



UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 1  
(Theory)

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.

Silent, 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, $\sigma$	=	$5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Radius of 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	=	$4,200 \text{ J kg}^{-1} \text{ K}^{-1}$
Universal gravitational constant, $G$	=	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Surface tension of water	=	$7.0 \times 10^{-2} \text{ Nm}^{-1}$
Density of water	=	$1000 \text{ kg m}^{-3}$
Gas constant, $R$	=	$8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Charge to mass ratio, $e/m$	=	$1.8 \times 10^{11} \text{ C kg}^{-1}$

## SECTION A

1. (a) Define the following:
- (i) Vector and Scalar quantities. (02 marks)
  - (ii) The newton. (01 mark)
- (b) Use the method of dimensions to show that  $\text{Nkg}^{-1}$  and  $\text{ms}^{-2}$  are equivalent. (02 marks)
- (c) Figure 1 shows forces of 3.0 N, 3.5 N, 4.5 N and 5.0 N acting on a body  $P$  of mass 500 g. If  $P$  was initially at rest, calculate the distance  $P$  moves in 5 s. (06 marks)

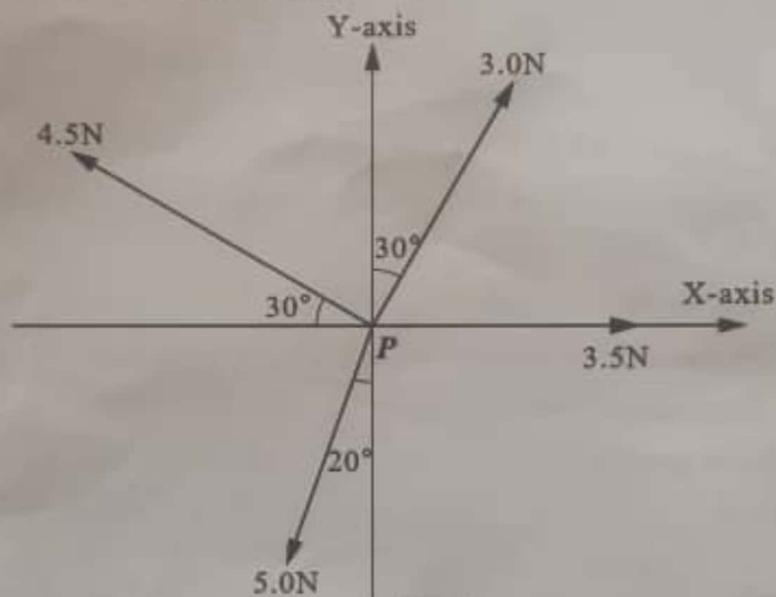


Fig. 1

- (d) (i) Explain why the tension in a cable of a lift when it is ascending is different from when it is descending. (03 marks)
- (ii) Explain the circumstances under which a person in a lift may feel weightless. (02 marks)
- (e) A stone is projected horizontally with a velocity of  $30 \text{ ms}^{-1}$  from a height of 60 m above the ground. Find how far the stone travels horizontally. (04 marks)
2. (a) Define the following:
- (i) Acceleration. (01 mark)
  - (ii) Instantaneous velocity. (01 mark)

- (b) A child wishing to reach the top of a vertical pole, climbs 3 m in 1 s and slides downwards 2 m in the next second. The child climbs another 3 m in 1 s and slips by 2 m in the next second. The process is repeated until the top is reached in a total time of 9 s.
- Using graph paper, draw a displacement time graph for the motion of the child. (04 marks)
  - Find the height of the pole. (01 mark)
- (c)
- State the laws of friction. (03 marks)
  - Balls *A* and *B* of respective masses 5 kg and 3 kg, move in a straight line in the same direction on a horizontal surface. When *A* knocks *B* which is moving at  $15 \text{ ms}^{-1}$ , it stops but *B* continues to move in the same direction and comes to rest in a distance of 81.5 m. Calculate the velocity of *A* before collision, assuming the coefficient of friction between the balls and the surface is 0.25. (05 marks)
- (d) A stone tied to a string is whirled in a horizontal circle. Explain the motion of the stone when the string breaks. (05 marks)

- 3.
- State **Hooke's law**. (01 mark)
    - Use the molecular theory to explain Hooke's law. (04 marks)
  - Describe the justification of the existence of molecules in gases. (04 marks)
  - Explain the significance of banked tracks. (02 marks)
    - Derive an expression for the speed of a bicycle rider round a circular path. (03 marks)
  - Show that the speed of a satellite in an orbit close to the earth surface is given by;

$$V = (gR_e)^{1/2}.$$

Where *V* is the speed of a satellite, *g* is the acceleration due to gravity and *R<sub>e</sub>* is the radius of the earth. (03 marks)

- Calculate the period of the satellite in the orbit, if the radius of the earth is  $6.4 \times 10^3 \text{ km}$  and acceleration due to gravity is  $9.81 \text{ ms}^{-2}$ . (03 marks)

- 4.
- Define the terms **surface tension** and **angle of contact**. (02 marks)
    - Account for the temperature dependency of surface tension. (03 marks)

- (b) When a capillary tube is held in a vertical position with one end just dipping in a liquid of surface tension,  $\gamma$ , and density,  $\rho$ , the liquid rises to a height  $h$ . Derive an expression for  $h$  in terms of  $\gamma$ ,  $\rho$  and radius,  $r$  of the tube. Assume the angle of contact is zero. (04 marks)
- (c) Water enters a house through a pipe of diameter 2.4 cm at a pressure of  $3.6 \times 10^5 \text{ N m}^{-2}$ . The pipe leading to the second floor bathroom 6.0 m above, is 1.2 cm in diameter. If the velocity of water as it enters the house is  $3.0 \text{ ms}^{-1}$ ,
- calculate the velocity of water at the outlet of the pipe leading to the second floor bathroom. (03 marks)
  - use Bernoulli's principle to find the pressure of the water through the pipe in the bathroom. (04 marks)
- (d) A sphere of radius,  $r$ , and of material of density,  $\rho$ , falls vertically through a liquid of density,  $\sigma$ , and viscosity,  $\eta$ . Derive an expression for its terminal velocity in terms of the quantities given and acceleration due to gravity,  $g$ . (04 marks)

## SECTION B

5. (a) What is meant by the following:
- Super heated water? (01 mark)
  - Super cooled vapour? (01 mark)
- (b) Explain how;
- a gas in a vessel exerts pressure. (03 marks)
  - the atmosphere surrounding the earth prevents it from becoming unbearably cold. (03 marks)
- (c) A container of volume  $0.2 \text{ m}^3$  contains hydrogen gas of molar mass  $2 \text{ g mol}^{-1}$  at a pressure of  $1.5 \times 10^4 \text{ Pa}$  and a temperature of  $27^\circ\text{C}$ .  
Calculate the;
- number of hydrogen molecules in the container. (03 marks)
  - mean square speed of the molecules. (03 marks)
  - root mean square speed of oxygen molecules at the same temperature. (Molar mass of oxygen =  $32 \text{ g mol}^{-1}$ .) (02 marks)
- (d) Sketch a graph of saturated vapour pressure of a liquid against temperature and explain the shape of the curve. (04 marks)



6. (a) Define the following as applied to heat: (03 marks)
- Conduction.
  - Convection.
  - Radiation.
- (b) (i) Define thermal conductivity and state its units. (02 marks)
- (ii) Explain why in the experiment to determine the thermal conductivity of a metal, the specimen is made thin and long. (02 marks)
- (c) The sun radiates as a black body at 6000 K and it is  $1.5 \times 10^{11}$  m from the earth. Given that the radius of the sun is  $7 \times 10^8$  m, find the;
- solar flux on the earth's surface. (03 marks)
  - time it will take 2.5 kg of ice at its melting point to melt when placed at the focal point of a concave mirror of diameter 0.8 m whose axis is parallel to the sun's radiation. (03 marks)
- (Specific latent heat of fusion of ice is  $3.36 \times 10^5 \text{ J kg}^{-1}$ )
- (d) (i) Explain how a bolometer strip is used to detect radiation. (04 marks)
- (ii) Explain why the intensity of solar radiation on top of the earth's atmosphere is higher than that on the earth's surface. (03 marks)
7. (a) (i) What is meant by **isothermal** and **adiabatic** processes in a gas? (02 marks)
- (ii) State the conditions necessary to achieve the processes in (a) (i). (04 marks)
- (iii) Explain why air coming out of a valve of a ball feels cold. (02 marks)
- (b) A mass of air initially occupying a volume of  $2000 \text{ cm}^3$  at a pressure of 76 cmHg and a temperature of  $20^\circ\text{C}$  expands adiabatically and reversibly to twice its volume. It is then compressed isothermally and reversibly to a volume of  $3000 \text{ cm}^3$ .
- Find the final temperature and pressure of the gas. (06 marks)
  - Indicate the two processes on a P-V diagram. (02 marks)
- (The ratio of the specific heat capacities of air = 1.40).
- (c) Show that the work done,  $W$ , by a gas in expanding from volume  $V_1$  to  $V_2$  at constant pressure,  $P$ , is
- $$W = P (V_2 - V_1).$$
- (04 marks)

## SECTION C

8. (a) (i) What is a **nuclide**? (01 mark)
- (ii) Define an **isotope** and give **two** examples. (02 marks)
- (iii) What is meant by irradiation? (01 mark)
- (b) Describe how the radiations emitted in a cloud chamber may be identified. (03 marks)
- (c) Polonium  $^{210}_{84}\text{Po}$  decays to lead  $\left(^{206}_{82}\text{Pb}\right)$  by emitting an alpha particle.
- (i) Write a nuclear equation for the reaction. (01 mark)
- (ii) Calculate the energy of disintegration in MeV. (04 marks)
- (iii) Calculate the speed of the emitted alpha particles. (04 marks)
- |                        |             |
|------------------------|-------------|
| Mass of polonium       | = 209.983 U |
| Mass of lead           | = 205.986 U |
| Mass of alpha particle | = 4.003 U   |
- (d) (i) Explain why it is difficult to separate isotopes U-238 and U-235. (02 marks)
- (ii) Give **one** biological use and **one** industrial use of radiation. (02 marks)
9. (a) Define the following:
- (i) Fusion. (01 mark)
- (ii) Fission. (01 mark)
- (b) (i) Sketch the variation of binding energy per nucleon against mass number. (01 mark)
- (ii) Use the sketch in (b) (i) to explain the origin of fusion and fission energies. (04 marks)
- (c) (i) What is meant by photoelectric emission? (01 mark)
- (ii) Write down Einstein's photoelectric equation and define each symbol in the equation. (02 marks)
- (iii) Describe an experiment based on the Einstein's photoelectric equation to determine Plank's constant. (07 marks)
- (d) Show that the path followed by an electron between two charged metal plates is parabolic. (03 marks)

10. (a) (i) What is meant by an intrinsic material? (01 mark)
- (ii) Explain how a p-n junction is made. (05 marks)
- (iii) With the aid of a circuit diagram, describe how a transistor can be used as a voltage amplifier. (04 marks)
- (b) (i) Sketch a two-input AND gate and its corresponding truth table. (04 marks)
- (ii) Explain how a two-input AND gate may be designed such that its output is used to sound an alarm when it is dark. (03 marks)
- (c) State **three** differences between positive rays and cathode rays. (03 marks)