535/1
PHYSICS
Paper 1
(Theory)
May 28, 2026
$2^{1}/_{2}$ Hours

Total Weighted Score	
Initials	

CALVINE SCIENCE FOUNDATION
PRE-MOCK ASSESSMENT 2026
Uganda Certificate of Education
S.4 PHYSICS
Set I
Paper 1
(Theory)
2 Hours: 30 minutes

INSTRUCTIONS TO CANDIDATES:

This examination 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****. Respond to only* ***one*** *item from each part.*

Respond to ***five*** *items in all.*

Any ***additional item(s)*** *responded to will not be marked.*

All responses ***must*** *be written in the answer booklet(s) provided.*

Responses to each item should start on a fresh page.

Indicate the item number you are responding to clearly at the top of the page.

Graph paper is provided.

Mathematical tables and silent non-programmable calculators may be used.

SECTION A

*Respond to **all** items in this section.*

Item 1

During the annual sports day at Greenfield High School, the organizers setup a high-powered public address (PA) system near the main classroom block to broadcast announcements across the sports field. Two students stood in line with the loudspeaker but at different distances. Student A at 990 m and student B at 1320 m.

In the afternoon, some announcements sounded unclear, with words overlapping and mixed up. This was caused by sound reflections from the nearby classroom block, warm air creating temperature gradients, and variations in the speed of sound along the path. Later in the evening, when the air cooled and wind speed decreased, the announcements became much clearer and easier to understand.

After the sports events, the organizers arranged a night entertainment show using colored flash lights (red, blue and green). One student wore a yellow T-shirt while another wore cyan dress. They observed that their clothes appeared to change color under different lights. This effect occurred because different materials reflect and absorb colored light differently, affecting how the human eye perceives the colors.

Hint

- *Speed of sound in air = 330 ms^{-1}*
- *Student A heard the sound after 3 s and student B after 4 s.*

Task

(a). Explain why the two students heard the sound at different times and hence compute the distances from the loud speakers.

(b). Why do you think the announcements were unclear in the afternoon but clearer in the evening? Justify your answer with reasons.

(c). Explain why clothes appeared to change color under the colored flash lights.

Item 2

During a scheduled presidential visit to a busy district, the security team at the airport was tasked with ensuring the safety of the president and the public. To do this, they relied on state-of-the art X-ray scanners to inspect passengers' luggage

for dangerous items, including firearms, explosives, and other prohibited materials.

On a routine check, the scanner flagged one of the bags as suspicious. The security personnel examined the X-ray images, but the images appeared unclear and blurry. This made it difficult to identify the contents of the bag and assess whether it contained any hazardous items. Concerned about the safety implications, the team decided to investigate further.

They found that the unclear images were caused by stray, unknown radiation interfering with the X-ray scanner. A detailed analysis was conducted, and it was discovered that the source of the radiation was Uranium, a radioactive element, with a half-life of 24 days. Laboratory measurements confirmed that after 120 days, the mass of Uranium remaining was 3 g.

The security team realized that the presence of Uranium not only affected the clarity of the X-ray images but also posed potential health risks due to radiation exposure. They needed to understand both the Physics behind the imaging issues and the potential dangers associated with handling radioactive materials.

Task

As a student of physics, assist the security personnel to:

(a). Explain the type of X-rays used in airport scanners and the principle of X-ray imaging that allows the detection of items inside the luggage.

(b). Calculate the initial mass of the Uranium sample before decay, using the given half-life and remaining mass.

(c). Discuss the short-term and long-term dangers associated with exposure to radioactive materials, including potential health risks.

Item 3

Sarah, a 16 year old student from Jinja, observes the night sky for a week using her telescope and notebook. She notices that some stars appear brighter than others and vary in color, some bluish white, others reddish. She records their brightness, colors and positions.

Over the next few nights, she observes the Moon changing from a thin crescent to full moon, sketching its shape each evening. She reflects on how the Moon's orbit and position relative to the Sun and Earth cause the different shapes.

Sarah also studies the lifecycle of stars from the school library and learns that stars are not permanent, they are born from clouds of gas and dust and spend most of their lives fusing hydrogen into Helium.

One morning, Sarah call her cousin in Canada and notices that while it is 6:00 a.m. in Jinja, it is 8:00 p.m. in Canada and this left her wondering and in disbelief.

Task

As a student with prior understanding of astronomical events, help Sarah understand:

(a). How the apparent brightness of stars arises and how astronomers distinguish this from their color.

(b). Why the moon appears to change shape gradually?

(c). Describe the main stages involved in the lifecycle of a star.

(d). Explain why there is a time difference between Jinja and Canada.

SECTION B

Part I

Respond to only one item from this part

Item 4

A group of investors based in Kampala is planning to establish a large-scale ceramics and construction materials manufacturing company. Their business plan includes the production of concrete pavers, blocks, and bricks to supply both residential and commercial construction projects. To achieve high-quality and uniform products efficiently, the investors decide to use a modern hydraulic press as a core component of their production line.

Upon contacting the equipment supplier, they receive a detailed manual containing schematic diagrams, operational guidelines and safety instructions. The manual highlights the importance of maintaining the hydraulic fluid temperature below $20^{o}C$ as exceeding this limit could reduce the efficiency of the press. Under optimal conditions, the hydraulic press is capable of achieving an output work of 2000 J while maintaining an operational efficiency of 80%.

During practical trials, it is observed that operation of the press generates approximately 340,000 J of heat in the hydraulic fluid. The investors, who lack formal physics or engineering knowledge, are uncertain about the implications of this heat generations, the amount of fluid required, and whether the press will function safely and effectively. They seek guidance on how to manage the system to avoid overheating and ensure reliable production.

Additional technical information

- *Specific heat capacity of the hydraulic fluid: $1750 Jkg^{-1}K^{-1}$*

- *Density of the hydraulic fluid: 800kgm^{-3}*
- *Minimum energy input required for the press to start: 1600J*
- *Conversion factor: 1litre = 0.001m^{3}*

Task

As a student of physics tasked with advising the investors, you are required to:

(a). Explain the working principle of a hydraulic press.

(b). Discuss why hydraulic oil is preferred over air in the press system.

(c). Determine whether the hydraulic press will remain effective if the system contains 10 litres of hydraulic fluid.

(d). Advise the investors on whether the press is safe to start operating and justify your answer with reasoning.

(e). Describe the main components of concrete and explain why concrete is considered a durable and effective material for modern construction projects.

Item 5

A teacher living in Kampala is expecting five guests for an overnight stay at his home. To ensure that his guests are comfortable and safe while bathing, he decides to prepare warm water in advance. He uses his 5-litre electric kettle, which is equipped with an automatic heating element that switches off as soon as the water reaches its boiling point of 100^{o}C.

Once the water in the kettle reaches 100^{o}C, he carefully pours it into a large insulated container that already contains 20 litres of cold water initially at 10^{o}C. He stirs the water thoroughly to ensure that the temperature is uniform throughout the container. His goal is to prepare water that is safe and comfortable for bathing, taking into account both the risk of scalding and the need to efficiently use energy and resources.

Support material

- *Density of water ρ = 1000kgm^{-3}*
- *Specific heat capacity of water c =4200Jkg^{-1}K^{-1}*

Task

(a). Advise the teacher whether the water is safe for bathing considering that water temperature above 30^{o}C may be uncomfortable or could cause scalding.

(b). If all the five guests are to use an equal volume of water, determine the number of litres each guest can use.

(c). Since all guests will bathe one after another in the same bathroom, suggest a practical method to keep the water warm for an extended period.

(d). Propose an alternative approach the teacher could adopt to ensure the water reaches a safe and comfortable bathing temperature without relying solely on pouring boiling water into cold water.

Part II

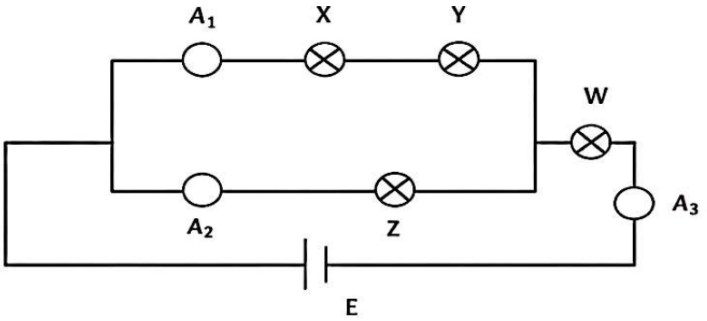
Respond to only one item from this part

Item 6

A building contractor Mr. Okello, is completing the electrical installation of a two bedroom house located in a semi-urban area. He wants each main room to have a ceiling light bulb of resistance 3Ω so that the lights operate properly and independently. The house is supplied by a battery of Electromotive force E to ensure safety and monitor current flow, ammeters are to be used in the circuit. During testing, Mr. Okello connects all the bulbs in the circuit shown in the support information and adjusts the supply until the total current drawn from the battery is 4.5 A. ammeter A_1 reads 2.5 A.

He installs bulb W in the reading room and connects an analog energy meter which initially reads 9259.4kWh. In the bedroom, he installs bulb Z with a digital energy meter which initially reads 45967.1 kWh. After one month of normal use, the analog meter reads 9389.1 kWh and the digital meter reads 46074.4kWh. The electricity tariff charged by the supplier is 780/= per unit (kWh)

Support information



(All bulbs are identical and have resistance 3Ω. All ammeters are ideal)

Task

As a learner of physics

(a). Advise Mr. Okello which bulbs (W, X, Y and Z) should be installed in the reading room and bedroom and give reasons for your choice.

(b). Determine the value of Electromotive force E of the battery used in the installation.

(c). Using the meter readings, determine which room (reading room with bulb W or bedroom with bulb Z) will pay a higher electricity cost for the month. Calculate the cost for each room and advise Mr. Okello on how to reduce the cost at the end of the month.

Item 7

A group of senior secondary physics from Nyanza High School were conducting an extended field study on household electrical devices to understand their practical applications and safety mechanisms. They visited the residence of a local engineer who had agreed to demonstrate an electrical bell system. The engineer instructed the students to press a switch located beside the main entrance door. Immediately, a loud ringing sound was heard and the door was automatically released through a mechanical linkage. The students were informed that the electric bell operates on a mains voltage of 240 V and has a power rating of 40 W.

Curious and eager to apply theoretical knowledge, the students began to ask several questions: how the bell operates at the microscopic level, what would occur if the bell were installed in a residence supplied with 120 V mains, how the sound intensity could be amplified and what the actual current drawn by the bell is when operating under rated conditions. Additionally, they wanted to assess the safety implications of using the bell in systems with different voltages and explore strategies for improving efficiency without compromising safety.

Task

Using your comprehensive knowledge of electricity and magnetism, help the students:

(a). Explain precise detail how an electric bell functions.

(b). Predict and analyze the consequences of connecting the same bell to a house hold mains supply of 120 V instead of 240 V.

(c). Propose multiple practical methods to increase the loudness of the electric bell's sound without changing the rated voltage.

(d). Calculate the current drawn by the electric bell when connected to its rated voltage.

(e). Critically evaluate the safety risks and operational inefficiencies associated with using the bell in households with voltages differing from the rated value.