1}$. |
| *Universal gravitational constant, G* | $= 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$. |
| *Avogadro's number, $N_A$* | $= 6.02 \times 10^{23}\ mol^{-1}$. |
| *Surface tension of water* | $= 7.0 \times 10^{-2}\ Nm^{-1}$. |
| *Density of water* | $= 1000\ kgm^{-3}$. |
| *Gas constant, R* | $= 8.31\ Jmol^{-1}K^{-1}$. |
| *Charge to mass ratio, e/m* | $= 1.8 \times 10^{11}\ Ckg^{-1}$. |
| *The constant* $\frac{1}{4\pi\varepsilon_0}$ | $= 9.0 \times 10^{9}\ F^{-1}m$. |
| *Faraday constant, F* | $= 9.65 \times 10^{4}\ Cmol^{-1}$. |

## SECTION A

**1.** (a) (i) State the laws of static friction. *(03 marks)*

(ii) Use the molecular theory of matter to explain the laws stated in (a) (i). *(06 marks)*

(b) Describe briefly how to measure the limiting friction between a wooden block and a plane surface. *(04 marks)*

(c) A block of wood of mass 3.95 kg rests on a horizontal table of height 5.0 m at a distance of 6.0 m from the edge of the table. A bullet of mass 50.0 g moving with a horizontal velocity of 500 $ms^{-1}$ hits and gets embedded in the block. If the coefficient of dynamic friction between the block and the table is 0.3;

(i) find the initial velocity of the block after the collision with the bullet. *(02 marks)*

(ii) calculate the horizontal distance from the table to the point where the block hits the ground. *(05 marks)*

**2.** (a) Define the following as applied to materials:

(i) Stress. *(01 mark)*

(ii) Young's Modulus. *(01 mark)*

(b) The velocity of compressional waves travelling along a rod made of material of Young's Modulus, $E$, and density, $\rho$, is given by $V = \left(\frac{E}{\rho}\right)^{½}$. Show that the formula is dimensionally consistent. *(02 marks)*

(c) Derive an expression for the energy stored in a stretched wire within the elastic limit. *(03 marks)*

(d) A uniform wire of length 2.49 m is attached to two fixed points $A$ and $B$, a horizontal distance 2 m apart. When a 5 kg mass is attached to the mid-point $C$ of the wire, the equilibrium position of $C$ is 0.75 m below the line $AB$. Neglecting the weight of the wire and taking Young's Modulus for its material to be $2 \times 10^{11}$ $Nm^{-2}$, find the;

(i) strain in the wire. *(04 marks)*

(ii) stress in the wire. *(02 marks)*

(iii) energy stored in the wire. *(04 marks)*

(e) (i) Sketch the stress-strain curve for glass and explain its shape. *(02 marks)*

(ii) Why does glass break easily? *(01 mark)*

3. (a) (i) Define **centripetal acceleration**. (*01 mark*)

(ii) Show that the force $F$ on a body of mass $M$ moving in a circle of radius $r$ with constant speed $V$ is given by $F = \frac{MV^2}{r}$. (*05 marks*)

(iii) Derive the condition for a car to move round a banked circular track without slipping. (*04 marks*)

(b) Describe how a helical spring may be used to dertermine the acceleration due to gravity. (*05 marks*)

(c) A particle moving with simple harmonic motion, has a speed of 8.0 $ms^{-1}$ and an acceleration of 12 $ms^{-2}$ when it is 3.0 m from its equilibirum position. Find the;

(i) amplitude of motion. (*03 marks*)

(ii) maximum acceleration. (*02 marks*)

4. (a) Define the following:

(i) Pressure. (*01 mark*)

(ii) Relative density. (*01 mark*)

(b) (i) State Archimedes Principle. (*01 mark*)

(ii) Describe an experiment to determine the relative density of a liquid. (*04 marks*)

(c) (i) Derive the expression for Bernoulli's equation. (*05 marks*)

(ii) Explain why a person standing by the road side may be pulled towards the road when a very fast moving bus passes by. (*03 marks*)

(d) A water tight drum tied to a cable anchored on the sea-bed floats 500 m beneath the sea surface as shown in figure **1**.

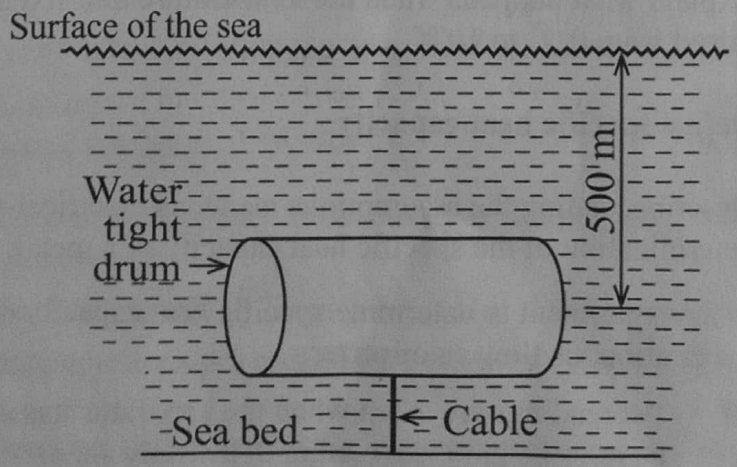


**Fig. 1**

If the weight of the drum is 500 N and its volume is 25 $m^3$, calculate the;

(i) pressure on the drum due to the sea water. (*02 marks*)
(ii) tension in the cable assuming it is vertical. (*03 marks*)

## SECTION B

**5.** (a) Define the following:

(i) Tripple point of water. (*01 mark*)
(ii) Absolute zero temperature. (*01 mark*)

(b) Explain why tripple point of water is taken as a standard in modern thermometry instead of ice and steam points. (*04 marks*)

(c) (i) What is a **thermometric property**? (*01 mark*)
(ii) State **three** qualities of a good thermometric property. (*03 marks*)

(d) (i) A constant volume thermometer was used to measure temperature when the atmospheric pressure was 760 mmHg. The following values were obtained.

| | **Length of Mercury in closed limb (mmHg)** | **Length of Mercury in open limb (mmHg** |
|---|---|---|
| Bulb in ice | 140 | 130 |
| Bulb in steam | 140 | 330 |
| Bulb at room temperature | 140 | 170 |

Calculate the room temperature. (*05 marks*)

(ii) List **two** advantages of the constant volume gas thermometer over the mercury in glass thermometer. (*02 marks*)

(e) Explain what happens when the temperature of a fixed mass of ice is raised from 0 °C to 10 °C. (*03 marks*)

**6.** (a) Define **specific heat capacity**. (*01 mark*)

(b) Describe, stating the assumptions made, an electrical method for the determination of the specific heat capacity of a metal. (*08 marks*)

(c) In an experiment to determine specific heat capacity of a liquid using the continuous flow calorimeter;

(i) the readings are taken when the apparatus has attained a steady state. Explain the meaning of a steady state. (*02 marks*)
(ii) Explain why two sets of readings are taken. (*01 mark*)

(d) When water is passed through a continuous flow calorimeter at the rate of 100 g $min^{-1}$, the temperature rises from 16 °C to 20 °C, when the p.d across the heater is 20 V and the current is 1.5 A. When another liquid at 16 °C is passed through the calorimeter at the rate of 120 g $min^{-1}$, the same temperature change is obtained at a p.d of 13 V and current 1.2 A. Calculate the specific heat capacity of the liquid.
*(04 marks)*

(e) (i) Define **latent heat**. *(01 mark)*

(ii) Explain why latent heat of vaporisation is always greater than that of fusion. *(03 marks)*

7. (a) (i) Explain how a thermocouple is used to measure temperature on a celsius scale. *(05 marks)*

(ii) State **two** advantages of a thermocouple. *(01 mark)*

(b) (i) Two cylindrical bodies *A* and *B* are made of the same material but the length of *A* is twice that of *B* and the cross sectional area of *B* is a third that of *A*. If the ends of *A* and *B* are subjected to the same temperature difference, find the ratio of the rate of heat flow through *A* to the rate of heat flow through *B*.
*(03 marks)*

(ii) In the determination of thermal conductivity of copper, when water flows round the cool end of a copper rod at a rate of 600 $cm^3$ per minute, its temperature increases by 3.3 °C. The temperatures at two points, a distance 5.2 cm apart, along the copper rod are 70 °C and 30 °C respectively. Find the thermal conductivity of copper if the radius of the rod is 1.2 cm.
*(04 marks)*

(c) Describe an experiment to measure thermal conductivity of cork.
*(07 marks)*

## SECTION C

8. (a) What is meant by the following as applied to radioactivity?

(i) Activity. *(01 mark)*

(ii) Decay constant. *(01 mark)*

(b) (i) Explain briefly, why radioactivity is referred to as random and spontaneous. *(02 marks)*

(ii) The half life of $^{230}_{92}Th$ is $2.4 \times 10^{11}$ s. Find the number of disintegrations per second that occur in 1 g of $^{230}_{92}Th$.
*(03 marks)*

(c) (i) Describe, with the aid of a labelled diagram, how the Wilson cloud chamber can be used to detect ionising radiation.
*(06 marks)*

(ii) Explain the difference in the patterns of the tracks seen in the chamber when $\alpha-$ and $\beta-$ particles are present in the chamber. (*02 marks*)

(d) (i) What is meant by **mass defect**? (*01 mark*)

(ii) Calculate, in MeV, the energy released when helium nucleons are produced by fusing two neutrons and two protons. (*04 marks*)

*Mass of a proton* = 1.00759 u.
*Mass of a neutron* = 1.00898 u.
*Mass of helium* = 4.00277 u.
1 u = 931 MeV.

**9.** (a) (i) What is meant by a **p-n junction** as applied to semiconductors? (*01 mark*)

(ii) Explain the term **doping** as appllied to a p-n junction diode. (*03 marks*)

(b) (i) Explain, with the aid of a labelled diagram, the I-V characteristic of a junction diode. (*03 marks*)

(ii) Describe how full wave rectification can be achieved using a bridge rectifier. (*04 marks*)

(c) The input resistance of a certain n-p-n transistor in the common emitter connection is 3 kΩ. The small current amplification transfer ratio is 100. The internal resistance of the emitter-base junction is negligible and the load resistor is 6 kΩ. Find the voltage gain. (*04 marks*)

(d) (i) Explain the mechanism of the thermionic emission. (*03 marks*)

(ii) The gain control of a Cathode Ray Oscilloscope (C.R.O) is set at 0.5 $Vcm^{-1}$, and an alternating voltage produces a vertical line of length 2.0 cm with the time base off. Find the root mean square value of the potential difference. (*02 marks*)

**10.** (a) Define **specific charge** of a positive ion and state its unit. (*02 marks*)

(b) With the aid of a labelled diagram, describe how Bainbridge spectrometer can be used to determine the specific charge of positive ions. (*06 marks*)

(c) A beam of positive ions accelerated through a potential difference of 2,000 V enters a region of a uniform magnetic flux density **B**. The ions describe a cricular path of radius 3.2 cm while in the field. If the specific charge of the ions is $8.5 \times 10^7$ C $kg^{-1}$, derive an expression for the charge to mass ratio of the ions and use it to calculate the value of **B**. (*05 marks*)

(d) State the use of each of the following features of Cathode Ray Oscilloscope (C.R.O):

(i) Anode system. *(01 mark)*
(ii) Y-plates. *(01 mark)*
(iii) The grid. *(01 mark)*

(e) An electron with energy 5 kV moves in the direction of an electric field of intensity $1.6 \times 10^4\ Vm^{-1}$. What distance will the electron move before coming to rest? *(04 marks)*



END