P510/1
PHYSICS
Paper 1
AUGUST, 2024
2½ hours

JINJA JOINT EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

MOCK EXAMINATIONS – AUGUST, 2024

PHYSICS

Paper 1

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

*Attempt not more than **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 maybe used.
Assume where necessary;

- Acceleration due to gravity, g = $9.81ms^{-2}$.
- Electron charge, e = $1.6x10^{-19}$C.
- Mass of the earth = $5.97x10^{24}kg$
- Thermal conductivity of copper = $390Wm^{-1}K^{-1}$
- Specific heat capacity of water = $4200Jkg^{-1}k^{-1}$.
- Density of water = $1000kgm^{-3}$
- Electron mass = 9.11×10^{-34} Kg
- Plank's constant = 6.6×10^{-34} Js
- Avogadro's constant, $N_A = 6.02 \times 10^{23}$ mol^{-1}
- Charge to mass ratio e/m = $1.8 \times 10^{11}Ckg^{-1}$
- Radius of the earth = 6.4×10^{6} m

SECTION A

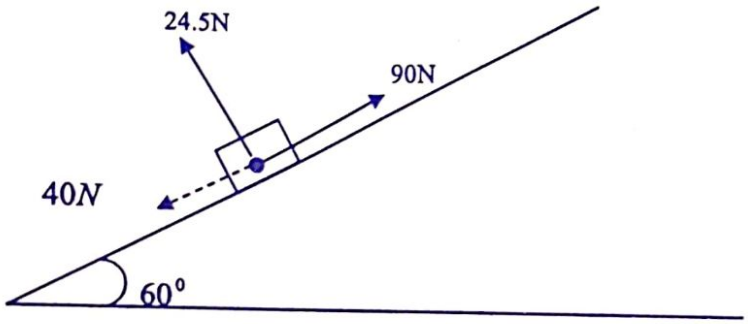
1. (a) Define the terms
   (i) Free fall (01 mark)
   (ii) Gravitational field. (01 mark)

(b)(i) Two balls A and B of masses m_1 and m_2 initially approaching each other with velocities u_1 and u_2 respectively had ahead on collision. If A continued in its original direction with a velocity v_1 while B reversed its direction with a velocity, v_2, show that $u_1 + u_2 = v_2 - v_1$, if the collision is perfectly elastic. (04 marks)

(ii) Explain why a martial arts player breaks a pile of bricks with ease (03 marks)

(c) Describe an experiment to determine the velocity of a bullet in a laboratory. (05 marks)

(d)



Three force of 90N, 40N and 24.5N act on a block placed on a smooth surface inclined at an angle of 60° to the horizontal. Calculate

(i) The acceleration of the block (03 marks)

(ii) The gain in kinetic energy 5s after moving from rest. (03 marks)

(iii)

2. (a)(i) Define the term work hardening as applied to elasticity. (01 mark)

(ii)Two ends of a steel rod of cross-sectional area A and coefficient of linear expansivity, $\propto$ is fixed on two rigid supports. If the Young's modulus of steel is E, derive the expression of force exerted on the supports when its heated from temperature θ_1 to θ_2. (02 marks)

(b)(i) State the condition in a body to be in mechanical equilibrium under the action of coplanar forces. (01mark)

(ii) A non-uniform beam AB of mass 20kg and length 7.0m is hinged at A which is a point on a vertical wall. The beam is maintained in a horizontal position by means of an elastic rope of cross sectional area $12cm^2$ and young's modulus of $1.2 \times 10^7 Nm^{-2}$ attached to a point C on a wall 4.0m vertically above A and attached to a point 5.0m from A along the beam. Given that the center of gravity along the beam is located at a point 3.0m from A. Calculate the original length of the rope and the reaction at the hinge. (05 marks)

(c) (i) Distinguish between conservative and non-conservative fields. (02 marks)

(ii) Explain the laws of solid friction between two solid surfaces in contact using the molecular theory. (06 marks)

(d) Describe an experiment to determine limiting frictional force between two wooden solid surfaces. (03 marks)

3. (a) (i) State Archimedes' Principle. (01mark)

(ii) Use Archimedes' principle to derive an expression for the resultant force on a body of weight W and density σ, totally immersed in a fluid of density ρ. (04 marks)

(b) A simple hydrometer consisting of a stem of uniform cross sectional area 1.0 cm^2 and a loaded bulb of volume 3.0 cm^3 floats in water so that a certain mark **x** on its stem is 4 cm below the water surface. It floats in a liquid of density 0.9 gcm^{-3} with **x** 6 cm below the liquid surface. It is then placed in a liquid of density1.1gcm^{-3}, calculate;

(i) The distance of **x** from the bulb of the hydrometer (03 marks)

(ii) Depth of **x** below the surface of liquid with density 1.1 gcm^{-3} (02 marks)

(c) (i) Define the terms **surface energy** and **surface tension**. (02 marks)

(ii) Show that **surface tension** and **surface energy** are numerically equal. (03 marks)

(d) (i) Calculate the work done against surface tension force in blowing a soap bubble of diameter 15 mm, if the surface tension of soap solution is $3.0 \times 10^{-3} Nm^{-1}$. (03 marks)

(ii) Calculate the excess pressure inside the soap bubble in d (i) above. (02 marks)

4. (a) State Kepler's laws of planetary motion. (03 marks)

(b) (i) Sketch a graph showing the variation of acceleration due to gravity with distance from the center of the earth below and above the earth's surface. (02 marks)

(ii) Derive an expression for the acceleration due to gravity g, inside the earth at a distance r, from the earth's surface given that the earth has a uniform density ρ. (03 marks)

(c) Given that the ratio of the radius of the moon to the radius of the earth is 0.93 and the ratio of the mass of the moon to the mass of the earth is 0.14, calculate the value of acceleration due to gravity on the moon's surface. (04 marks)

(d) State any two uses of artificial satellites. (02 marks)

(e) A satellite of mass 100kg is in a circular orbit at a height of 3.59×10^7m above the earth's surface.

(i) Find the mechanical energy of the satellite. (04 marks)

(ii) State what would happen if the mechanical energy was decreased. (02 marks)

SECTION B

2 (a) (i) Define the term thermometric property. (1 mark)

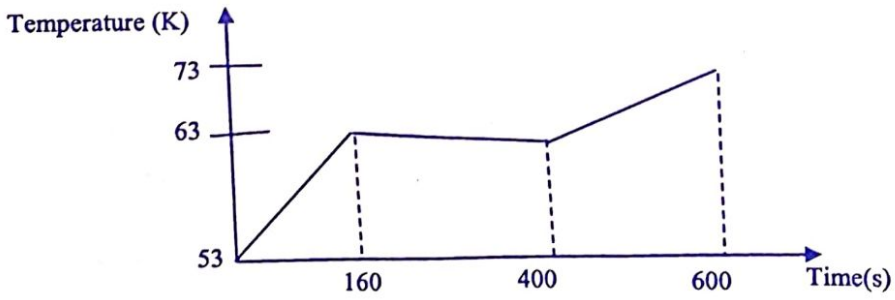
(ii) Using a well labelled diagram describe how unknown temperature on a kelvin scale can be determined using a platinum resistance thermometer. (5 marks)

(iii) A certain platinum resistance thermometer has a resistance of 2.4Ω at ice point, 3.34Ω at steam point. Find the value of the resistance of platinum coil of thermometer at -5°C. (3 marks)

(b) (i) Define specific latent heat of fusion (1 mark)

(ii) Explain why ice at 0°C provides a better cooling effect than water at the same temperature. (2 marks)

(c) Solid nitrogen at 53K absorbs heat at a constant rate until it starts melting at 63K as shown in the figure below



If the specific heat capacity of the solid nitrogen is 1.6x103 $Jkg^{-1}K^{-1}$, use the graph to calculate the,

(i) Specific latent heat of fusion of nitrogen. (4 marks)

(ii) Specific heat capacity of liquid nitrogen. (3 marks)

(d) State the main reason why water is used as a coolant in car engines. (1 mark)

6. (a) (i) Define molar heat capacity of a gas at constant pressure C_p and state its units. (02 marks)

(ii) Derive an expression for the difference between molar heat capacity at constant pressure C_p and molar heat capacity at constant volume C_v for a gas of n moles. (04 marks)

(b) A vessel of volume $1.0\times10^{-2}m^3$ contains an ideal gas at a temperature of 300 K and pressure 1.5×10^5Pa.

(i) Calculate the mass of the gas if it's density at temperature 285 K and pressure 1.0×10^5 Pa is$1.2kgm^{-3}$ (03 marks)

(ii) 750 J of heat is suddenly released into the gas and its pressure rises to 1.8×10^5 Pa. Assuming no heat is taken up by the vessel, calculate the temperature rise and the specific heat capacity of the gas at constant volume. (03 marks)

(c) Explain why the pressure of a gas increases when the gas is heated at constant volume. (03 marks)

(d) (i) Distinguish between an isothermal and an adiabatic change. (02 marks)

(ii) A gas expands adiabatically to twice it volume and then compressed isothermally to its initial volume. Indicate the two processes on a P-V curve and show the area representing the work done by the gas. (03 marks)

7. (a)(i) State the factors that determine the rate of heat flow through solids. (02 marks)

(ii) Explain the mechanism of heat conduction through solids. (03 marks)

(b) With use of a well labelled diagram, describe an experiment to determine the coefficient of thermal conductivity of glass. (06 marks)

(c) 2.5 kg of water in an aluminum container of mass 1.0kg, uniform thickness 3.0mm and base area $0.1m^2$ is heated by an electric fire and its temperature rise from 20°C to 100°C in 7 minutes 16 seconds. Assuming no heat is lost to the surrounding find (s.h.c of water = $4200Jkg^{-1}K^{-1}$, s.h.c of aluminum = 400 $Jkg^{-1}K^{-1}$ $L_v = 2260000\ Jkg^{-1}$)

(i) The power of the electric fire. (02 marks)

(ii) the rate at which water boils away. (02 marks)

(iii) the temperature of the underside of the aluminum container. (03 marks)

(d) Explain why a metal surface feels cooler to the touch than a wooden one. (02 marks)

SECTION C

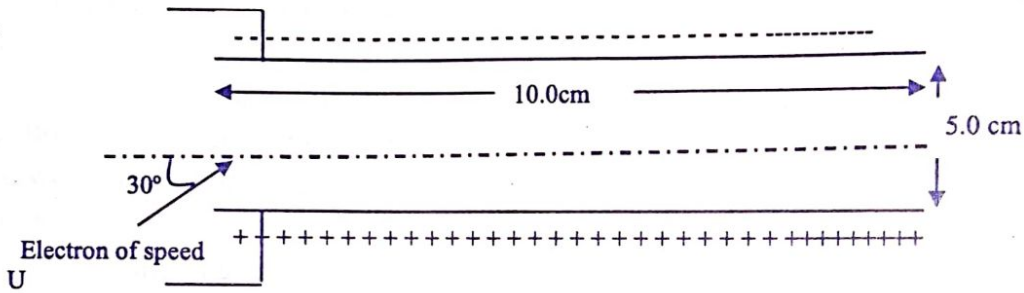
8. (a) (i) what is meant by photoelectric emission? (01 mark)

(ii) State the characteristics of photoelectric emission. (04 marks)

(b) With use of a well labeled diagram, describe a simple experiment to demonstrate photoelectric emission. (04 marks)

(c) Sodium has a work function of 2.3eV and it is illuminated by light of wavelength 5.0×10^{-7}m. Find the;
(i) Threshold frequency of sodium. (02 marks)
(ii) Maximum velocity of the photoelectrons emitted. (02 marks)
(iii) Stopping potential with light of this wavelength (02 marks)
(d) (i) Explain any one application of photoelectric emission. (03 marks)
(ii) Draw a sketch graph of photo-current against potential difference across a photocell for two different intensities but the same frequency of incident radiation. (02 marks)

9. (a)(i) Explain what is observed when a beam of α-particles is incident on a gold foil, (06 marks)
(ii) A beam of α-particles of energy 4.2MeV is incident normal to a gold foil. What is the closest distance of approach by the α-particles to the nucleus of a gold atom? [Atomic number of gold = 79] (03 marks)
(b) (i) State Bohr's postulates of the hydrogen atom (03 mark)
(ii) Explain the occurrence of **emission** and **absorption** line spectra. (03 marks)
(c) An electron moving with a speed Ums^{-1} enters midway between two horizontal parallel plates at an angle of 30° to the horizontal as shown in the diagram below.



The plates are 10.0cm long and 5.0cm apart. If the voltage across the plates is 250V, and the electron takes 3.85×10^{-8} seconds to traverse the region between the plates, find,
(i) the speed U. (02 marks)
(ii) the velocity of the electron as it emerges from the region between the plates (03 marks)

10. (a) Define
(i) Half-life (1 mark)
(ii) Decay constant (1 mark)
(b)(i) Describe how a Geiger-Muller tube is used to detect ionizing radiations. (5 marks)
(ii) When alpha particles of energy 5.0Mev enter an ionization chamber, ionizing current of 150mA is produced. Calculate the energy of an alpha particle. (3 marks)
(c) An atom $^{238}_{92}U$ has half-life 1.4×10^{17}seconds and emits alpha particles of each of energy $2Mev$. Calculate the frequency of energy released by alpha particles emitted by $2.0\times10^{-4}kg$ of U-238 atom. (4 marks)
(d)(i) Use the decay law to obtain the relationship between half-life, $T_{\frac{1}{2}}$ and decay constant, λ for radioactive sample of original mass 0.5g undergoing disintegration. (3 marks)
(ii) A living tree has radioactive atoms of half-life 200years and count rate of 19counts per gram per minute. Wood cut from such a tree was used to build a ship and when 4g of rotting wood is taken from a ship it is found to have activity of 56counts per minute. Calculate the age of the ship. (03 marks)

 End