535/1

PHYSICS

Paper 1

July/ August, 2024

2hrs and 30 minutes

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ALLIANCE JOINT EXAMINATIONS BOARD (AJEB)

Uganda Certificate of Certificate

PHYSICS

Paper One

JOINT MOCK

2hrs and 30 minutes

INSTRUCTIONS TO CANDIDATES:

➢ This paper consists of two sections; A and B. It has seven examination items.

➢ Section A has three compulsory items.

➢ Section B has two parts; I and II. Answer one item from each part.

➢ Answer five items in all.

➢ Any additional item(s) answered will not be scored.

➢ All answers must be written in the booklets provided.

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SECTION A

(*All Items In This Section Are Compulsory*)

Item One.

At a science fair held at night on a beach, a group of students demonstrated various scientific phenomena. One student used a speaker to produce sound waves with a frequency of **512Hz**, which traveled through the air. Another student shone a bright LED light, emitting light waves with a frequency of **5.8×10^{14}Hz**, to illuminate a floating platform where experiments were displayed. The audience sat on the sand, wearing white clothes, and noticed that their clothes appeared to change color as the LED light passed through a rotating glass prism, creating a spectrum of colors. Two observers, Girl X and Girl Y, stood at different distances from the speaker. Girl X heard the sound after 2 seconds, while Girl Y heard it after **3** seconds. The beach was 20m away from a tall lighthouse, and the light from the lighthouse was used to project patterns onto the water to guide boats.

Hint: Speed of sound in air = **340m/s**, Speed of light in air = **3.0×10^{8}m/s**

Tasks:

(a) Why do you think Girl **X** and Girl **Y** heard the sound at different times. (*attach an explanation*)

(b) Describe why the color of the audience's clothes appeared to change when the **LED** light passed through the rotating prism.

(c) Discuss why the **LED** light was preferred over a traditional incandescent bulb for illuminating the experiments at night.

Item Two.

During a family gathering, your younger cousin excitedly shows you a video of the International Space Station (ISS) passing overhead at night. They ask why the ISS is visible even though it's dark on Earth, and why some planets appear brighter than others in the sky. This sparks a lively discussion about space phenomena, with some family members sharing misconceptions, such as believing that all planets are equally distant from the Sun or that the Moon produces its own light. Your aunt mentions that the solar system only includes planets and the Sun.

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Task:

"Your cousin is confused about why the ISS is visible at night and why planets like Venus appear exceptionally bright."

a) Explain these phenomena in simple terms, *using concepts like reflected sunlight, orbital paths, and the Earth's rotation. Include a labeled diagram to illustrate how sunlight reaches the ISS and planets*.

b) Spot out and provide evidence of at least four other components of the solar system.

Item Three.

After a nuclear accident at a power plant in a coastal town, residents were evacuated due to high radiation levels. Scientists monitored the decay of radioactive isotopes over time, recording the following data:

Time (days)	**0**	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**
Count Rate (min^{-1})	**200**	**158**	**125**	**99**	**78**	**62**	**49**	**39**	**31**

The government declared the area unsafe until radiation levels dropped below a critical threshold (half-life < 50 days). Scientists estimated that full decontamination would take 2 years (730 days).

Tasks:

a) Help the people know the value of the half-life and advise them accordingly.

b) Sensitize the people about the risk associated with radioactive materials and how they should be handled.

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SECTION B

Part I

(*Answer one Item from this part*)

Item Four.

A small-scale farmer in a rural area wants to install an elevated water tank to provide consistent water pressure for irrigation and household use. The tank must supply water at **15 kPa**, and the farmer plans to build a ladder for maintenance, with each step **30 cm** high. Due to frequent temperature fluctuations, the pipes are prone to cracking, so the farmer needs advice on material selection and proper installation.

Given:

- Density of water (ρ) = **1000 kg/m³**
- Acceleration due to gravity (g) = **10 m/s² Tasks:**

a) T**o** which level should the water tank be raised in order to achieve **15 kPa** pressure that is needed.

b) What would be the length of the ladder that could be used to draw the water from the tank.

c) Recommend two suitable pipe materials that can withstand thermal expansion/contraction. Justify your choices.

d) **(b)** Suggest **one safety precaution** to prevent pipe bursts during extreme weather and why do you choose such a way forward.

Item Five.

In a rural village, the community fetches water from a deep well using a manual hand cranked winch system. The villagers, especially the elderly, find it difficult to operate the winch daily. They have requested assistance in designing a more efficient system to draw water. Additionally, the village uses a charcoal stove to heat 15 liters of water daily from 25°C to 95°C for cooking and drinking. The stove's efficiency is low, and the villagers want to explore alternative heating methods.

Hint:

- Specific heat capacity of water = 4200 $Jkg^{-1}K^{-1}$
- Density of water = 1000 kgm^{-3}
- Energy content of charcoal = 30 MJ/kg
- Efficiency of charcoal stove = 20%

Tasks:

(a) Propose a simple machine (other than a hand-cranked winch) that can be used to draw water from the well with less effort.

(b) Explain how the machine works and how efficient it is to help in drawing water.

(c) Guide us on how to acquire the amount of heat energy required to boil the 15 liters of water.

(b) Suggest an alternative heating method and explain how it improves efficiency compared to the charcoal stove.

Part II

(*Answer one Item from this part*)

Item Six.

A high school student has salvaged a small electric motor from a broken computer cooling fan. Through research, the student learned that this motor can be repurposed as a **wind turbine generator** to charge a small battery for powering LED lights in a garden shed. The student seeks guidance on how to modify the motor and optimize its performance.

Task:

(a) Guide us through the ***setting up and working principle*** of the electric motor and explain how it can function as a generator when mechanically rotated.

(b) Identify **two factors** that limit the efficiency of the makeshift wind turbine and suggest modifications to address them.

(b) Propose a simple ***mechanical or electrical addition*** to enhance power output and justify your choice.

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Item Seven.

During a thunderstorm, a tree branch fell onto overhead power lines near a residential area, causing a power surge that damaged several appliances in a home. The household's circuit breaker tripped, preventing further damage, but the residents are concerned about future incidents. The main supply voltage is 230 V, and the circuit breaker has a resistance of 460 Ω.

Hint:

- Voltage (V) = 230 V
- Resistance (R) of circuit breaker = 460 Ω

Task.

(a) Sight out one measures (in details, talk about its action) the home-owner can take to protect the house from power surges caused by lightning.

(b) Step by step, obtain the **current rating** of the circuit breaker and determine the minimum current that would cause it to trip.

(c) Discuss about **three safety precautions** the family should follow during thunderstorms to avoid electrical hazards.

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END