

## ST JOSEPH'S S.S.S – NAGGALAMA

PHYSICS O'LEVEL SEMINAR HELD ON 28<sup>TH</sup> JUNE 2025

***PART ONE: 535/1 (Physics Theory)***

### LIGHT AND WAVES

#### ITEM 1.

One hot afternoon, some learners walked along a tarmac road in the Eastward direction to check on a new swimming pool. On the road, they saw an ambulance van at a distance and its siren sound kept on increasing as it approached them. They also saw what looked like a pool of water in front of them on the road but the water disappeared whenever they reached the spot where they had seen it and it reappeared to another spot ahead. Later on, the weather changed and there was a light drizzle though the sun was still bright. In the Eastern direction, they observed a semi – circular distribution of colours in the sky. They finally reached a swimming pool, however the pool- attendant warned them to be careful when they are to use the swimming pool because it may appear shallow when filled with water. The adventure ended in argument because the learners had different views about the observations and experiences, they had that day.

#### HINT:

- To hear the loud sound from the ambulance, the distance is utmost 2km from the observer.
- The time taken to hear loud sound from the approaching ambulance is 4s,
- Speed of sound in air is  $330\text{ms}^{-1}$

**Task:** Use your Knowledge of Physics to assist the learners understand,

- (a) why the sound they heard from the ambulance kept on increasing?
- (b) what they observed on the tarmac road and in the sky?
- (c) why the pool attendant warned them?

## ITEM 2.

A mast to improve the communication quality is constructed at a distance of 480m from the nearby hill and has a red source of light installed at its peak. During the installation, the workers realised that it had a red glass cover with a bulb producing white light. More so, they could not explain how it works and they were loudly communicating to each other. During morning hours, the identical sound took 3 seconds and 2.9 seconds in the afternoon to be received. The image of the mast was captured using a lens camera and then displayed to the rest of the staff at the telecommunication company headquarters using a projector whose object slide 10cm high positioned 20cm from the converging lens to form an image 40cm on the screen.

**Task:** As a Physics learner,

- (a) explain why such lights are always used at the top of every mast.
- (b) explain to the workers how the source of light works
- (c) guide the workers; why there was variation in time of receiving an identical sound.
- (d) describe how the image of the mast was captured
- (e) by scale drawing, determine the focal length of the lens used in the projector.

## ATOMIC MODELS AND NUCLEAR PROCESSES

### ITEM 3.

National Aeronautics and Space Administration (NASA) is designing a space craft to travel beyond the solar system, where sunlight is too weak to power solar panels. Engineers choose a Radioactive Thermoelectric Generator (RTG) that uses Plutonium-238 which has a half-life of 87.7 years. They are planning to have a mission powered by this source and it is expected to last 263.1 years.

**Task:** As a Physics student,

- (a) explain why radioactive materials like Plutonium -238 are suitable power sources for deep space missions.
- (b) describe how an RTG, is able to produce the electrical power.
- (c) Why is it important that the radioactive material has a relatively long half-life?
- (d) determine the percentage of the material that remains active by the end of the mission.

#### ITEM 4.

In a school Physics laboratory, students were tasked by their teachers to study about how X-rays are produced and how Radiographer in hospitals use X-ray machines to check for a fractured bone in a patient and then present their findings using simulations. The students formed discussion groups but everything looked to be hard for them.

**Hint:** Speed of light in a vacuum =  $3.0 \times 10^8 \text{ms}^{-1}$

**Task:** As a learner of Physics, help the students to:

- (a) understand how the radiations are produced
- (b) describe how a bone fracture can be detected using the radiation
- (c) determine the frequency of the radiation if the machine emits those of wavelength  $1.0 \times 10^{-10}$  m.

#### ITEM 5.

The government of Uganda plans to set up a nuclear power plant that is to produce electricity and reduce on the energy cost in the country. The following suggestions were fronted by one of the members of the parliament during plenary discussion about the project;

The workers at the plant were to be sensitized about the safety measures or precautions when dealing with radioactive elements in the plant since these elements undergo radioactive decay releasing dangerous particles.

A brief report about how the plant produces electricity was also to be presented by the team handling the project.

**HINT:**

- The radioactive material will not be used to produce electricity when its mass is less than 50g and has half-life of 2years.

**Task:** As a physics learner who has been selected to be part of the team;

- (a) explain how electricity is produced by the plant.
- (b) suggest the safety measures that should be presented to the parliament.
- (c) assuming one 1 kg of radioactive material is to be used, establish how long it will take for the material to be replaced.

## SPACE AND EARTH PHYSICS

### ITEM 6.

A team of Participants had an online meeting and in their introductions, they were told to mention their country of residence and the time. One from UK said, it was 12:00 pm (noon), one from Uganda said that it was, 3:00pm and that from New York said, it was 7:00am. This puzzled the Participants. The topics of discussion were climatic change guided by change in seasons and their effects, and the sun as the beginning and end of life on earth; without which life would be impossible.

**Task:** You are one of the presenters in this meeting, use the knowledge of Physics;

- (a) help the participants understand the cause of difference in time.
- (b) explain to the participants the change in seasons and their effects.
- (c) help the participants to understand the phrase “why life would be impossible without the sun.”

### ITEM 7.

In a certain country, one television (TV) reporter was reporting live near the ocean about the rise and fall in water levels and how it has affected the neighboring communities. Viewers in another country were watching live night broad cast of news bulletin during that time. The viewers wondered how it could be day and night at the same time. Another reporter in Australia was reporting about the dry spell that has caused wild fires while the one in Europe reported about ice and snow that has hindered transportation of people and their goods. This puzzled viewers the more.

**Task:** As a physics learner;

- (a) help the viewers understand the possibility of being day in one country and night in another country.
- (b) explain the cause of fall and rise in water levels and how it has affected communities around.
- (c) help the viewers understand the cause the dry spell in Australia, when there is ice and snow in Europe.

### ITEM 8.

A group of explorers who were heading towards Africa from South America were travelling by ship. They got lost along the way and one of them thought about an app installed in a Smart Phone that would guide in their travel.

He immediately activated it and it accurately guided them to their destination. However, the other explorers were left wondering how possible this could be.

While on their journey, they saw a bright star in the sky in the morning and they wondered how it was formed and why it appears brighter as compared to others. Besides, there was continuous fluctuation of light from the star reaching them from brighter to brightest.

This left them appreciating nature without explanation of the cause.

**Task:** As a Physics learner;

- (a) help the explorers understand the operation of the app that guided them in the journey.
- (b) explain how the star was formed.
- (c) explain the fluctuations of light from the star
- (d) help the explorers understand why the star appears brighter as compared to others.

## MECHANICS AND HEAT

### ITEM 9.

In a certain referral hospital, a nurse on internship had to inject medicine into a patient's vein, but she lacked knowledge on how to use a syringe. The medicine was in powdered form and had to be mixed with  $100\text{cm}^3$  of water at a temperature of  $75^\circ\text{C}$ . To attain this temperature, water had to be heated using an electrical heater rated  $1500\text{W}$ . The doctor instructed the nurse that the patient must receive the medicine with in 20s

**Hint:**

- Specific Heat Capacity of water =  $4200 \text{ Jkg}^{-1}\text{K}^{-1}$
- Initial Temperature of water =  $20^\circ\text{C}$
- The Syringe had a plunger of cross sectional area (A) =  $2.5 \text{ cm}^2$
- Medicine could only enter the blood stream if its Pressure was greater than  $50\text{kPa}$ .

- Density of water =  $1\text{gcm}^{-3}$

**Task:** As a learner of Physics;

- (a) help the nurse to find out if the patient will receive the medication on time
- (b) explain to the nurse how the syringe works
- (c) establish if an effort of 15N applied by the nurse on the plunger of the syringe would allow the medicine enter the blood stream.

**ITEM 10.**

A woman Member of Parliament (MP) visited her home area in Northern Uganda to talk to the residents in the region and also find out some of the challenges they face. She conducted a meeting with the residents and in this meeting, they informed her that their biggest challenge was water scarcity. That the only reliable source of water in the region was a well which was 10m deep and they could use a rope on a 20 litre Jerrycan to get water from that well. They told her that this work is tiresome, makes them over sweat, the rope they were using becomes warm when it is over used by many residents who fetch water from that well and also their hands become rough and hard when they use this rope for so long. The representative of the residents requested her to install for them a machine which can draw water from that well and raise it to a height of about 10m and above which the MP did not understand clearly.

**Hint:**

- 1 litre of water =  $1000\text{cm}^3$
- Density of water =  $1000\text{kgm}^{-3}$
- Acceleration due to gravity,  $g = 10\text{ms}^{-2}$

**Task:** As a learner of Physics;

- (a) explain to the residents why the rope becomes hot when it is used for so long and why their hands become hard and rough
- (b) explain to the residents why they become tired when removing water using a Jerrycan from that well.
- (c) help the MP understand the machine; the residents are requesting for and how it works.

### ITEM 11.

A tourist visited a certain Hotel in Kampala where he decided to reside for the whole period he was to stay in Uganda. While at the Hotel, he complained that the room he was sleeping in was hot during day time and therefore, he could always over sweat. The food was always served late and the tea served was at a temperature of  $85^{\circ}\text{C}$ , yet he only takes tea at a maximum temperature of  $30^{\circ}\text{C}$ . The Hotel attendant was advised to buy a cooking appliance that makes cooking faster at a high boiling point of water greater than  $100^{\circ}\text{C}$  and also use small pieces of ice at  $0^{\circ}\text{C}$  to cool down the tea to the required temperature.

#### HINT:

- Capacity of tea-cup =  $\frac{1}{4}$  Litre
- Density of tea =  $1000\text{kgm}^{-3}$
- Specific heat capacity of tea =  $4200\text{JkgK}^{-1}$
- Specific latent heat of fusion of ice,  $l_f = 334000\text{Jkg}^{-1}$
- Ignore the heat absorbed by the tea cup

**Task:** As a Physics learner, help the hotel attendant to; -

- (a) understand the electrical appliance he should buy and how it makes cooking faster.
- (b) determine the mass of ice needed to reduce the temperature of the tea
- (c) understand the possible cause of hotness in the room during the day and suggest possible solutions too this challenge
- (d) explain to the tourist how sweating regulates the body temperature

### ITEM 12.

During an emergency landing upon touchdown of the aeroplane travelling at  $85\text{ms}^{-1}$ . The pilot engages brakes fully to stop the plane on the available runway of 1500 metres long. During braking, 30% of its initial energy is lost in form of heat. However, it is important to monitor the temperature raise during braking.

#### HINT:

- Mass of aeroplane =  $2 \times 10^5\text{kg}$

- The total resistance force experienced by the plane on the runway is  $6.0 \times 10^5 N$
- S.H.C of brake material =  $450 Jkg^{-1}K^{-1}$
- Total mass of brake components (all wheels included) =  $800kg$

**Task:** Use the knowledge of Physics to:

- (a) describe the energy transformations that occur as the plane slows down.
- (b) determine the initial energy of the airplane at touch down and the distance the plane requires to stop.
- (c) determine the temperature rise of the brake material during emergency stop.
- (d) suggest the possible risks involved if the brakes have not cooled down fully before the next take off.

## ELECTRICITY AND MAGNETISM

### ITEM 13.

In a certain place, a house was connected to 240V mains supply and the owner wished to connect a TV set rated 120V, 75W, a flat iron rated 120V, 6000W, an electric bell of resistance  $5\Omega$  that would instantly produce sound to alert the house owner about the visitors at the gate when the switch was pressed and 4 bulbs each rated 120V, 60W either in series or parallel connection for lighting purposes. The house owner also bought a power king extension with a fuse rated 5A where he plugged in his TV set and flat iron. The TV set is operated for 5 hours per day.

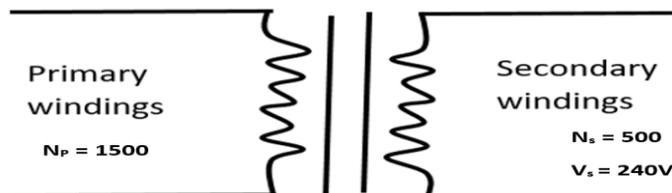
**Task:** As a learner of Physics;

- (a) comment on the effectiveness of the fuse in the extension if it would support the above electrical appliances when plugged in the extension altogether
- (b) assist the house owner to know the best way to connect the bulbs in the house and explain why?
- (c) explain how sound was produced when a switch was pressed
- (d) determine the amount of money required to keep the TV operating the whole day, if the electricity rate is UGX. 680 per KWh.

**ITEM 14.**

In the recent rainy season there was a powerful electric discharge that was observed striking severely, damaging an area transformer causing power shutdown. The strike led to a voltage increase in the transformer's secondary coils well above the standard 240V that is required by households.

The figure below shows the windings of coils in the secondary and primary.



This Unexpected event led to wide spread damage, burning numerus home appliances and resulting in significant financial losses for residents.

Upon investigating the incidence, the team from the local area electricity distribution company discovered a critical electricity anomaly.

The homes that suffered the most damage had poorly connected or inadequate earthing systems. Therefore, the team has organized a sensitization program for the citizens and you as physics student, you are invited to be part of the facilitators.

**Hint:** A good ideal transformer should be operated at an efficiency of between (95%-99%).

**Task:** As a Physics student, sensitize the area citizens by;

- (a)(i) suggesting ways on how they can safe guard themselves from the electric discharge.
- (ii) explain the purpose of earthing in the house hold electrical system
- (b)Several households wish to install automatic electric bulbs that work in case of darkness and day. Explain how such bulbs would work.
- (c) A transformer to be replaced is expected to deliver an output of 20kW with a primary current of 28.7A. Comment whether such a transformer can be recommended as a good one for use.
- (d)Discuss the factors that might affect the efficiency of the transformer and suggest the ways to minimize each of them.

### ITEM 15.

A car battery with an e.m.f. of 12.0V was procured and installed in a car to run the following components;

- i. A car radio with components of total resistance  $4.0 \Omega$
- ii. Two head lights with a total resistance of  $0.20 \Omega$
- iii. Two hind lights of total resistance  $0.35 \Omega$

After the components were run for some time, the battery ran down and it could not start the car engine.

**Task:** As a learner of Physics;

- (a) advise the car owner on the form of connection suitable for the above components
- (b) guide the car owner, on what he can do such that the battery makes the car start again.
- (c) suggest what the car owner can do to prolong the life span of his car battery.

### ITEM 16.

In a certain city, there is a tall building in which there is a magnetic separator that sorts iron and steel metals from the scrap. One day there was a heavy down-pour accompanied by flashes of light in the sky that set the building on fire. The police rescue team immediately came and extinguished the fire though the workers did not know the exact cause of the fire.

One of the prominent engineers in the city advised the owner to install the device that can arrest such occurrences on the building; but the owners did not have an idea of the device. As they were looking for the solutions, the magnetic separator broke down and the workers ran to the owner complaining about how the machine can no longer sort the metals effectively. The owner who had no idea of how the machine works called his mechanical engineer and explained the situation. The Engineer advised him to import it from Dubai and the machine operates on 240V with a fuse rated 5A. When he went to one of the wholesale shops dealing in machines, he found there a similar machine with a labelled Resistance of  $50\Omega$  and bought it.

**Task:** As a physics learner,

- (a) help the workers understand the cause of the fire
- (b) explain how the device to be used arrests the occurrence
- (c) help the owner understand how the machine he bought works and comment on its effectiveness.

## ***THE PRACTICAL CORNER***

### ***PART TWO: 535/2/3 (Physics practical)***

#### **Scenario**

A technician was repairing a faulty radio set and needed a resistor with a resistance of  $2\Omega$ . He picked one resistor from a newly purchased pack that was marked  $2\Omega$ , *but* after installing it, the radio still failed to work properly. The technician suspects that the resistor might have been wrongly labelled during packaging at the factory. This time, he has acquired another resistor from a different source. Before using it, he wants to be sure that it has a correct resistance needed to repair the radio. However, the technician lacks the device for measuring the actual resistance of the resistor and has contacted you for assistance.

#### **Task:**

You are provided with a resistor having a similar property as the one the technician acquired, confirm whether it is suitable for use in the radio.

THANK YOU FOR COMING

IT HAS BEEN A PLEASURE; YOU HONOURING OUR INVITATION

NOTE THAT EVERY YEAR, WE HAVE THIS ALWAYS

BE REMINDED THAT THE A'LEVEL SEMINAR FOR 2025 IS ON 11<sup>TH</sup> OCTOBER

FOR MORE INFORMATION ABOUT OUR ANNUAL SEMINARS

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