PHYSICS KNOWLEDGEBASE

2020

MAINS ELECTRICITY

TEACHERS OF PHYSICS

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1. Explain why mains electricity is transmitted through alternating current and not direct Current.
   - ✓ *Because electricity is transmitted over long distance from the source. Thus minimizes power loss.*
   - ✓ *It can be stepped up to very high voltage*

2. State the energy transformation that takes place in a hydroelectric power station.
   - ✓ $Kinetic \rightarrow Potential \rightarrow Mechanical \rightarrow Electrical$

3. Electrical energy is distributed as alternating current (a.c) at high voltage. Explain why:
   I. A very high voltage is necessary.
   - ✓ *To minimize power loss*

   II. Thick aluminum transmission lines are recommended to carry the current.
   - ✓ *Aluminum is a good conductor of electricity; it is light and cheaply available.*

   III. The power is transmitted as Alternating voltage (a.c)
   - ✓ *So that it can be stepped up to very high voltage.*

4. State **two** dangers of high voltage transmission.
   - ✓ *There is a risk of fire to nearby structures or vegetation when the cables get too low.*
   - ✓ *There is a risk of electric shock in case the poles collapse or hang too low.*
   - ✓ *Harmful effects of electric field.*

5. What is the purpose of having a national grid in power transmission?
   - ✓ *National grid system ensures that there is power to consumers even when one of the power stations fails.*

6. State two factors which affect heating in electric circuits.
   - ✓ *The resistance, **R** of the conductor.*
   - ✓ *The time, **t** which the current flows.*
   - ✓ *The amount of current, **I**.*

7. A man driving a car in rain discovers that the moment he alights from it, while touching its body he gets an electrical shock. Why was he not getting the shock while inside even if he touches metallic parts?
   - ✓ *The outer part of the vehicle has air particles in motion which causes static charges, responsible for the shock.*

8. Name a device used to change light energy directly into electrical energy.
   - ✓ *Solar cell*
   - ✓ *Photovoltaic cell*

THREE PIN PLUGS

1. Explain why three pin plugs are preferred to two pin plugs in the use with iron box.
   - ✓ *They have an Earth pin which is longer and thicker than the Live and Neutral pins. This provides path for any current leakage to find its way to the Earth. This prevents electric shock.*

2. Explain the letters L, N and E usually marked on the three pin plug.
   - ✓ $\boldsymbol{L}$ *→ Live bus bar. Its connected to live wire and the fuse.*
   - ✓ $\boldsymbol{N}$ *→ Neutral bus bar. Its connected to all neutral wires.*
   - ✓ $\boldsymbol{E}$ *→ Earth terminal. Its earthed through a thick copper bar burried deeply in the earth.*

3. State two reasons why the earth pin is normally longer than the other two pins.
   - ✓ *The length is made larger, because this allows the Earth pin to make the contact first and later when the supply is disconnected and it breaks the contact ensuring high safety.*
   - ✓ *Insertion of a longer earth pin first helps in opening the shutters, which thereafter facilitates the insertion of the other two pins.*

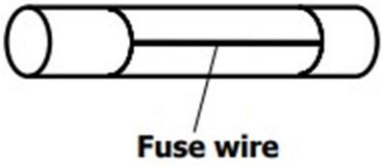
4. Give two advantages of a circuit breaker instead of a fuse in domestic wiring.
   - ✓ It breaks the circuit instantaneously, whereas the wire fuse takes time to melt down.
   - ✓ It is reset for use once the fault has been corrected, as opposed to the wire fuse which has to be replaced.

5. Distinguish between a fuse and a circuit breaker.
   - ✓ ***Fuse*** *→ its a thin wire which melts when current exceeds its limit.*
   - ✓ ***Circuit breaker*** *→ its an electric device which disconnects the circuit when the current exceeds a certain value by electromagnetism.*

6. State the importance of a fuse in a circuit and explain how it works.
   - ✓ *A fuse is a device that helps to safeguard electrical components against excess current in a circuit.*
   - ✓ *In case of excessive current in the circuit, the fuse melts down stopping flow of current.*
   - ✓

7. What property does a fuse wire have that makes it suitable for controlling excessive current in circuit?
   - ✓ *It has a low melting point.*

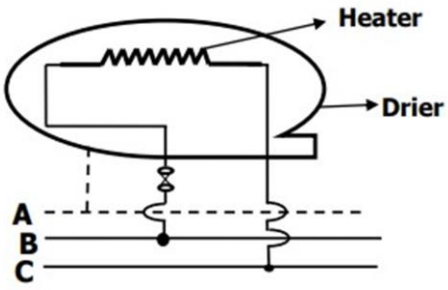
8. Figure below shows a typical example of a fuse.



What modification can be done to the fuse wire to give it a higher rating?

- ✓ *By using a thick fuse wire.*

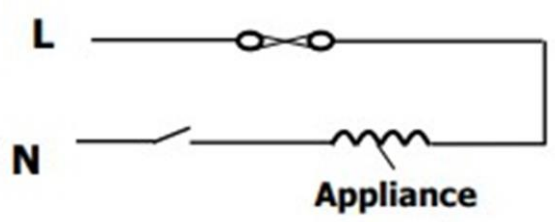
9. Figure below shows part of a ring main circuit connected to the hair drier in a salon.



I. Identify the parts **A**,**B** and **C**

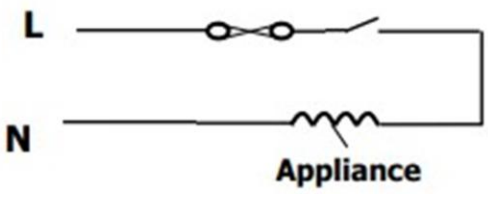
- ✓ $A \rightarrow Earth$
- ✓ $B \rightarrow Live$
- ✓ $C \rightarrow Neutral$

10. Fig shows part of a domestic wiring system with a fault. Identify the fault and draw a diagram with the correction.

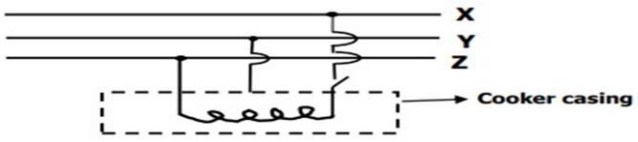


- ✓ ***Fault*** $\rightarrow$ *Switch connected on the neutral wire.*

Correct diagram



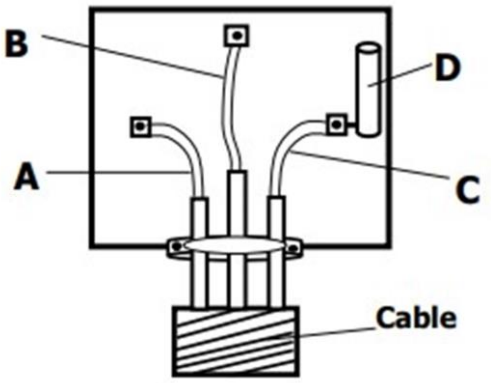
11. The figure shows the electric wiring of an electric cooker X, Y and Z are main wires.



live wire.

Identify **Y** and **X** giving reasons.

12. Study the figure below:-



I. What name is given to the fitting in the diagram?

- ✓ *Three pin plug*

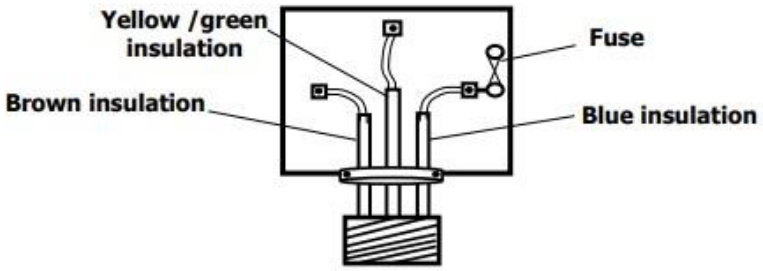
II. Identify the parts labelled **A**, **B**, **C** and **D**

- ✓ $A \rightarrow Neutral\ wire$
- ✓ $B \rightarrow Earthing$
- ✓ $C \rightarrow Live\ wire$
- ✓ $D \rightarrow Fuse$

III. State the colours **A**, **B** and **C**.

- ✓ $A \rightarrow Black/Blue$
- ✓ $B \rightarrow Green\ or\ Green\ with\ yellow\ stripes.$
- ✓ $C \rightarrow Red\ or\ Brown$

13. Figure below shows a flex to the 13A – 3pin.



I. List **TWO** mistakes and suggest corresponding remedies.

- ✓ *Neutral has a brown insulator instead of a blue or a black insulator.*
- ✓ *Live wire has a blue insulator instead of a brown or red insulator.*

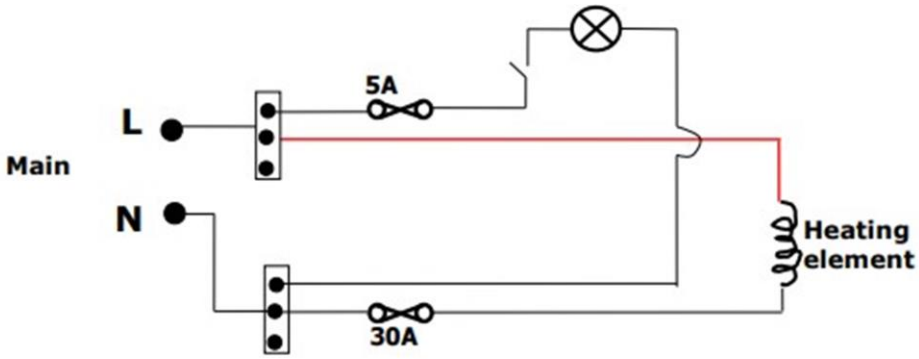
II. Why would it be wrong to fit an electric wire in a bathroom on the wall directly above the bath?

- ✓ *There will be a risk of electric shock since the water is a good conductor of electricity.*

III. What would happen if this plug was connected to the mains of the socket?

- ✓ *The plug will function normally.*

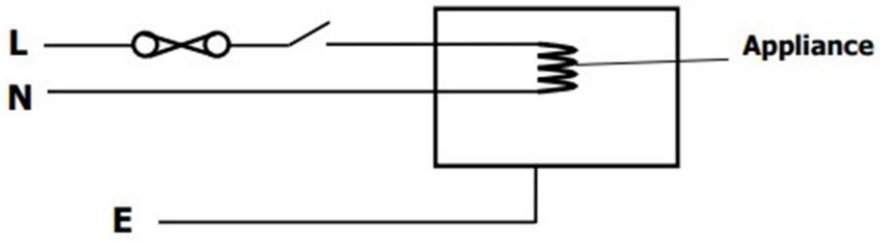
14. The fig 4 below shows a section of a circuit in domestic wiring.



Identify one defect in the wiring.

- ✓ *Connecting the **30A** fuse along the neutral line of the heating element.*

15. Figure shows a modern mains appliance.



I. State the purpose of lead **E**

✓ *To provide a path for a fault current to flow to the earth.*

II. Explain why the fuse is connected to the live wire.

✓ *Because live wire is at full potential.*

Domestic Wiring

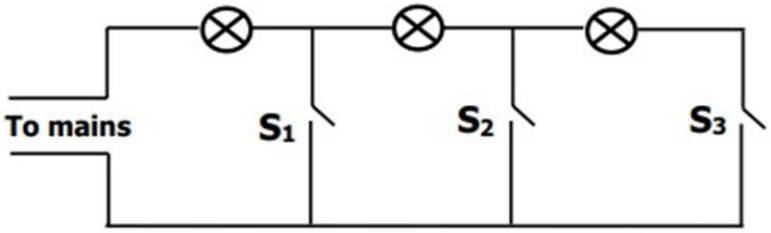
1.

1. In domestic ring there are various circuits which may be used. Name three circuits.
   - ✓ *Lighting circuit*
   - ✓ *Cooker circuit*
   - ✓ *Ring main circuit*

2. What is normally contained in a consumers control unit in a domestic wiring system?
   - ✓ *Main switch*
   - ✓ *Live bus bar*
   - ✓ *Neutral bus bar*
   - ✓ *Earth terminal*

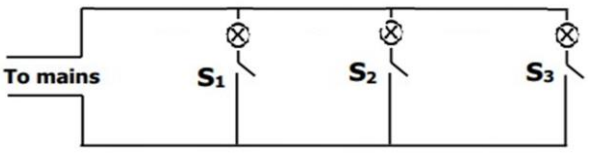
3. Explain why bulbs in a long corridor are not wired in series.
   - ✓ *In case one bulb faults or blows off, it creates an open circuit to the rest of the bulbs. Hence not lighting.*

4. An electrician installed electric wiring in a house and connected the bulbs and the switches as shown in figure below.



I. State what happens when switch:
   - ✓ S_1 only is closed → *Only bulb* B_1 *will light.*
   - ✓ S_2 only is closed → *Bulbs* B_1 *and* B_2 *will light with less brightness because of increased resistance.*
   - ✓ S_3 only is closed → *All bulbs lights with much less brightness as compared to when* S_2 *is closed.*
   - ✓ All the switches are closed → *Only bulb* B_3 *will light because* B_1 *and* B_2 *will be short circuted.*

II. Redraw a diagram showing the best position the bulbs should be installed.



III. Explain why you consider this your arrangement to be the best.

- ✓ *When bulbs connected in parallel, resistance is significantly reduced. Hence lights with much brightness.*
- ✓ *In case one blows out, it does not affect the lighting of the other bulbs.*

Calculations

1. An electric iron rated 240V, 750w is to be connected to a 240v mains supply through a 3A fuse. Determine whether the fuse is suitable or not.

$$P = IV$$
$$I = \frac{P}{V}$$
$$I = \frac{750W}{240V}$$
$$= 3.125A$$

$$\textit{The 3A fuse is not suitable.}$$

2. An 8000w heater is used for a total of 1.5 hours a day. Calculate the cost of using this shower for a month of 30days if the cost of an electrical unit is ksh5.40

$$\textit{Total power consumed in 30 days}$$
$$8000W \times 1.5h \times 30 = \frac{360000W}{1000}$$
$$= 360kW$$

$$1unit = Ksh5.40$$
$$360unit = ?$$
$$\frac{360 \times 5.40}{1}$$
$$= Ksh1,944$$

3. A heater is marked 3kW, 240V. The fuses available are marked 10A, 13A and 20A. Which fuse is most suitable?

$$P = IV$$
$$I = \frac{P}{V}$$
$$I = \frac{(3 \times 1000)W}{240V}$$
$$= 12.5A$$

$\boldsymbol{The\ most\ suitabl\ fuse\ is\ 13A\ fuse.}$

4. An electric heater rated 240V, 3000W is to be connected to a 240V mains supply, through a 10A fuse. Determine whether the fuse is suitable or not.

$$\boldsymbol{P = IV}$$
$$\boldsymbol{I = \frac{P}{V}}$$
$$\boldsymbol{I = \frac{(3000W}{240V}}$$
$$\boldsymbol{= 12.5A}$$
$\boldsymbol{The\ 10A\ fuse\ is\ not\ suitable.}$

5. What current will a 500Ω resistor connected to a source of 240V draw?

$$\boldsymbol{V = IR}$$
$$\boldsymbol{I = \frac{V}{R}}$$
$$\boldsymbol{I = \frac{240}{500}}$$
$$\boldsymbol{= 0.48A}$$

6. A house has a lighting circuit operated from a 240 volts mains supply. Three bulbs rated 100w 240v, ten bulbs rated 40w 240v and eight bulbs rated 60w 240v are switched on at the same time. What is the most suitable fuse for this circuit?

$\boldsymbol{Total\ power\ consumed}$
$$\boldsymbol{(3 \times 100W) + (10 \times 40W) + (8 \times 60W)}$$
$$\boldsymbol{300 + 400 + 480 = 1180W}$$

$$\boldsymbol{I = \frac{P}{V}}$$
$$\boldsymbol{I = \frac{1180W}{240V}}$$
$$\boldsymbol{= 4.917A}$$

7. When a current of 2.0A flows in a resistor for 10 minutes, 15000 Joules of electrical energy is dissipated. Determine the voltage across the resistor.

$$\boldsymbol{E = VIt}$$
$$\boldsymbol{V = \frac{E}{It}}$$
$$\boldsymbol{V = \frac{1500}{2.0 \times 10 \times 60}}$$
$$\boldsymbol{= 12.5V}$$

8. An electric bulb rated 40W is operating on 240v mains. Determine the resistance of its filament.

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P} \rightarrow \frac{240^2}{40}$$

$$= 1440\ \Omega$$

9. A house has five rooms with 240V, 60W bulbs. If the bulbs are switched on from 7.00 p.m to 10.30 p.m.

   I. Calculate the power consumed per day in kilowatt-hours.

$$Power\ consumed\ by\ 5\ 60W\ bulbs \rightarrow 60W \times 5 = 300W \rightarrow 0.3kW$$

$$Power\ consumed\ per\ day \rightarrow 0.3 \times 3.5 = 1.05kWh$$

$$Power\ consumed\ in\ a\ week \rightarrow 1.05 \times 7 = 7.35kWh$$

   II. Find the cost per week for lighting these rooms at Ksh. 6.70 per unit.

$$Cost\ per\ week = No.of\ kWh \times Cost\ per\ kWh$$
$$\rightarrow 7.35kWh \times 6.70$$
$$= Ksh.49.25$$

10. How many 100W electric irons could be safely be connected to a 240V mains circuit fitted with a 13A fuse?

$$P = IV$$
$$P = 13 \times 240$$
$$= 3120W$$

$$1\ elctric \rightarrow 100W$$
$$?\leftarrow 3120W$$

$$\frac{3120W}{100W} = 31.20$$

$$31\ electric\ irons\ can\ be\ safely\ connected.$$

11. Determine the largest number of 75W bulbs which can be safely used to run on a 240V source with a 5A fuse.

$$P = IV$$
$$P = 5 \times 240$$
$$= 1200W$$

$$1\ bulb \rightarrow 75W$$
$$? \leftarrow 1200W$$
$$\frac{1200}{75} = 16$$

$$16\ bulbs\ can\ safely\ run.$$

12. Find the maximum number of 75W bulbs that can be connected to a 13A fuse on a mains supply of 240V.

$$P = IV$$
$$P = 13 \times 240$$
$$= 3120W$$

$$1\ bulb \rightarrow 75W$$
$$? \leftarrow 3120W$$
$$\frac{3120}{75} = 41.6$$

$$41\ bulbs\ safely\ be\ connected.$$

13. Calculate the power of a devise which has a p.d of 250V applied across it when a current of 0.5A passes through it.

$$P = IV$$
$$P = 0.5 \times 250$$
$$= 125W$$

14. An electric heater takes a current of 12.5A from 240V power supply.Calculate:
    I. Its power rating.

$$P = IV$$
$$P = 12.5 \times 240$$
$$= 3000W$$

II. Its resistance

$$R = \frac{V}{I}$$
$$R = \frac{240}{12.5}$$
$$= 19.2\ \Omega$$

15. A 75W lamp and a 1.5kW water heater are connected in turn to a 240V supply.
    I. Calculate the current in each appliance.

$$I_{lamp} = \frac{75}{240}$$
$$= 0.3125A$$
$$I_{Heater} = \frac{1.5 \times 1000}{240}$$
$$= 6.25A$$

    II. Explain the difference you would expect to find between the wiring used to connect the bulb and the water heater to the mains supply.

✓ *No earth connection for bulb water. Water heater has connection.*

16. A power line from a power substation to a town some distance away, has a resistance of 0.10 Ω per kilometer. Determine the rate of energy loss in the transmission of power over 50km at a current of 60 Amperes.

$$Total\ resistance\ for\ 50km \rightarrow 0.10\Omega \times 50 = 5\Omega$$
$$Rate\ of\ energy\ loss \rightarrow P = I^2R$$
$$P = 60^2 \times 5$$
$$= 18000W\ \therefore\ 18000Js^{-1}$$

Power Cost

1. An electric bulb rated 12V, 36W allows current to pass through for 1hour.How much electrical energy is dissipated by the bulb?

$$Energy = power \times time$$
$$= \frac{36}{1000}$$
$$= 0.036kWh$$

2. An immersion heater rated 1.5KW is used continuously for 30min per hour per day. Calculate the cost per week per ksh 6.70 per unit.

$$Power\ consumed\ in\ 1\ week \rightarrow 1.5 \times \frac{1}{2} \times 24 \times 7$$
$$= 126kWh$$
$$Cost \rightarrow 126kWh \times 6.70$$
$$= Ksh\ 844.2$$

3. An immersion heater rated 300W is used continuously for 45 minutes per day. Calculate the cost per week at 60cts per unit.

$$\frac{300}{1000} \times \frac{45}{60} \times 1 \times 7$$
$$= 1.575kWh$$

$$Cost \rightarrow 1.575kWh \times \frac{60}{100}$$
$$= Ksh\ 0.95$$

4. A 50w bulb is used continuously for 36 hours. Determine the cost of energy consumed at a cost of Kshs. 2 per unit.

$$\frac{50}{1000} \times 36 \times 2$$
$$= Ksh\ 3.6$$

5. A 60W bulb is used continuously for 36 hours. Determine the energy consumed, giving your answer in kilowatt hour (kWh)

$$\frac{60}{1000} \times 36$$
$$= 2.16kWh$$

6. Determine the cost of using an electrical iron box rated 1500W, for a total of 30 hours given that the cost of electricity per kWh is Kshs. 8.

$$1.5 \times 30 \times 8$$
$$= Ksh\ 360$$

7. Electrical energy costs Kshs. 1 per kWh unit. Find the cost of using an electric heater of power 7.5kW for a day.

$$7.5 \times 24 \times 1$$
$$Ksh\ 180.0$$

8. An electric iron box is rated 2500W and uses a voltage of 240V. Given that electricity costs Kshs. 1.10 per Kwh, what is the cost of using it for 6 hours? What is the cost of operating all the parts at once for 30 minutes if electricity costs Sh.10.00 per unit?

$$Cost\ for\ 6hrs \rightarrow 2.5kW \times 6h \times Ksh\ 1.10$$
$$= Ksh\ 15$$

$$Cost\ of\ operating\ all\ parts\ for\ 30min$$
$$2.5kW \times \frac{1}{2}h \times 10$$
$$= Ksh\ 12.5$$

9. An electric cooker has an oven rated 2500w, a grill rated 1500w and two plates each of 1000w. This cooker operates directly from 240v supply. What is the cost of operating all the parts at once for 30 minutes if electricity costs Sh.10.00 per unit? (3mks)

$$Total\ power$$
$$(1 \times 2.5) + (1 \times 1.5) + (2 \times 1) = 6kW$$

$$Cost \rightarrow 6kW \times \frac{30}{60} \times 10$$
$$= Ksh\ 30$$

10. Four 40W bulbs and six 100W bulbs were switched on for 5 hours a day for domestic use in a certain institution. Find the monthly bill for the consumer given that the cost of electricity in the country is at Sh. 5.50 per unit (Take 1 month = 30 days and standing charge of Sh. 150)

$$4 \times \frac{40}{1000} \times 5.50 \times 5 \times 30 = 132$$

$$6 \times \frac{100}{1000} \times 5.50 \times 5 \times 30 = 495$$

$$\textit{Total cost} \rightarrow 132 + 495 + 150 = \textit{Ksh}\ 777$$

11. A plug is connected to a hair dryer rated 100W, 240V A.C If the hair dryer runs for 3 hours per day for 7 days, calculate the.

I. The no. of kWh used

$$\frac{100}{1000} \times 3 \times 7$$
$$= 2.1\textit{kWh}$$

II. The cost of electricity paid at a rate of ksh. 5.50 per unit

$$2.1\textit{kWh} \times 5.50$$
$$= \textit{Ksh}\ 11.55$$

12. Calculate the cost of using the following appliances in one month (30 days) of the company rate is Ksh.9.50 per unit.
    - A 2000W water heater for 2 hours per day.
    - A 75W bulb for 10 hours per day.
    - A 1500W electric iron for 1 hour per day.
    - A standing charge of Ksh.200.
    - Fuel cost levy at 70 cents per unit.

$$2 \times 2 \times 30 \times 9.50 = 1140$$
$$\frac{75}{1000} \times 10 \times 30 \times 9.50 = 213.75$$
$$1.5 \times 1 \times 30 \times 9.50 = 427.5$$

$$\textit{Total energy} \rightarrow 120 + 22.5 + 45 = 187.5$$
$$\textit{Fuel cost} \rightarrow 187.5 \times 0.70 = 131.25$$

$$Total\ cost \rightarrow 200 + 131.25 + 427.5 + 213.75 + 1140$$
$$= Ksh\ 2112.50$$

13. A 2kW electric heater is used for 10hrs. Calculate the cost of electricity if it costs 30ksh/ unit.

$$2 \times 10 \times 30 = Ksh\ 600$$

14. An immersion heater is rated 5 KW 250V. It is used for 2 hours daily. If electricity cost sh12.00 per unit, calculate the weekly cost of running the heater.

$$5 \times 2 \times 12 \times 7 = Ksh\ 840$$

15. An electrical heater of power 2.5kW is used every day for 45min. Calculate the cost electrical energy consumed in Kilowatt hours in a month of 30 days if the cost per unit issh16.50.

$$2.5 \times 0.75 \times 30 \times 16.5 = Ksh\ 928.13$$

16. A student has a large number of 240V, 60W coloured bulbs he wishes to use for decorations so that the bulbs operate normally.

    i. How many bulbs can be connected to a 240V supply through a 5A fuse?

$$P = VI$$
$$240 \times 5$$
$$= 1200W$$

$$1\ bulb = 60W$$
$$?\leftarrow 1200W$$
$$\frac{1200 \times 1}{60} = 20\ bulbs$$

    ii. If electric energy cost Kshs. 3.00 per unit, what will be the cost of running the above circuit for 5 hours a night for 20 nights?

$$\boldsymbol{Total\ ectricity\ cost \rightarrow \frac{1200}{1000} \times 5 \times 20 \times 3 = ksh\ 360}$$

17. Suppose you have the following appliances for use in your house.

Appliances	Power rating (W)	Time used hours/day
Cooker	5000	2½
TV set	100	3
Electric kettle	1500	½
Radio.	50	8

Calculate the cost of electrical energy consumed in Kilowatt hours in a month of 30 daysif the cost per unit issh12.60

$$Cooker \rightarrow 5 \times \frac{5}{2} \times 30 \times 12.60 = 472.5$$
$$Tv \rightarrow \frac{100}{1000} \times 3 \times 30 \times 12.60 = 113.4$$
$$Kettle \rightarrow 1.5 \times {}^{1}/_{2} \times 30 \times 12.60 = 283.5$$
$$Radio \rightarrow \frac{50}{1000} \times 8 \times 30 \times 12.60 = 151.2$$

Ksh 1020.60