

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	$= 9.81 \text{ ms}^{-2}$.
Electron charge, e	$= 1.6 \times 10^{-19} \text{ C}$.
Electron mass	$= 9.11 \times 10^{-31} \text{ kg}$.
Mass of the earth	$= 5.97 \times 10^{24} \text{ kg}$.
Plank's constant, h	$= 6.6 \times 10^{-34} \text{ Js}$.
Stefan's Boltzmann's constant, σ	$= 5.67 \times 10^{-8} \text{ Wm}^{-2} \text{ K}^{-4}$.
Radius of the Earth	$= 6.4 \times 10^6 \text{ m}$.
Radius of the Sun	$= 7 \times 10^8 \text{ m}$.
Radius of earth's orbit about the sun	$= 1.5 \times 10^{11} \text{ m}$.
Speed of light in a vacuum, c	$= 3.0 \times 10^8 \text{ ms}^{-1}$.
Thermal conductivity of copper	$= 390 \text{ Wm}^{-1} \text{ K}^{-1}$.
Thermal conductivity of aluminium	$= 210 \text{ Wm}^{-1} \text{ K}^{-1}$.
Specific heat capacity of water	$= 4200 \text{ J Kg}^{-1} \text{ K}^{-1}$.
Universal gravitational constant, G	$= 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$.
Avogadro's number, N_A	$= 6.02 \times 10^{23} \text{ mol}^{-1}$.
Surface tension of water	$= 7.0 \times 10^{-2} \text{ Nm}^{-1}$.
Density of water	$= 1000 \text{ kgm}^{-3}$.
Gas constant, R	$= 8.31 \text{ Jmol}^{-1} \text{ K}^{-1}$.
Charge to mass ratio, e/m	$= 1.8 \times 10^{11} \text{ Ckg}^{-1}$.
The constant $\frac{1}{4\pi\epsilon_0}$	$= 9.0 \times 10^9 \text{ F}^{-1} \text{ m}$.
Faraday constant, F	$= 9.65 \times 10^4 \text{ Cmol}^{-1}$.

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, ρ , is given by $V = \left(\frac{E}{\rho}\right)^{1/2}$. 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 $2 \times 10^{11} \text{ Nm}^{-2}$, 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
- $$F = \frac{MV^2}{r} \quad (05 \text{ marks})$$
- (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 determine 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 equilibrium 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.

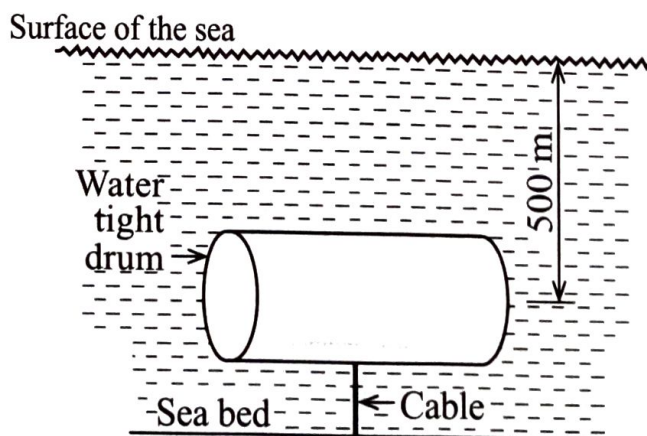


Fig. 1

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) Triple point of water. (01 mark)
 - (ii) Absolute zero temperature. (01 mark)
- (b) Explain why triple 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 ${}^{230}_{92}\text{Th}$ is $2.4 \times 10^{11} \text{ s}$. Find the number of disintegrations per second that occur in 1 g of ${}^{230}_{92}\text{Th}$. (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 α - and β - 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 applied 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 k Ω . The small current amplification transfer ratio is 100. The internal resistance of the emitter-base junction is negligible and the load resistor is 6 k Ω . 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 circular path of radius 3.2 cm while in the field. If the specific charge of the ions is $8.5 \times 10^7 \text{ C kg}^{-1}$, 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 $1.6 \times 10^4 \text{ Vm}^{-1}$. What distance will the electron move before coming to rest? (04 marks)