DOMESTIC ELECTRICITY - PHY

: ELECTRICAL INSTALLATION OF HOUSE

- A house is supplied with electricity from substations by using two cables.
  - (a) Live Cable
  - (b) Neutral Cable
- The live cable is red/brown colour while neutral cable is black/blue in colour
- The live wire is at pd at 240 V while the neutral wire is 0V i.e Neutral cable is Earthed at the substations, the electricity supplied into the house from substations has the frequency of 50 Hz or 60 Hz

PLUG

What is plug?

- Plug is an electrical device which is used to connect electrical appliance to the supply by pushing it in the socket.

TYPES OF PLUG

- There are two types of plug, namely
  - (a) Two-pin plug
  - (b) Three-pin plug

(A) TWO PIN-PLUG

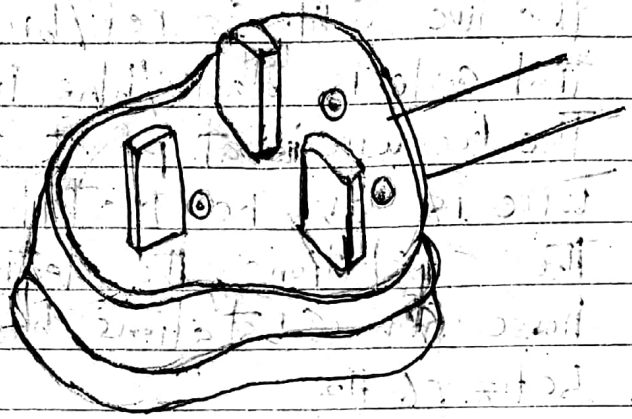
What is two pin plug?

- Two pin pl which does not have a fuse and earth pin.

(B) THREE-PIN PLUG

What is three pin plug?

- Three pin plug is the kind of plug in which their three cables are connected to three pins i.e Live pin, Neutral pin and earth pin



USES OF PLUG

- Plug is used to connect elkctrical applrance to the main supply

ELECTRICAL APPLIANCES

- Are the devices which need electricity in order to function.

EXAMPLE

- The following are the examples of electrical appliances
  - (i) Electrical oven
  - (ii) Frrdge
  - (iii) Iron
  - (iv) Heater
  - (v) Televisions.

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WIRING OF A HOUSE

- Consider the following cases of wiring
  (a) Wiring of the two pins - plug.
  (b) Wiring of the three pins plug.

(A) WIRING OF THE TWO PINS - PLUG.

- Two pins plug consists of live and Neutral wire Two pins plug it has no earth wire and when the leakage of current occur the shock happens

(B) WIRING OF THREE - PINS PLUG

- The three pins - plug consist live, neutral and earthed cable.

ROLE OF EARTH CABLE

- The earth cable is used to conduct leakage of current from the live wire safety into the earth's ground without causing shock
- The length of live wire is shorter than that of Neutral wire while the length of earthed wire is the longest when connected to the pins of the plug.

COLOUR CODE

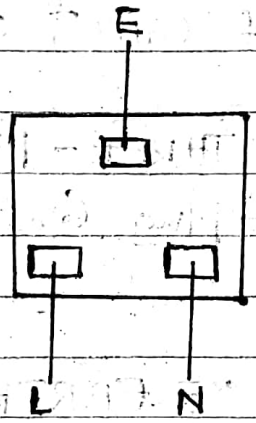
- The table below shows the colour code of the cables

CABLE	COLOUR CODE
LIVE WIRE	RED / BROWN
NEUTRAL WIRE	BLACK / BLUE
EARTH WIRE	GREEN / YELLOW

SOCKET

What is Socket?

- Socket is an electrical device consist of three holes which is used to connect electrical appliance to the main supply.
- The pins of flug are pushed into the socket so as the electrical applience to be connected to the main supply



FUNCTION OF SOCKET

- Socket used to connect electrical appliance to the main supply.

FUSE

What is Fuse?

- Fuse is an electrical device made of special thin wire (copper wire) which melts when electric current flows exceed the safety value
- The Fuse destroys itself in order to protect the electrical applrance from excess current

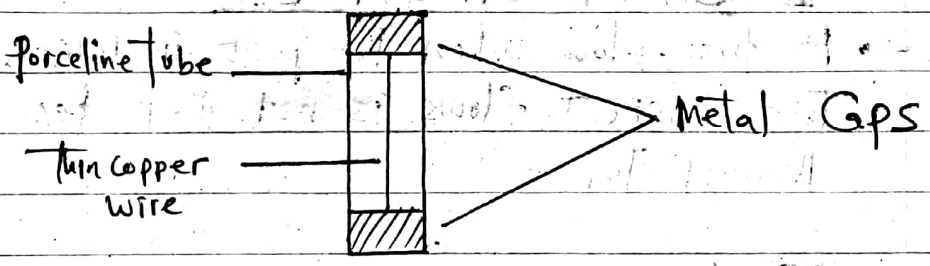
TYPES OF FUSE

- There are two types of fuse, namely:
  (a) Catridge fuse
  (b) Re-wireable fuse.

(A) CATRIDGE FUSE

What is Catridge Fuse?

- Catridge Fuse is the kind of fuse which consist a thin copper wire enclosed in a porcelain tube (Insulating material) involving two metal caps at its ends.



- The Catridge Fuse is connected in series with live wire which then help by the clips at the back of the plug.

(B) RE-WIREABLE FUSE

- This is the kind of fuse consist of copper wire which is connected in fuse link
- The fuse link consists of two pins in which the copper wire (Fuse) is connected in series with live pin.

BLOWING OF FUSE

- A Fuse blow when either of the following occur
  (i) Over loading a Fuse
  (ii) Short-circuited
  (iii) Old age of Copper wire

EXPLANATIONS

I. OVER LOADING A FUSE

- A fuse blow when the current flowing throug h the fuse exceeds maximum safety value

II. SHORT CIRCUITED

- A fuse blow when the path in which the elec tric current flows is not that designed by the Manufacture.

III. OLD AGE OF COPPER WIRE

- A Fuse blows when using old age of Copper wire inside the porcelain tube

REPLACING A FUSE

- When the fuse has been blown it should be repla ced with the fuse of the same rating

Example : When the fuse of 3A blown it should be replaced with the fuse rated 3A

Thus :

(i) If the blown fuse is replaced with the fuse rated high Eg. 5A, the electrical appliance will be destroyed.

(ii) If the blown fuse is replaced with the fuse rated low Eg: 2A, the electrical appliance will not functi on.

- The electrical appliance has a Gable which mar ks a power and voltage in which the electri cal appliance should be connected

ELECTRICAL POTENTIAL

What is Electrical potential?

- Electrical potential is the work done per Unit charge
- Electrical potential is denoted by letter V

Mathematically

Electrical potential, $V = \frac{\text{Work done, w.d}}{\text{charge, Q}}$

$$V = \frac{w.d}{Q}$$

Where

w.d = Electrical energy, H

Hence

$$V = \frac{H}{Q}$$

$$H = VQ \quad \text{---(i)}$$

- From fundamental equation of Current electricity

$$Q = It$$

Then (i) becomes

$$H = ItV$$

SI UNIT OF ELECTRICAL ENERGY

From

$$H = ItV$$

$$H = AsV$$

∴ The SI unit of electrical energy is AsV called Joule (J) other units are Kilojoule (KJ) and Mega Joule (MJ)

RELATIONSHIP

$$1AsV = 1J$$
$$1KJ = 1000J$$
$$1MJ = 1000,000J$$

ELECTRICAL POWER

What is electrical power?

- Electrical power is the electrical energy per unit time taken
- Electrical power is denoted by capital letter "P"

Mathematically

$$P = \frac{H}{t}$$

Where by:

P = Electrical power

H = Electrical energy

t = Time taken

- As we said before that

$$P = \frac{H}{t}$$

But: $H = ItV$

then

$$P = \frac{ItV}{t}$$

$$P = \frac{It\cancel{V}}{\cancel{t}}$$

$$P = IV$$

Extra Knowledge

$$P = IV$$

- from ohm's law, $V = IR$.

$$P = (IR)I$$

$$P = I^2R$$

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Also

$$V = IR$$

$$\frac{IR}{R} = \frac{V}{R}$$

$$I = \frac{V}{R}$$

then

from: $P = IV$

$$P = \left[\frac{V}{R}\right] \times V$$

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

SI UNIT OF ELECTRICAL POWER

From

$$P = \frac{H}{t}$$

$$P = \text{Joule, J} / \text{second, s}$$

∴ The SI unit of electrical power is Joule per second called Watt (W). Other Units are: Kilo watt (Kw) and Megawatt (Mw)

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RELATIONSHIP I

1 J/s = 1 W
1 Kw = 1000 W
1 Mw = 1000,000 W

Example - 01

(a) What is meant by a Fuse?

(b) Briefly explain why fuse a made with a very thin wire but heater are made of thick wire

(c) Fuse wires are labelled 3A, 5A, 12A, 18A and 20A. Select the best fuse for a 240V, 2.856 Kw electric heater.

Solution

(b) The Fuse wire is made is made thin so that wire resistance to be high and protecting excess Current on entering the electrical appliance while the heater wire is made thick so that resistance to be low and allowing large electric current entering to the heater.

(c) Data given

P.d (Voltage) = 240V

Power, P = 2.856 Kw

= 2856 W

Current, I = ?

From

$P = IV$

$\frac{W}{V} = \frac{P}{V}$

$$I = \frac{P}{V}$$

$$= \frac{2856W}{240V}$$

$$= 11.9 W/V$$

$$\approx 12 A$$

∴ The Suitable Fuse is 12A

Example-02

(a) Explain briefly why most plugs have the three pins?

(b) In three pins plug we find wire labelled N, L and E

(i) What do these letters mean?

(ii) What is Internationally Colour Code for the wires labelled N, L and E

(c) Fuses are labelled 41A, 33A, 16A, 1A and 19A. Which of these most suitable for

(i) a 240V, 4.5KW electrical oven

(ii) a 238V, 9.8KW electrical kettle

(iii) a 215V, 200W freezer.

Solution

(a) Most plug has three pins because the live pin to let in current, Neutral pin to let out current and the earth pin to Conduct leakage current to the earth's ground.

(b) i) N stand for neutral wire
L stand for live wire
E stand for earth wire

(ii) The colour code for neutral wire is blak or blue
The colour code for live wire is Red or brown.
The colour code for earth wire is Yellow or green.

(c) i) Electrical oven

Voltage, V = 240V

Power, P = 4.5 Kw

= 4500 W

Current, I = ?

From

$P = IV$

$I = \frac{P}{V}$

$= \frac{4500W}{240V}$

$= 18.75$

$= 19A$

∴ The suitable fuse for electrical oven is 19A

ii) Electrical kettle

Voltage, V = 238V

Power, P = 9.8Kw

= 9800W

Current, I = ?

From

$P = IV$

$I = \frac{P}{V} = \frac{9800W}{238V}$

$= 41.2$

$= 41A$

∴ the suitable fuse for electrical kettle is 41A (13)

(iii) Freezer

Voltage, $V = 215\,V$

Power, $P = 200\,W$

Current, $I = ?$

Recall

$$I = \frac{P}{V}$$

$$= \frac{200\,W}{215\,V}$$

$$= 0.9$$

$$\approx 1\,A$$

∴ The suitable fuse for freezer is 1A

Example-03

A resistor of $100\,\Omega$ is connected across a battery of 12V. How much energy is dissipated across the resistor in 5s?

Solution

Resistance, $R = 100\,\Omega$

Voltage, $V = 12\,V$

Electrical energy, $H = ?$

Time, $t = 5\,s$

From

$$H = ItV$$

But $V = IR$, $I = \frac{V}{R}$.

$$H = \left(\frac{V}{R}\right) tV$$

$$H = \frac{V^2}{R} t$$

$$= \frac{12 \times 12}{100} \times 5$$

$$= 1.44 \times 5$$

$$= 7.2\,J$$

Example-04

- A bulb draws a current 0.5A from a 240V source. Calculate the energy dissipated in 10 minutes.

Solution

Current, $I = 0.5A$

Voltage, $V = 240V$

Time, $t = 10min$

$= 600sec$

Electrical energy, $H = ?$

From

$$H = ItV$$

$$H = 0.5A \times 600sec \times 240V$$

$$= 72000\,J$$

$$= 72\,kJ$$

Example-05

- Three resistors with resistances 9Ω, 12Ω and 15Ω are connected in series across a 12V battery. Calculate the energy dissipated by the 12V resistor in 10 seconds

Solution

Resistance, $R_T = 9\Omega + 12\Omega + 15\Omega$

$= 36\Omega$

Voltage, $V = 12V$

Time, $t = 10S$

Electrical energy, $H = ?$

From

$H = ItV$

Recall

$V = IR$.

$I = \frac{V}{R}$.

then : $I = \frac{12}{36}$

$= 0.3A$

Heat energy $(H) = I^2Rt$

$= (0.3)^2 \times 12 \times 10$

$= 10.8J$

Example-06

(a) A current of 0.4A flows through bulb connected to a 12V battery for 3S. What is the energy transfered.

(b) A hair drier takes 10000J of energy from the main power supply in 5 seconds. Calculate its power in Kilowatt.

Solution

(a) Data

Current, $I = 0.4A$

Voltage, $V = 12V$

Time, $t = 35$

Electrical energy, $H = ?$

From

$H = ItV$

$H = 0.4A \times 35 \times 12V$

$= 14.4J$

(b) Data

Electrical energy, $H = 10000\ J$

Time, $t = 5s$

Power, $P = ?$

From

$P = \frac{H}{t}$

$= \frac{10000\ J}{5s}$

$= 2000\ W$

$= 2kW$

Example-07

→ Calculate the heat lost by a wire of resistance 16Ω when a current of 30A flows through it in 1 Second.

Solution

Resistance, $R = 16\Omega$

Current, $I = 30A$

Time, $t = 1s$

From

$$H = ItV$$

But; $V = IR$

$$H = It(IR)$$
$$= I^2tR$$
$$= 30^2 \times 1 \times 16$$
$$= 14400J$$

TEST YOUR CAPACITY

(08) Calculate the energy dissipated by a resistor of 12Ω in 4 second if a voltage of 6V is supplied.

(09) A bulb uses a current of 0.2A from 240V source. Calculate the heat energy generated by the bulb in 15 seconds.

(10) If electric heater takes a current of 3A when connected to a 240V power supply. Calculate its power rating.

Answers

(08) $H = 12J$

(09) $H = 720J$

(10) $P = 720$ watts

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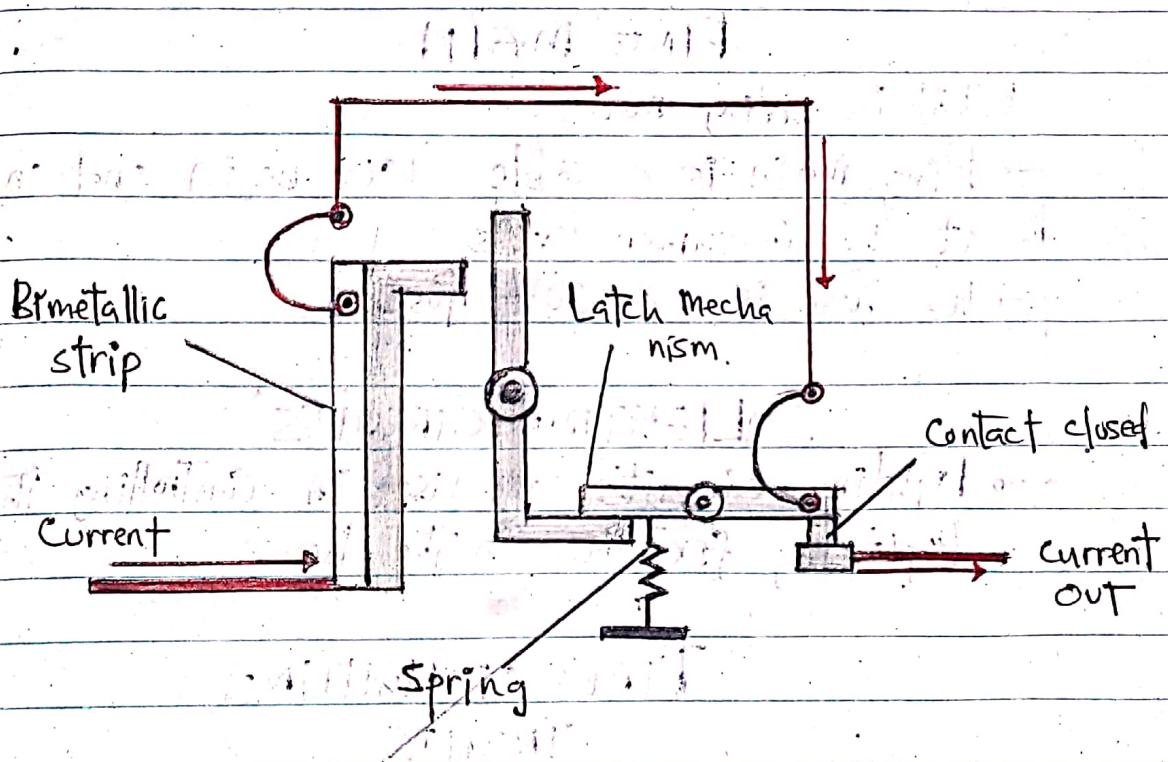
CIRCUIT BREAKER

What is Circuit breaker?

- Circuit breaker is an electric device which breaks the flow of electric current in a circuit when the current exceed a specific value.

OR

- Circuit breaker is a type of a switch that cuts off the flow of current when current in a circuit exceeds a specific value.
- Unlike the fuse which destroys itself. The circuit breaker use LATCH MECHANISM made up of electromagnet which breakes the circuit when the electric current exceeds the specific value.



HOW IT WORKS

- When the current exceeds, it increases the temperature and bimetallic strip bends to push latch mechanism, enables the spring to cut off current.

DOMESTIC WIRING

- The power Company Connects power to the house up to the Consumer unit where the house wiring starts.

CONSUMER UNIT

- This is the place where the main switch, main fuse and distribution board are placed in a single box or unit

NB:

In many houses the main Sockets are Connected to a ring main

RING MAIN

What is Ring main?

- Ring main is a cable which begin and ends at the Consumer unit
- Its fuse is of 30A fuse

LIGHTING CIRCUITS

- Lighting circuits are used in Controlling the lighting fixtures In the house

TYPES OF LIGHTING CIRCUITS

- There are two types of lighting circuits, namely
  (a) Loop - In lighting Circuit
  (b) Junction box lighting Circuit

DETECTION OF FAULTS IN ELECTRICAL APPLIANCES

- There are two devices used to detect faults in electrical appliances, namely
  (a) Multimeter
  (b) live mains lead Indicator (Tester).

(A) MULTIMETER

- Is an electrical device used to measure the resistance, current and voltage of an electric appliance.

(B) TESTER

- It is used to detect the leakage of current from an electrical appliance.

YOU SHOULD KEEP THAT IN MIND

- There are two types of Domestic wiring circuit
  (i) Ring main circuit
  (ii) Lighting circuit

POWER, ENERGY AND COST

- Let us recall the previous formula of power which was

$$P = \frac{H}{t}$$

But:

$$H = MC\Delta\theta$$

Hence:

$$P = \frac{MC\Delta\theta}{t}$$

Where by:

P = Power

m = mass

c = Specific heat capacity

$\Delta\theta$ = Change in temperature $(\theta_2 - \theta_1)$

t = time

Example - 11

→ A electrical kettle has a wire of resistance 5Ω. 1kg of water is to be heated from room temperature 300K up to its boiling point 373K using the kettle. If we acquire the thermal capacity of the kettle, what current must flow in the resistance wire if the water is to be heated in 10 minutes (Specific heat capacity of water = 4200J/kgK).

Solution

$H = mc\Delta\theta$

$= \{1kg \times 4200J/kgK \times (373-300)K\}$

$= 306,600J$

Recall

$H = I^2Rt$ but $V = IR$

$H = It(IR)$

$H = I^2tR$

Make I the subject

$$\frac{I^2tR}{tR} = \frac{H}{tR}$$

$$I^2 = \frac{H}{tR}$$

$$I = \sqrt{\frac{H}{tR}}$$

$$I = \sqrt{\frac{306,600}{5 \times 600}}$$

$$= 10.1$$

$$\therefore I = 10.1\ A$$

Example-12

(a) Define the term electrical power

(b) state its unit

(c) An Immersion heater draws a current of 30A when connected to 240V electricity supply. Calculate the power rating of the heater

Solution

(a) Electrical power is the electrical energy per unit time taken or is the rate at which electrical energy is transfered

(b) Its SI unit is watts

(c) Data given

Voltage, $V = 240V$

Current, $I = 30A$

Power, $P = ?$

from

$$P = IV$$

$$= 30A \times 240V$$

$$= 7200\ W$$

Example-13

(a) An electrical kettle is labelled 250V 100W
   i) What is the significance of the figure
   ii) Calculate the current taken by an electric kettle.

(b) What is the cost of using a bulb (240V, 100W) for twelve days given that the light are used for ten hours every day (1kwh = Tsh 60)

Solution

(a) i) The 100 Joules passes after 1 second by a force of 250V

ii) Data given

Voltage, V = 250V

Power, P = 100W

Current, I = ?

From

$P = IV$

$I = \frac{P}{V}$

$= \frac{100W}{250V}$

$= 0.4A$

(b) Data

Voltage, V = 240V

power, P = 100W

For 12 days cost = ?

1st Change 100w into Kw

$1Kw = 1000w$

$x = 100w$

$\frac{1000x}{1000} = \frac{100}{1000}$

$x = 0.1Kw$

2nd Put 0.1 Kw to Kwh

$0.1Kw \times 12 \times 10hr = Unit$

$12Kwh$

Recall

$1Kwh = 60Tsh$

$12Kwh = ?\ y$

$\frac{y \times 1Kwh}{1Kwh} = \frac{12Kwh \times 60Tsh}{1Kwh}$

$y = 12 \times 60Tsh$

$= 720Tshs.$

∴ The cost is 720 Tshs.

Example-14

A house has five rooms each with 60w, 240v bulb If the bulb are switched on from 7.00 pm to 10:30 pm, determine the power (in Kilowatt-hours) Consumed by the bulb per day by the bulbs

Solution

Data given

Power, $P = 60w$

Voltage, $V = 240V$

Time, $t = 3:30$

Bulb (60w, 240v) ⇒ five rooms

Power Connected by five bulbs in one hour!

$60W \times 5 = 300W$

Change 300w into kw

$= 0.3kW$

Power consumed by the five bulb each day {In Kilowatt-hour}

$= 0.3kw \times 3.5hr$

$= 1.05kwh.$

Example-15

If an electric heater rated at 2kw is used for 4 hours. What is the energy supplied in kwh.

Solution

Data

Power, $P = 2kw$

Time, $t = 4hours$

Energy, $H = ?$

From

$H = ItV$

But $P = IV$

then

$H = Ivt$

$H = Pt$

$= 2kw \times 4hr$

$= 8kwh$

Example-16

If electricity cost per unit (c/u) for Tanzanian electrical supplies Company (TANESCO) is sh. 435. Calculate the cost of using

(a) a 3kw electrical heater for 8 hours
(b) a 75w bulb for 8 hours
(c) a 1500w shaving machine for 10 minutes

Solution

(a) Data

$P = 3kw$

$t = 6$ hours

$E = ?$

From

$E = Vt$ But $P = IV$

$E = Pt$

$= 3kw \times 6hours$

$= 18 kwh$

Cost $= sh\ 435 \times 18$

$= sh\ 7830$

(b) Data

Power, $P = 75w = 0.075kw$

Time, $t = 8hr$

Energy, $E = ?$

Recall

$E = Pt$

$= 0.075\ kw \times 8hr$

$= 0.6 kwh$

Cost $= 0.6kwh \times sh\ 435$

$= sh.\ 725$

© Data

Power, $P = 1500\,W$

Time, $t = 10\,min$

$= (10/60)\,hr$.

Energy, $H = ?$

From

$H = Pt$

$= \frac{1500}{1000} \times \frac{10}{60}$

$= 0.25\,kwh$.

Cost $= 0.25kwh \times 435\,shs$

$= 108.75$

$=$ Sh 108 Cent 75

Example – 17

Calculate the total cost of running simultaneously of refrigerator rated 500w and a TV set rated 90w for 10 hours if electricity cost Tsh. 400/= per kwh.

Solution

REFRIGARATOR

Power, $P = 500w$

$= 0.5kw$

Time, $t = 10hrs$

Energy, $H = ?$

From

$H = IVt$

$H = Pt$

$= 0.5kw \times 10hr$

$= 5kwhr$

Cost

$1kwhr = Tsh\ 400$

$5kwhr = ?.y.$

$y = \frac{Tsh\ 400 \times 5kwhr}{1kwhr}$

$= Tsh\ 2000/=$

IV

Power, $P = 90w$

$= 0.09kw$

Time, $t = 10hrs$

Energy, $H = ?$

From

$H = IVt$

$= Pt$

$= 0.09kw \times 10hr$

$= 0.9kwhr$

Cost

$1kwhr = Tsh\ 400$

$0.9kwhr = y$

$$y = \frac{0.9\text{kwhr} \times \text{Tsh } 400}{1\text{kwhr}}$$

$$= 360$$

$\therefore$ Tsh 360/=

Total Cost = Cost of refrigerator + Cost of TV

= Tsh 2000/= + Tsh 360/=

= 2360 Tshs

TEST YOUR CAPACITY

(18) Calculate the current and resistance of the plate of an electric iron rated 240V 2000W

(19) What is the cost of using an electrical iron rated 240V, 2000W for 10 hours if the electrical energy cost Tsh 100 per unit (1 unit = 1kwh).

(20) An electric heater of resistance 10Ω is connected to 120V mains supply. How much energy does it use when it is in operation for 2 hours?

Answers

(18) $I = 8.33A$

$R = 28.9\Omega$

(19) Cost = Tsh 2000/=

(20) $H = 1.04 \times 10^7 J$

Example - 21

(a) Explain why electrical appliances have to be earthed.

(b) Explain why the earth pin is thicker and longer in three - pin plug.

(c) A television set (TV) rated 40W is switched on for 5 hours every day.

i) How much electrical energy in Kwh does this TV consume in 30 days?

ii) If the price of a unit of electricity is Tsh 229.60, what is the total electricity cost of watching this TV in 30 days?

Solution

(a) To protect them from shock.

(b) Earth pin is thicker and longer in three pin-plug so that it does not enter into the live or neutral sockets.

(c) i) Electrical energy, $E = ?$

From

$$\text{Energy} = \text{Power} \times \text{Time}$$

$$= 40\text{w} \times \frac{5\text{h}}{\text{days}} \times 30\text{days}$$

$$= 6000\text{wh}$$

$$= 6\text{Kwh}$$

ii) Cost = ?

$$\text{Cost} = \text{price} \times \text{total units}$$

$$= \frac{\text{Tsh } 299.60}{1\text{Kwh}} \times 6\text{Kwh}$$

$$= \text{Tsh } 1377.60$$

NOTSI ZA MKONO
PHYSICS - III

VOLUME - 2

I. DOMESTIC ELECTRICITY
II. MEASUREMENT OF THERMAL ENERGY
III. OPTICAL INSTRUMENT. PT 1

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