P510/1
PHYSICS
Paper 1
(Theory)
Nov./Dec. 2023
2½ hours

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	=	$9.81\ ms^{-2}$
Electron charge, e	=	$1.6\times10^{-19}\ C$
Electron mass	=	$9.11\times10^{-31}\ kg$
Mass of the earth	=	$5.97\times10^{24}\ kg$
Plank's constant, h	=	$6.6\times10^{-34}\ Js$
Stefan's-Boltzmann's constant, σ	=	$5.67\times10^{-8}\ W\ m^{-2}\ K^{-4}$
Radius of earth	=	$6.4\times10^{6}\ m$
Radius of the sun	=	$7\times10^{8}\ m$
Radius of earth's orbit about the sun	=	$1.5\times10^{11}\ m$
Speed of light in a vacuum, c	=	$3.0\times10^{8}\ ms^{-1}$
Thermal conductivity of copper	=	$390\ Wm^{-1}\ K^{-1}$
Thermal conductivity of aluminium	=	$210\ Wm^{-1}\ K^{-1}$
Specific heat capacity of water	=	$4{,}200\ J\ kg^{-1}\ K^{-1}$
Universal gravitational constant, G	=	$6.67\times10^{-11}\ N\ m^{2}\ kg^{-2}$
Surface tension of water	=	$7.0\times10^{-2}\ Nm^{-1}$
Density of water	=	$1000\ kg\ m^{-3}$
Gas constant, R	=	$8.31\ J\ mol^{-1}\ K^{-1}$
Charge to mass ratio, e/m	=	$1.8\times10^{11}\ C\ kg^{-1}$

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 Nkg^{-1} and 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)*

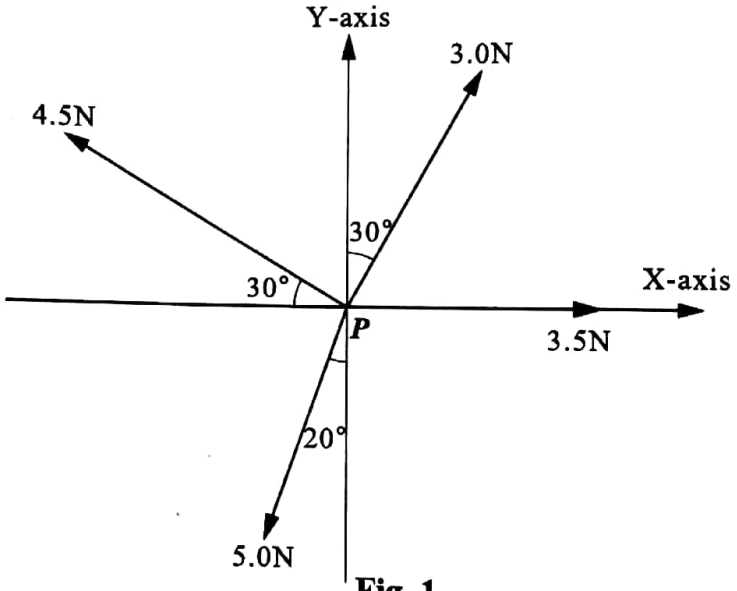

Fig. 1

(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 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 1s 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.

(i) Using graph paper, draw a displacement time graph for the motion of the child. *(04 marks)*

(ii) Find the height of the pole. *(01 mark)*

(c) (i) State the laws of friction. *(03 marks)*

(ii) 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 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. (a) (i) State **Hooke's law**. *(01 mark)*

(ii) Use the molecular theory to explain Hooke's law. *(04 marks)*

(b) Describe the justification of the existence of molecules in gases. *(04 marks)*

(c) (i) Explain the significance of banked tracks. *(02 marks)*

(ii) Derive an expression for the speed of a bicycle rider round a circular path. *(03 marks)*

(d) (i) 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_e is the radius of the earth. *(03 marks)*

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

4. (a) (i) Define the terms **surface tension** and **angle of contact**. *(02 marks)*

(ii) Account for the temperature dependency of surface tension. *(03 marks)*

Turn Over

(b) When a capillary tube is held in a vertical position with one end just dipping in a liquid of surface tension, γ, and density, ρ, the liquid rises to a height h. Derive an expression for h in terms of γ, ρ 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 3.6×10^5 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 ms^{-1},

(i) calculate the velocity of water at the outlet of the pipe leading to the second floor bathroom. *(03 marks)*

(ii) 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, ρ, falls vertically through a liquid of density, σ, and viscosity, η. 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:

(i) Super heated water? *(01 mark)*

(ii) Super cooled vapour? *(01 mark)*

(b) Explain how;

(i) a gas in a vessel exerts pressure. *(03 marks)*

(ii) the atmosphere surrounding the earth prevents it from becoming unbearably cold. *(03 marks)*

(c) A container of volume 0.2 m^3 contains hydrogen gas of molar mass 2 g mol^{-1} at a pressure of 1.5×10^4 Pa and a temperature of 27°C.

Calculate the;

(i) number of hydrogen molecules in the container. *(03 marks)*

(ii) mean square speed of the molecules. *(03 marks)*

(iii) root mean square speed of oxygen molecules at the same temperature. (*Molar mass of oxygen=32 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:
(i) Conduction.
(ii) Convection.
(ii) Radiation. (03 marks)

(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 1.5×10^{11} m from the earth. Given that the radius of the sun is 7×10^{8} m, find the;

(i) solar flux on the earth's surface. (03 marks)

(ii) 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* $3.36 \times 10^{5}\ Jkg^{-1}$)

(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 cm^3 at a pressure of 76 cmHg and a temperature of 20 °C expands adiabatically and reversibly to twice its volume. It is then compressed isothermally and reversibly to a volume of 3000 cm^3.

(i) Find the final temperature and pressure of the gas. (06 marks)

(ii) 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 ${}^{210}_{84}Po$ decays to lead $\left({}^{206}_{82}Pb\right)$ 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.

9. (a) Define the following: *(02 marks)*

(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)*