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)*

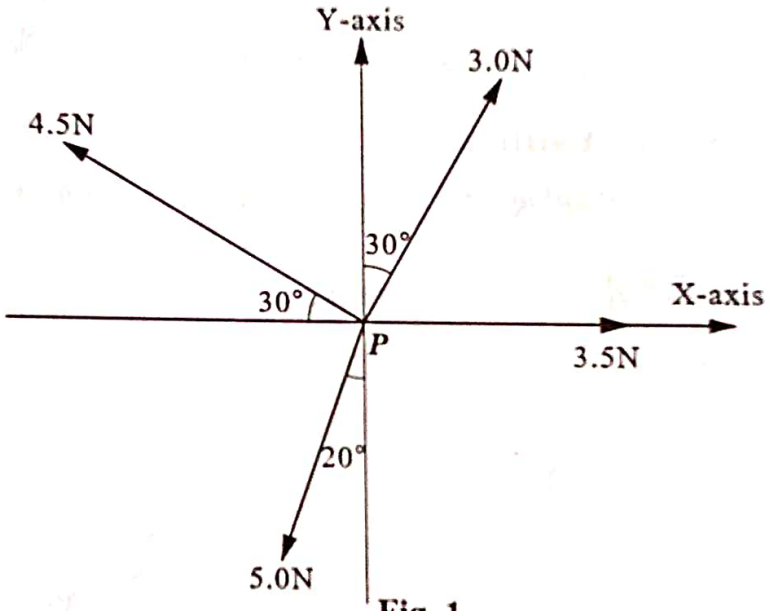

Fig. 1

(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)*

$F = ma$ N

MLT^{-2} =

LT^{-}

(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)*

(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: *(03 marks)*

(i) Conduction.
(ii) Convection.
(ii) 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 1.5×10^{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 3.36×10^{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)*

PV = nRT
8.31
A
AX
AΔX

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. *(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*)

END

$hf = hf_o + eV_s$

$f \quad h \quad h$