

**THE MEGA PHYSICS SEMINAR HELD AT VISION FOR AFRICA HIGH
SCHOOL NAKIFUMA ON 13TH JULY 2024**

Uganda Certificate of Education

PHYSICS

Paper 1

Theory

SECTION A

THEME: LIGHT AND WAVES

Item 1

During the music gala in a hall, one of the adjudicators observed the following;

- the colour of cloth of one of the presenters changed from yellow dress with red dots to red dress with black dots on entering the stage.
- the sound from the nearest loud speaker reached him after 0.05s
- he kept on hearing the voices of two people singing yet he was seeing only one person on the stage.

Hint,

Speed of sound in air = 320 ms^{-1}

Task

Using the knowledge of physic, help the adjudicator to understand,

- (a) Why the colour of the cloth changed.
- (b) Why the sound was reaching him after 0.05s
- (c) The origin of the second voice and how it can be minimized.

Item 2

A certain tycoon is intending to construct a first-class hotel in your community. As he was consulting from the technical personnel, he was given the following guide lines on the some of the facilities he wanted to put in place;

- Swimming pull should be having label of its depths at different points to avoid relying on a deceptive look.
- The multipurpose hall must have a soft wall or use curtains along the wall.

- The entrance with security personnel should have strictly white lights as the inside of the hall may have any other LED lights for decoration.

Task

Using the knowledge of physics, help the business man understand;

- (a) the cause of deceptive look.
- (b) the reason behind multipurpose hall having a soft wall and curtains.
- (c) why the entrance must have white lights and how decoration on individuals is attained from inside the hall.

THEME: MODERN PHYSICS

Item 3

During charity work in the hospital by Red Cross Society of a certain school, a certain liquid containing a radioactive material spilled on one student accidentally, having been placed on an open place by a medical intern. The hospital authorities immediately took the student for a mandatory self-isolation within the hospital premises. The parents accused the hospital of negligence and demanded to see their child in a weeks' time.

Hint

- The liquid had an activity of 250 counts per second when tested immediately, with a half-life of 2 days.
- The back ground count rate in the Laboratory was 50 counts per second.
- The student can be safe to re-join the public if the count rate falls below 10 counts per second.

Task

Use your knowledge of physics to:-

- (a) Determine how long the student will be self-isolated.
- (b) Enlighten the parents on the dangers of having their child at home without medical monitoring.
- (c) Explain to the medical intern how such materials should be handled.

Item 4

In a certain family, a child got accident while playing with his friends and it was suspected to be broken leg. The family was referred by nearby health facility to go for

X-ray radiography. The family had already misconception about how X-rays on how they are produced and the related dangers to their child, therefor they were unwilling to go for it. X-ray machine requires a voltage of about 4kV to operate but the available main voltage supply is 10kV.



Hint: Available resistors are 300Ω and 200Ω

Task

As physics learner,

- (a) Help the family
 - (i) Clear the misconception about X-rays
 - (ii) Understand how X-rays can be used to solve the problem of the family.
- (b) Using the knowledge of digital electronics, help your friends understand how a 10kV voltage would be used to operate the machine.

THEME: EARTH AND SPACE PHYSICS

Item 5

In some southern part of south Africa, people were being ordered to vacate their areas and relocate to other parts of the country in anticipation of the heavy rains in the coming months, that are likely to cause flooding and landslides. The Local authorities have been requested by the Ministry of Disaster Preparedness to sensitize the people about the issues. However, they are finding difficulties in explaining to the people:-

- Why rains will be experienced in their area while other parts of the continent are experiencing dry season.

- How it is possible to predict accurately weather patterns before they occur.
- Why there are two seasons threatening them with high rainfall in a period of just a year.

Task

As a student of physics, help the Local authorities understand:-

- (a) Variations In seasons as realized by the locals at the same time of the year.
- (b) How the weather is always accurately predicted before it happens.
- (c) Why the community is experiencing that challenge twice in the same year.

Item 6

An elder in a certain village was narrating his experience of a visit to London to his family members. Amidst the many narrations, the elder said that in London, day time was longer than night with 16 hours of day and 8 hours of night, this was unique to family. The elder also added that stars were rare organisms that died at day time and resurrected at night. Furthermore, the elder also stated that the shape of the moon kept changing over a month's cycle. Some of those experiences are equally found in their village but others were news to them. Unfortunately, they all did not understand the occurrences.

Task

As a student of physics, help the elder and his family to understand;

- a) what the unique observed in London came about?
- b) the observation of stars at day time and night time.
- c) why the shape of the moon keeps on changing over the period of one month

SECTION B

PART I

THEME: HEAT AND MECHANICS AND PROPERTIES OF MATTER

Item 7

Your class intends to undertake a physics project to make a thermometer to be used in a physics laboratory. At the planning stage, the following questions have come up;

How to select the suitable liquid to be used

How to come up with the graduation on the thermometer.

Task

As a physics learner,

- (a) Help your friends understand;
 - (i) The factors you must consider to come up with a suitable liquid.
 - (ii) How the thermometer is going to be given the graduations.
- (b) If the volume of the liquid required is 5cm^3 , using the knowledge of principles of moments on how you would determine the density of the liquid to be used in the absence of a measuring cylinder or any other apparatus for measuring volume.

Item 8

The business man intends to install a storage gravity water tank in his home which should supply pressure at 10kPa . He also needs his tank to have a ladder with steps each of height 40cm for climbing up to clean his tank. To avoid bursting of the tank due to expansion and contraction of the pipes used due to extreme weather conditions, he has been advised to buy a pipes made of a material of specific heat capacity between $850\text{Jkg}^{-1}\text{K}^{-1}$ and $900\text{Jkg}^{-1}\text{K}^{-1}$.

Hint;

Density of water = 1gcm^{-3}

Acceleration due to gravity = 10ms^{-2} .

Task

Using the knowledge of physics;

- (a) Help the business man understand,
 - (i) the height the tank must be raised to.
 - (ii) the number of steps to be put in the ladder.
- (b) Help the business man understand by outlining the steps that would be taken to determine the suitability of the material of the pipes to be used.

Item 9

Your parents operating a diary business and buy on average five jerricans daily. Before buying any milk from any farmer, its purity is first tested using a hydrometer. One evening the hydrometer accidentally fell down and stopped working yet the milk

must be tested before buying. The milk put in a refrigerator which automatically switches off when the temperature of the milk has dropped from room temperature to a temperature of 10°C .

Materials; beam balance, measuring cylinder and beaker.

Hint;

Volume of each jerrican of milk is 20 litres

Room temperature = 24°C

Specific heat capacity of milk = $3.14\text{Jkg}^{-1}\text{K}^{-1}$

Density of pure milk = 1035kgm^{-3}

Task

Using the knowledge of physics, help the parents;

- (a) Determine the purity of the milk in absence of a hydrometer.
- (b) Understand how much heat energy is withdrawn by the refrigerator from the milk.

Item 10

In a certain home, water is got from underground well for cooking and some boiled for drinking, using a rope and a bucket. This is the responsibility of children. One day children raised a complain to the father that pulling water using a rope and a bucket is tiresome. They suggested that the simple machine for pulling be designed for them. The water for drinking is then boiled from a temperature of 24°C to 90°C using aluminum saucepan of mass 2kg and the volume of water boiled per day is 10 litres.

TASK

Using the knowledge of physics, help the family;

- (a) design the simple machine that can be used and understand how it works.
- (b) understand how to improve on efficiency of the machine in (a) above.
- (c) understand how much heat energy is used daily by the family to boil drinking water.

Use;

Specific heat capacity of aluminum = $900\text{Jkg}^{-1}\text{K}^{-1}$

Specific heat capacity of water = $4200 J kg^{-1} K^{-1}$

Density of water = $1000 kg m^{-3}$

PART II

THEME: ELECTRICITY AND MAGNETISM

Item 11

During a physics study tour to an electricity generation substation, learners were taken through the various processes of electricity generation to consumption. However, the learners observed the following, though they didn't understand due to limited time:-

- Electricity is transmitted at 13 KV in alternating current of 0.05 A.
- The voltage taken into houses for home consumption was 240 V with a little higher direct current in this case.
- The workers in the sub-station were wearing majorly rubber gloves and shoes.

Task

Using the knowledge of physics, help the learners understand:-

- (a) Why the power is transmitted in a different form to the one consumed.
- (b) And determine the exact current taken into the house for consumption.
- (c) How the voltage changed from the transmission voltage to the consumed voltage.
- (d) Why the workers chose the rubber shoes and gloves.

Item 12

A businessman constructed his house near a high-power line of 15 KV with 0.08 A. He intends to connect his house to the power and use some electrical appliances for a start. He consulted an electrician who assured him, that they can connect power line direct to reduce costs.

The businessman was warned by his colleagues that he risks burning down his house if he continues with the electricians' plan.

Hint

- The businessman wants to start up with the following in house.

Item	Number	Power rating	Time of use (hours)
Inside bulbs	4	60 W	8
Security bulbs	2	100 W	14
A television	1	120 W	20
A speaker	1	300 W	20
A fridge	1	600 W	4

Task

Using the knowledge of physics, help the business

- (a) Understand
 - i. Why his house can easily burn down and explain what he can do to get power safely.
 - ii. How he may recommend for the connection of the bulbs in the house and why?
- (b) Determine his weekly expenditure on electricity if the appliances are used daily, taking the unit cost of the electricity unit as Ushs. 550.
- (c) Know the practices he needs to adapt which ensure his safety basing on the location of his house.

Item 13

On a rainy day, a certain house was struck by lightning, instantly destroying its fuse in the meter box. The family members were all safe but were advised always to take precautions while it's raining.

Hint;

Power supplied to the house through the metre box is 240 V and the fuse made of a material of resistance 480Ω .

Task

Using the knowledge of physics;

- (a) Explain to the house owner how he can safe-guard his house from such occurrences in the future.
- (b) Suggest precautions the family members should always take to be safe when such a situation arises.

(c) Determine the rating of the fuse and the current above which may have caused it to burn.

Item 14

6. A home owner was recently told electricity from a power substation is transmitted at 12 KV using thick aluminum cables to be used in a house at 240V. The home owner is however confused by how the electricity changes voltage from one value to another and says the thick cables are a waste of money. Inside the house are two sets of appliances of resistance 20Ω and 30Ω but the house owner is not sure of how they should be connected to ensure they work effectively.

Use your knowledge of physics to;

- a) Help the home owner understand how the electricity changes from 12 KV to 240V.
- b) Why thick aluminum cables are used.
- c) How the appliances should be connected to ensure that they work effectively with a high amount of current.

Item 1

a) The ~~red~~ stage was lit with red light, therefore yellow dress absorbed yellow red light and reflected red. Blue dots absorbed all the red light and reflected none.

b) $t = 0.055, V = 320$

$$\text{Distance} = \text{speed} \times \text{time}$$
$$= 320 \times 0.055$$

He was $\approx 16\text{m}$ away from the nearest sound speaker

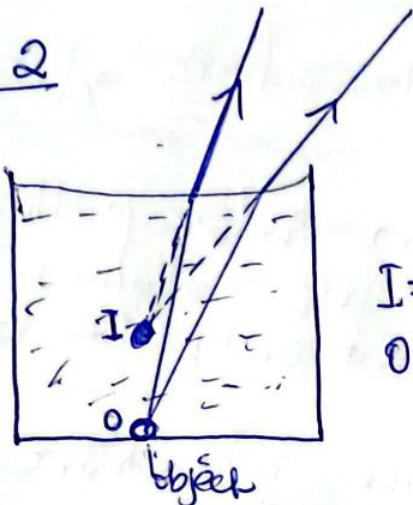
c) Second sound is echo.

minimised by - covering the walls with soft materials
- putting curtains in the hall
- covering the floor with soft carpet
- putting chairs in the hall with soft cushions.

The observer

Item 2

(a)



I = Image

O = object (bottom of the swimming pool)

Point at the

bottom

- As the ray of light moves from the bottom of the swimming pool, it undergoes refraction at the water air boundary.

- The rays are refracted away from the normal and so the point O which is at the bottom of the swimming pool will appear to be seen raised to point I as the refracted rays enter the eye.
- This makes the swimming pool appear shallow hence causing a deceptive look on the depth of the pool.

b)

- Soft wall and surfaces absorb most of the sound incident on it.

- The reflected sound is minimised in the hall, this also minimises on the reverberation hence the sound becomes clear in the hall.

c) - White light is a mixture of blue, green and red.

- The person passing through the gate while putting on any colour of cloth will absorb all the colours in white light and reflects the in the cloth.

- This makes identification of the individual correct.

Item 2

c) ~~What~~

- White light is a combination of all Colours.
- The Cloth of any person entering through the Gate will absorb all colours in white light and reflect only the one in the Cloth.
- This results into true Identification of the Colours of the Clothes ^{of the} people entering by the Security personnel.
- The decoration on individual is attained inside the hall by using bulbs of coloured lights.
- When coloured light falls on the person, the appearance will depend on the light falling and the cloth worn.
- As the lights keep changing, the appearance of the person and the wall also keeps changing - this will act as a good decoration inside the hall.

Item 3

a) Original Count rate = 250 Counts per second.

Background Count rate = 50 Counts per second.

True original Count rate = $(250 - 50)$ Counts per second
= 200 Counts Per second

Counts Per second remaining	Time taken (days)
200	0
100	2
50	4
25	6
12.5	8
6.25	10

NB: The learner plots a graph of counts per second against time and using 10 counts per second, the time is obtained.

b) The material can cause:-

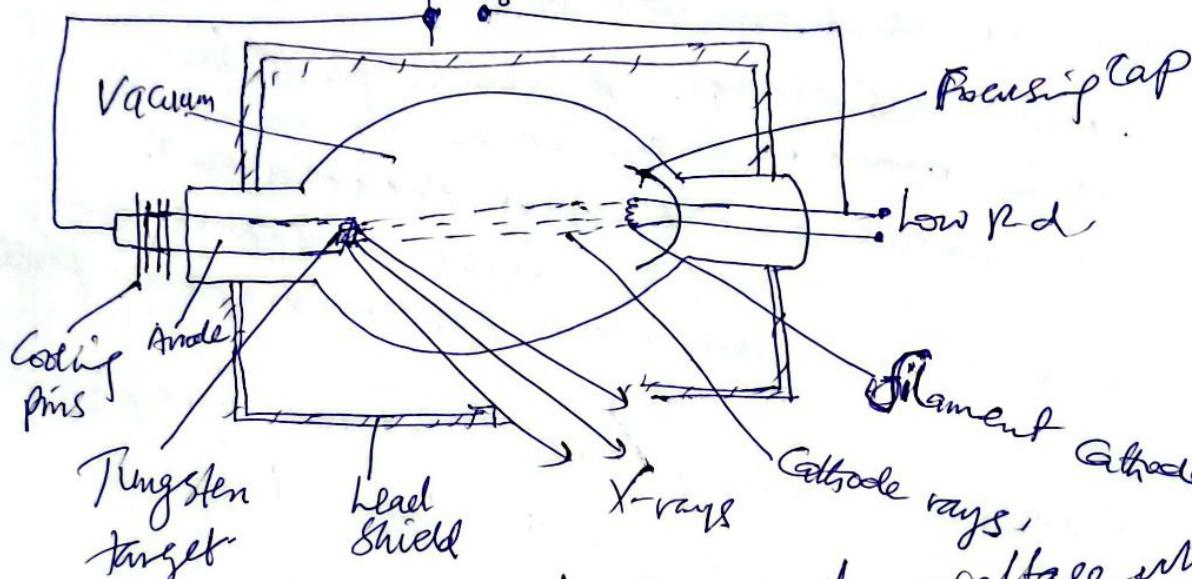
- cancer
- Damage of eye sight
- Mutation of the genes
- burning of deep lying cells.

c) The material should be:-

- handled using long pair of tongs
- stored in thick lead containers
- avoided the exposure unnecessarily
- avoid eating or drinking in their presence
- wounds need to be covered while before using radioactive source.

Item 4

a(i) Production of X-rays



- Cathode filament is heated using low voltage which emits electrons by thermionic emission
- Electrons are accelerated by high voltage \rightarrow at the note towards the target.
- Focusing cap focuses the fast moving electrons to the target.
- When fast moving electrons hit the target, they are brought to rest, and most of their K.E is converted to heat (99%) the rest to X-rays.

Health hazards of X-rays

- Destroys living cells in our bodies
- Causes genetic mutation
- Causes sterility
- Damage eye sight
- Causes Cancer.

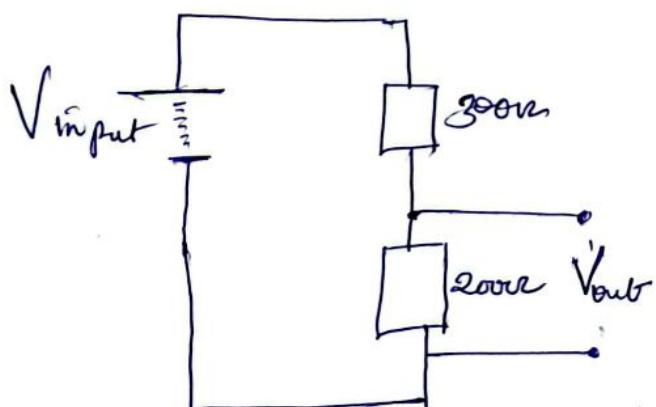
a(ii) - The photo

- The photographic film/plate is placed behind the suspected part of the body
- X-rays are then directed to the suspected part.
- X-ray will pass through ~~the~~ broken part but absorbed by ~~bones~~ unbroken bones.
- When the photographic plate is treated out, unbroken part will appear light and broken parts will appear dark on a photographic plate.

NB

Soft X-rays are used for medical radiography.

(b) By using a potential divider as shown below;



total resistance

$$R = 300 + 200 = 500\Omega$$

current in circuit

$$\sqrt{21\pi}$$

$$I = \frac{V}{R} = \frac{10000}{500} = 20A$$

P.d across 300Ω,

$$V = IR$$

$$= 20 \times 300 = 6000V$$

P.d across 200Ω

$$\sqrt{21\pi} \\ = 20 \times 200 = 4000V$$

He should connect the two resistors in series with 10kV and the output voltage to the machine across 200Ω resistor which like give 4kV.

Item 5

- (a) - Different seasons at the same time of the year is caused by tilting of the earth about its own axis and rotation of the earth around the sun.
- Side tilted towards the sun experiences summer while side tilted away experiences winter season.
 - Rotation either takes the earth near the sun or far from the sun resulting late change of season so seasons can be different in different parts of the earth depending on the tilt and rotation.
- (b) - By use of an artificial weather satellite.
- The satellite is launched into a geostationary orbit, they remain appearing stationary with respect to the earth, record and transmit images of the entire hemisphere continuously using sensors which are analysed and interpreted by the meteorologists.
- (c) - Tilt and rotation of a particular part of the Earth faces the sun twice in a year as the earth revolves about the sun.

ITEM 6

- (a) - In a certain season, as the earth rotates around the sun, the Northern hemisphere is tilted towards the sun at 23.5° , receiving the glare of the sun's rays for a longer time than the night time - hence being at the Northern hemisphere therefore some days can be longer than night as in 16 hours of day and 8 of night
- (b) - The stars are in the sky both at day and night.
- During day, the bigger star, the sun makes the sky bright that we cannot see the much dimmer (smaller or distant) stars.
 - At night, when the sky is dark, the light of the stars can therefore be seen.
 - After reflection of light from the sun
- (c) - The moonlight we see is actually the sun's light reflected off the the lunar surface.
- As the moon orbits the earth, the sun lights up different parts of it, making it seem as if the moon is changing in shape.
 - Our view of the reflecting part at a given time accounts for the changing shape of the moon.

Item 7

q (i) - Should be good conductor of heat

- Opaque

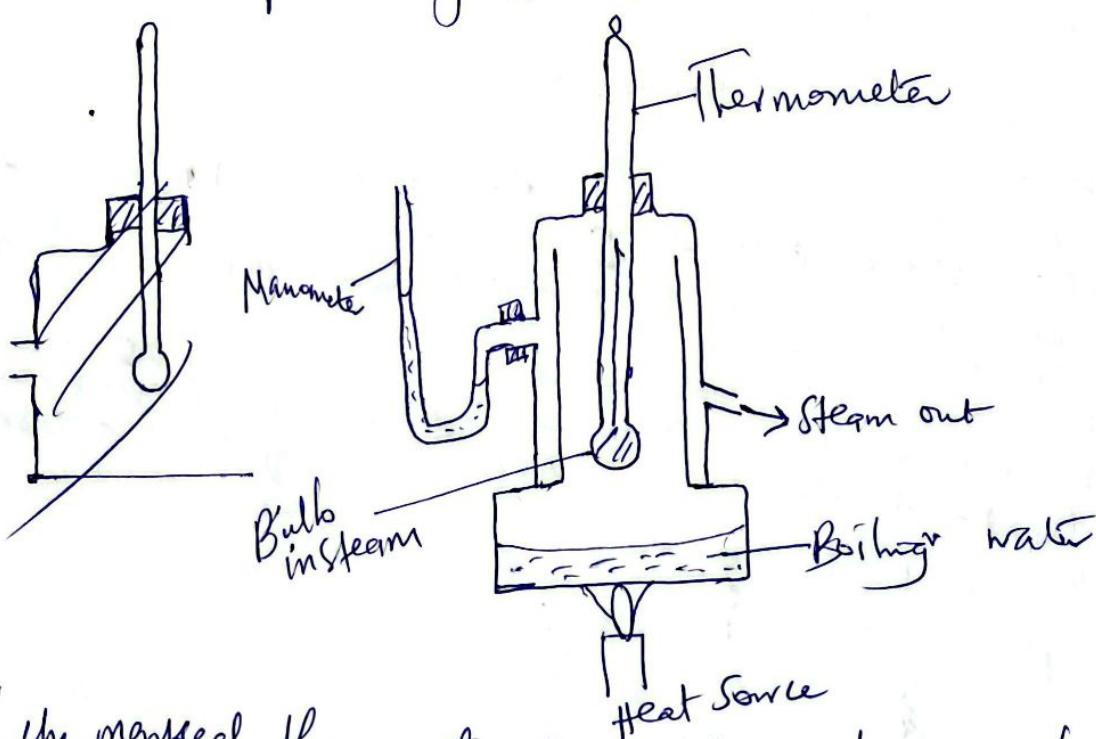
- expand uniformly

- should not wet glass / ~~not~~ not stick to the glass

- should have high boiling point and low freezing point

- Readily available.

(ii) - upper fixed point is first determined as follows



- The thermometer is placed in steam in a pyrometer
- The mercury thread rises until the point is reached when it becomes constant.
- This point is marked on the wall of the thermometer, this becomes upper fixed point.

Lower fixed point

- The thermometer is placed in pure melting ice in a filter funnel.

- The mercury thread drops until it becomes constant, this point is marked on the wall of glass.

- This becomes lower fixed point.

Graduations / Scales

Item 7

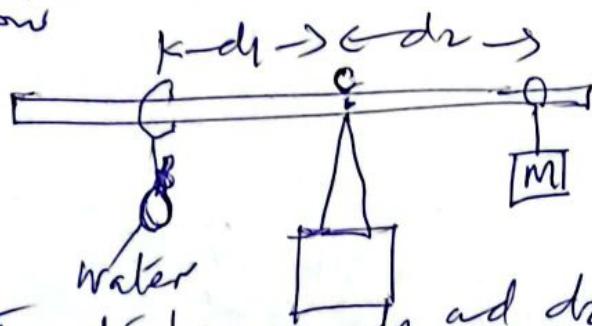
- The difference between the upper fixed point and lower fixed point is measured and recorded.
- This distance is divided into 100 equal divisions, this gives it the scale and each division is called a degree.

(b) Materials

- Metre rule
- 1 Standard mass M
- Liquid tied in a polythene (~~5 cm³~~)
- Knife edge
- wooden block
- Two threads of about 30cm

Procedures

- The metre rule is balanced on the knife edge and its balancing point C noted.
- Known mass is suspended from one side of the metre rule.
- The liquid is suspended from the opposite side of the metre rule and its position adjusted until the metre rule balances again as shown below



- The distances d_1 and d_2 are read and recorded
- Using the principles of moments, the mass of the liquid is got from, $M_o = \frac{M d_2}{d_1}$, M_o = mass of the liquid.

$$\begin{aligned} - \text{The density of the liquid} &= \frac{M_o}{V} = \frac{M_o}{5} \\ &= \left(\frac{M d_2}{5 d_1} \right) \text{ g cm}^{-3}. \end{aligned}$$

Item 8

(i) $P = h \rho g$

$$4000 = h \times 1000 \times 10$$

$$h = 4\text{m}$$

The tank should be raised to a height of 4m above the ground for water to flow to the taps with a pressure of about 40kPa.

(ii) Height = No of steps \times height of each step.

$$4 = n \times 0.4$$

$$n = 10 \text{ steps}$$

The ladder will require 10 steps.

(b)

- A small piece of the material is cut and its mass M_s measured and recorded.
- The piece is then heated to a known temperature θ_2 .
- The piece is quickly transferred to a copper calorimeter of known mass M_c and specific heat capacity c_c containing water of mass M_w at a temperature θ_1 .
- The mixture is well stirred until a maximum temperature θ is reached.
- Assuming no heat losses to the surroundings,

Heat lost by ~~steel piece cut~~ = Heat gained by water + Heat gained by the calorimeter

$$M_s C_s (\theta_2 - \theta) = M_w C_w (\theta - \theta_1) + M_c C_c (\theta - \theta_1)$$

$$C_s = \frac{M_w C_w (\theta - \theta_1) + M_c C_c (\theta - \theta_1)}{M_s (\theta_2 - \theta)}$$

C_s is specific heat capacity of the piece
If the value of C_s is between $850 \text{ J kg}^{-1}\text{K}^{-1}$ and $900 \text{ J kg}^{-1}\text{K}^{-1}$ then it will be suitable for use as pipes.

Item 9

- a) - A sample of milk is picked from a given supplier
- its mass, m , is measured using a beam balance.
- The volume V of the milk is then measured and recorded by pouring it in a measuring cylinder.
- The density of milk, ρ , is calculated from, density = $\frac{\text{mass} (m)}{\text{Volume} (V)}$
- If the density is approximately 1035 kg m^{-3} then the milk from that supplier is pure.

b) Heat withdrawn = heat lost by milk in dropping temp from 24°C to 10°C

$$= mc\Delta\theta$$

$$V = 5 \times 20 = 100 \text{ L} = 0.1 \text{ m}^3$$

$$\rho = 1035 \text{ kg m}^{-3}$$

$$\begin{aligned} m &= \rho V \\ &= 1035 \times 0.1 \\ &= 103.5 \text{ kg.} \end{aligned}$$

$$\begin{aligned} \text{Heat withdrawn} &= 103.5 \times 3.14 \times (24 - 10) \\ &= 4549.86 \text{ J} \end{aligned}$$

ITEM 10

(A) - Using a Pulley

A pulley is mounted above the well. The rope is threaded through the pulley and attached to a bucket of water in a well, the free end of the rope is pulled; this allows the bucket to be lifted upward from the well.

(b) - Using light materials for making the machine - Lubricating the movable parts.

(c)

$$\begin{aligned}\text{Heat supplied} &= \text{Heat to raise temp of water} + \text{Heat absorbed by Samoan} \\ &= m_w c_w (90 - 24) + m_s c_s (90 - 24) \\ &= 10 \times 42000 \times 66 + 2 \times 900 \times 66 \\ &= 2890800 \text{ J}\end{aligned}$$

The family uses 2890800 J of heat energy to boil drinking water. ✓

ITEM 11

(a) - Power is transmitted as alternating current and consumed as direct current majority.

- Alternating current ~~has less~~ can be transmitted across long distances at a high voltage with minimal energy loss
- Alternating current is easy to generate and step up. So it's the most efficient means of transmission

(b) - Current taken into the house is higher than the one transmitted.

- Voltage taken into the house is lower than the voltage transmitted.
- This is achieved by use of a step-down transformer, which gives the current as

$$\frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$\frac{13 \times 10^3}{240} = \frac{I_s}{0.05}$$

$$I_s = \frac{13 \times 10^3}{240} \times 0.05 \\ = 2.7 A$$

The current taken into the house is 2.7 A

- (c)
- This was achieved by use of a step-down transformer.
 - This has the number of turns in the secondary coil lesser than the number of turns in the primary coil
 - Reducing the voltage output from an initial high input.

- (d)
- Rubber being an insulator provides electrical insulation which protects from shock of electricity
 - Other reasons; durability, flexibility, grip.

Item 12

- (a) i. - Power being transmitted has a very high voltage (15 KV). This
- The current is alternating in the main transmission line
 - This easily destroys appliances and burns the house.
- ii. - He can get power safely by getting power from a transformer (stepdown) and a fuse connected in the main switch.

ii - Bulbs are connected in parallel

- Reasons:
 - Failure of one bulb does not affect another
 - Bulbs receive the same voltage as the source.

(b) Power Consumed = $(4 \times 0.06 \times 8) + (2 \times 0.1 \times 14) + (1 \times 0.12 \times 20) + (1 \times 0.3 \times 20) + (1 \times 0.6 \times 4)$

$$= 15.52 \text{ KWh}$$

$$\begin{aligned}\text{Total Cost} &= \text{Power Consumed} \times \text{Unit cost} \\ &= 15.52 \times 550 \\ &= 11 \text{ Shs. } 8,536.\end{aligned}$$

- (c) - Regular inspection of devices
- Clearing trees under the line of power.
 - All wires should be insulated.
 - Earthing should always be done

Item 13

(a) - By installing a lightning conductor in the building; this consists of a copper strip with spikes enter and a copper plate buried in the ground.

Working

- When a negatively charged cloud passes over a lightning conductor, positive charges are induced on the spikes and negative charges repelled to the ground.

- Due to high charge density at the spikes, the air around the spikes is ionized and negative ions are attracted to the spikes to neutralize some positive charges. The positive ions are repelled to the clouds to neutralize some negative charges in clouds.

- The charges are then easily conducted to the ground and neutralized. This protects the building from lightning.

(b) - Avoid taking shelter under tall trees when it's raining

- Putting on rubber sheet.

- Avoid using umbrellas that have pointed metal tops

- Avoid talking on phone while it's raining

$$\begin{aligned}
 (c) P &= \frac{V^2}{R} & V &= IR \\
 &= \frac{240^2}{480} & 240 &= I \times 480 \\
 P &= 120 \text{ W} & I &= 0.5 \text{ A}
 \end{aligned}$$

The fuse is having a rating of 120W, 240V.

The fuse got burnt down because of more than 0.5 A passed through it.

Item 14

- (a) - Voltage is changed from 13 KV to 240V using a step down transformer
- This transform has more turns in the primary coil than the turns in the secondary coil.
 - When 13 KV of voltage is fed into the primary coil, the alternating current creates a changing magnetic field in the primary coil which induces an emf in the secondary coil.
 - The induced emf depends on the changing flux and the number of turns in the secondary coil.
 - Therefore a smaller voltage is obtained from the secondary coil.
- (b)
- Resistance of a conductor is indirectly proportional to the cross-sectional area.
 - The resistance of a wire decreases as the cross-sectional area increases.
 - Therefore thick wires offer less resistance to the flow of current. That is why thick aluminium wires were used.
 - Also aluminium is a good conductor of electricity.
- (c)
- They can be connected in parallel
 - Reason given in Item 12(a)(ii)