MADE EASY

Electrical Engineering

Toppers Handwritten Notes

Network Theory

BY-Aditya Sir

NETWORK THEORY

-Aditya sir

ESE : 22-24 M
≈ 14 que.
Gate : 10M

◉ Topics:

① Basics :
- φ, I, V, P, N
- R, L, C
- KVL, KCL, ohm's Law
- Mesh Nodal
- Equivalent R, L, C, Z

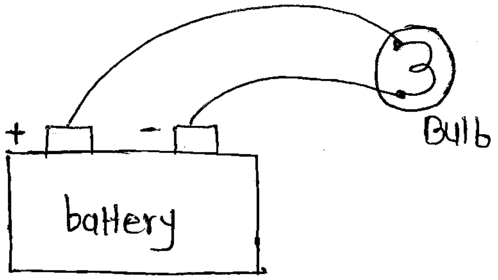
② Two-Port Network :
- Parameters (Z, y, h, g, T, t)
- Interconnection
- Gyrator

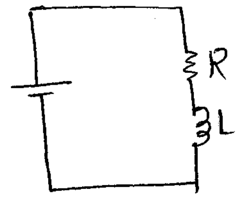
③ Theorems :
- superposition
- Thevenin
- Nortons
- Maximum power Transfer

  ] Gate (superposition – Maximum power Transfer)
- Reciprocity
- Millman's
- compensation
- substitution
- Tellegen's theorem

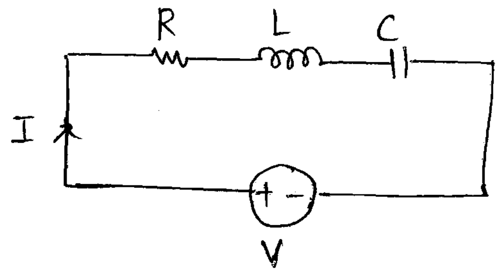
  ] ESE (superposition – Tellegen's theorem)

④ Transient :
- 1^{st} order circuit (RC, RL)
- 2^{nd} order circuits
- Initial condition
- Laplace transform

⊙ 

⟹ 

Electrical circuit : our main Aim is to transferred the energy from one Point to another Point. Hence for this We required An interconnection betⁿ electrical compo.

⊙ 

Interview

Highest basic quantity in electrical Network : Charge

⊙ Charge :- charge is the electrical property of the atomic partical of which the Matter Consist of. (C)

- [Electrical Property → Atomic Particles → Matter]

Charge on $\boxed{1e^- : -1.6 \times 10^{-19} C}$

Coulomb is the large Unit of charge.

Que: How many electron contributes towards 1C of charge?

Solⁿ :
$$1e^- = 1.6 \times 10^{-19} C$$
$$1C = \frac{1}{1.6 \times 10^{-19}} e^-s$$
$$\boxed{1C = 6.24 \times 10^{18} e^-s}$$

⊙ Law of Conservation of charge :

It states that, charge can be neither be created nor be destroyed. It can be only transferred from one body to another body.

Any eqⁿ with the help of show Low of conse. of Charge.

Continuity Eqⁿ : $\nabla . \bar{J} = -\frac{d\rho_v}{dt}$

Lec-2

② **Current :** The flow of the electrons or the time rate of change of charge through any cross-section is called as a current. (C/s or Amp)

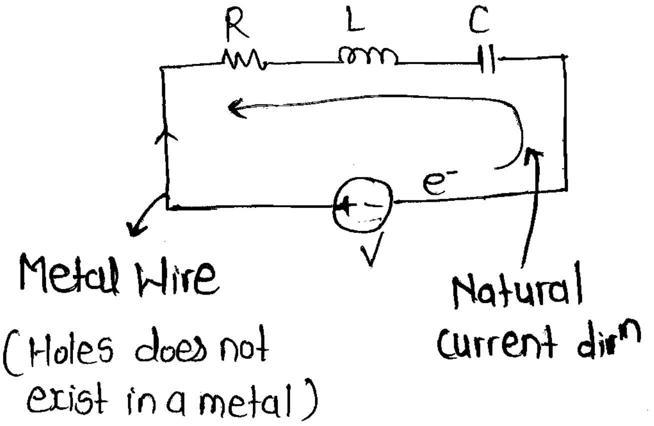
$$I_{av} = \frac{\Delta q}{\Delta t}$$ C/s or AMP.

• Instantaneous current i(t) :

$$i(t) = \lim_{\Delta t \to 0} \frac{\Delta q}{\Delta t} = \frac{dq}{dt}$$

$$i(t) = \frac{dq}{dt}$$

• Direction of current in electrical circuit :



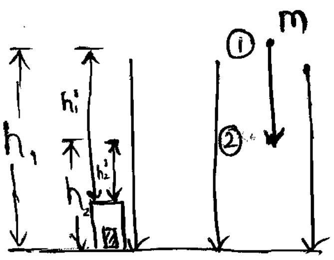
Conventionally, ---> the current direction is taken in the direction of the positive charge moment.

Naturally, ---> the current direction is in the direction of the flow of electrons.

③ **Voltage :** ① To move the electron from one point to another point in a particular direction & external force is required & in an electrical circuit this force is provided by the electromotive force (EMF) & it is given by

$$E = V = \frac{dW}{dq}$$ J/C or V

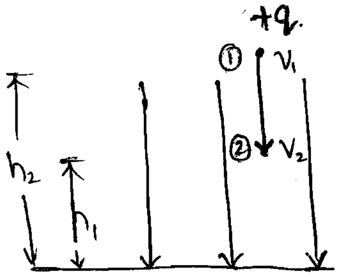
② Voltage or potential difference is the energy required to move a unit charge through an element.



Energy gained by the mass in moving from pt. ① to ② :

$= mg(h_1 - h_2)$

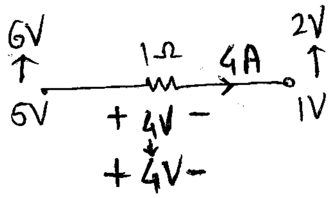
gravitational potential diff.



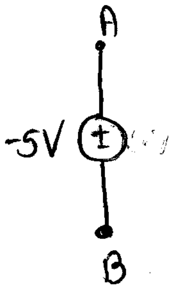
Energy gained by the charge in moving from pt ① to ② :

$= q(V_1 - V_2)$

Electrical Potential difference.

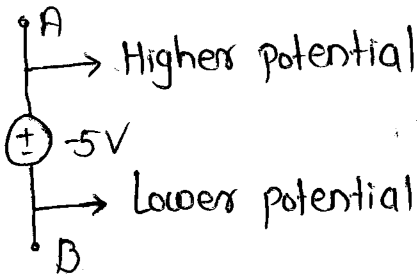


Que:



ⓐ $V_A > V_B$
ⓑ $A_A = V_B$
ⓒ $V_A < V_B$
ⓓ Cant Comment

Sol^n:



Higher Pot. − Lower Pot. = −5V

$V_A - V_B = -5V$

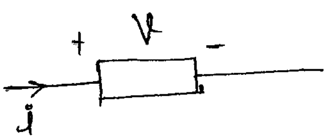
$V_A = V_B - 5$

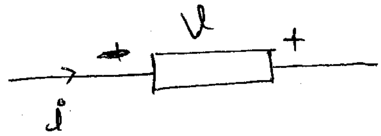
④ **Power:** It is the time rate of change of Energy [expending or absorbing] and (Watts)

$$\boxed{P = \frac{dW}{dt}} \quad J/s \text{ or } W$$

$$P = \frac{dW}{dq} \cdot \frac{dq}{dt}$$

$$\boxed{P(t) = v(t) \cdot i(t)}$$





$P = +vi$ (a) $\qquad P = -vi$ (b)

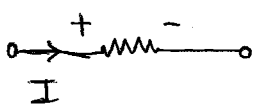
- Whenever we calculate the power by using the formula $V \times I$, We always get the power absorbed.

Fig. (a) Power absorbed or Power received or power dissipated

Fig. (b) Power absorbed is -ve. or Power is getting delivered ($P_{del} = +Vi$)

Note: (1) Whenever current entere into the +ve terminal of the voltage polarity, the element absorbs a power

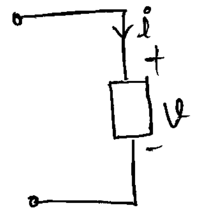
(2) And when the current leaves from the +ve terminal or current enter into the -ve terminal, then the element delivers the power.



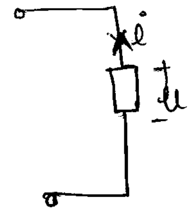
Power absorbed

Power delivered

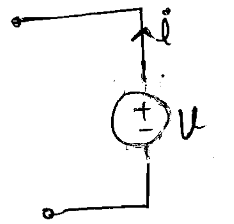
- Hence, for determine sign of the power, The voltage polarity & the c/n direction are important.



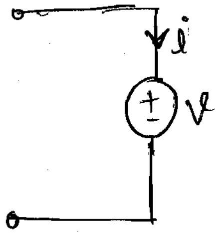
Power abso.
∴ Load



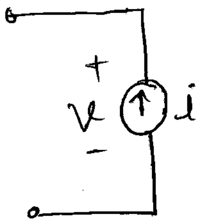
Power deli.
∴ Source



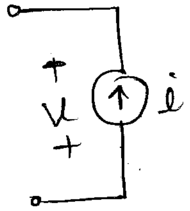
Power deli.
∴ Source



Power abs.
∴ Sink/Load



Power del.
∴ Source



Power abs.
∴ Load

- **Law of Conservation of Energy :**

It states that, Energy can neither be created nor be destroyed, It only be transform from one form to another Form.

∴ In Any Electrical Circuit :

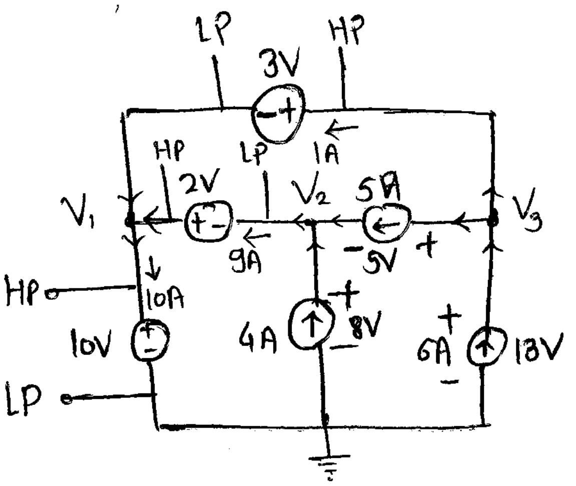
$$\Sigma P = 0$$

$$\Sigma P_{del.} = \Sigma P_{abs.}$$

- The algebric sum of the power at any instant of time in a circuit must be equal to zero.

Lec-3

Que. Find the power of each eleement In the below given electrical Network.



Solⁿ:

$P_{10V} = +10 \times 10$
$= +100\,W$

$P_{2V} = -9 \times 2$
$= -18\,W$

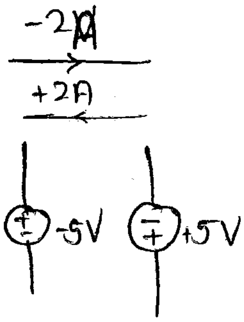
$P_{3V} = +3 \times 1$
$= 3W$

- By Nodal Analysis:

$V_1 - 0 = 10V$
$V_1 = 10V$

$V_1 - V_2 = 2V$
$-V_2 = 2 - 10$
$V_2 = 8V$

$V_3 - V_1 = 3V$
$V_3 = 13V$



$P_{4A} = -4 \times 8$
$= -32\,W$

$P_{5A} = +5 \times 5V$
$= 25\,W$

$P_{6A} = -13 \times 6$
$= -78\,W$

- Not Part of Solⁿ:

$\Sigma P_{abs.} = +100 + 3 + 25$ --- (+Ve Power)
$= 128\,W$

$\Sigma P_{del.} = +8 + 32 + 78$ --- (-Ve Power with +ve sign)
$= 128\,W$

$\therefore \Sigma P_{del.} = \Sigma P_{abs.}$

Que: How many electrons flow per second through the fillament offer 220V & 110W electric bulb.

Solⁿ: $P = V \times I$ $\quad I = \frac{P}{V} = \frac{110}{220} = \frac{1}{2}$ Amp

$I = \frac{Q}{t} = \frac{n.e^-}{t}$ where, n = Total no. of e^-

$\frac{n}{t} = 3.125 \times 10^{-8}$ --- $\left[\because \frac{n}{t} = \frac{I}{e^-} = \frac{1/2}{1.6 \times 10^{-19}}\right]$

⑤ **Energy :** It is the capacity or ability to do the work. (J or Watt-sec)

$$W(t) = \int_0^t p(t) \cdot dt.$$

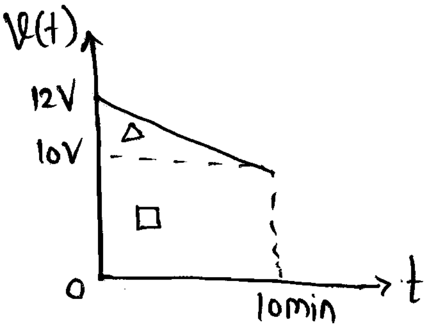
$$\boxed{W(t) = \int_0^t v(t) \cdot i(t) \cdot dt}$$

Que. A fully charged mobile phone with a 12V battery is good for 10 min talktime;

Gate 2009

Assume that during the talktime, battery delivers a constant C/n of 2A and its voltage linearly drop from 12V to 10V as shown in the fig.

How much energy dees the battery delivered during talktime.



Sol^n: $W = \int_0^t p(t) \cdot dt$

$= \int_0^t v(t) \cdot i(t) \cdot dt$

$= 2 \left[\int_0^{10min} v(t) \cdot dt \right]$

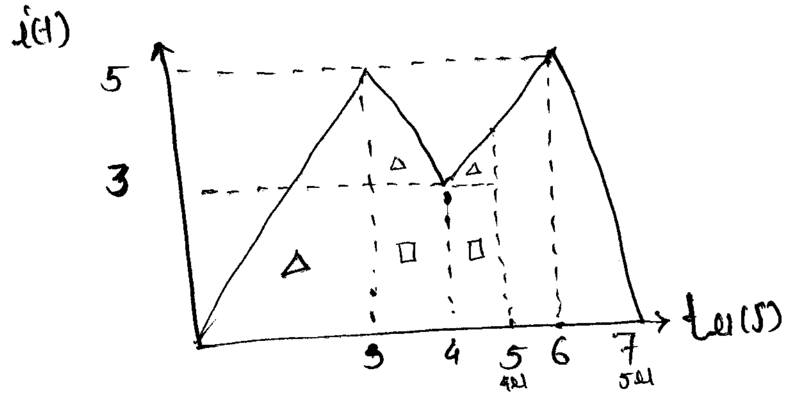
$= 2 \left[\left(\frac{1}{2} \times 10min \times (12-10) \right) + (10 \times 10) \right] \cdot 60$

$= 2 \, [10 + 100] \, 60$

$= 2 \times 6600$

$$\boxed{W = 13.2 \text{ KJ}}$$

Que. A c/n $i(t)$ as shown in the fig. is passed thr a capacitor. A charge in μC aquire by the cap^r in $5\mu s$. will be....



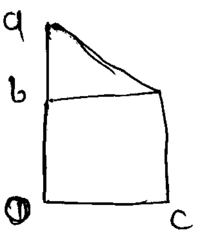
Sol^n: $i(t) = \dfrac{dq}{dt}$

$$q = \int_{-\infty}^{t} i(t)\,dt.$$

$$q(t) = \int_{-\infty}^{0} i(t)\,dt + \int_{0}^{t} i(t)\,dt.$$

$$\boxed{q(t) = q(0) + \int_{0}^{t} i(t)\,dt} \ \star$$

$$q(t) = 0 + \int_{0}^{5\mu} i(t)\,dt$$



Area: $\frac{1}{2}(a-b)c + bc$

$= \frac{1}{2}ac - \frac{1}{2}bc + bc$

$= \frac{1}{2}ac + \frac{1}{2}bc$

$$\boxed{\text{Area} = \frac{1}{2}(a+b)c} \ \star$$

$$\therefore \text{Area} = \int_{0}^{3\mu} i(t)\,dt + \int_{3\mu}^{4\mu} i(t)\,dt + \int_{4\mu}^{5\mu} i(t)\,d(t)$$

$= \left[\frac{1}{2} \times 5 \times 3\right] + \left[\frac{1}{2}(5+3).1\right] + \left[\frac{1}{2}(4+3).1\right]$

$= \left[\frac{15}{2} + \frac{8}{2} + \frac{7}{2}\right]\mu$

$q(t) = \frac{30}{2}\mu$

$$\boxed{q = 15\mu C}$$

que: Cn flowing through the ckt element is given by. $i(t) = (8t + 5)A$. Find amount of charge passing thr the element in an interval of 0 to 3 sec.

Sol^n: Given;

$i(t) = (8t+5)\,A$

$$q(t) = 0 + \int_0^t i(t)\,dt$$

$$q(t) = 0 + \int_0^3 (8t+5)\,dt$$

$$= 8 \cdot \frac{t^2}{2}\Big]_0^3 + 5 \cdot t\Big]_0^3$$

$$= 4(3)^2 + 5(3)$$

$$= 36 + 15$$

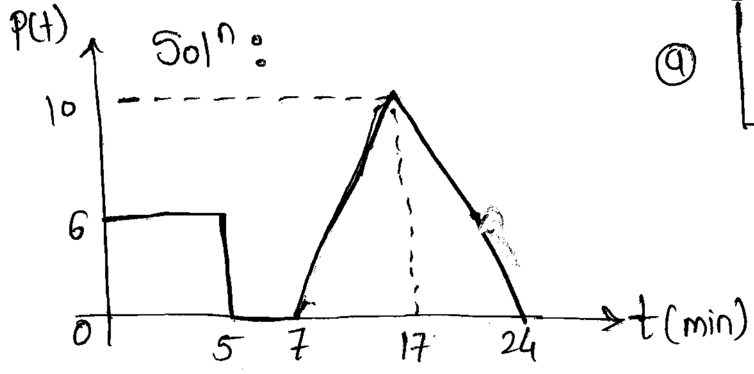
$$q(t) = 51C$$

Que: The Power supplied by a certain battery is constant. 6 W for the 1st 5 min. then. 0 for the following 2 min. the value that increases from 0 to 10 W for the next 10 min. and a power that decreases linearly from 10 W to 0 in the following 7 min.

ⓐ What is the total energy in J. expended during this 24 min. interval. ~~second~~.

ⓑ What is the avg. Power in Watt during this time.

Sol^n:



ⓐ $$W = \int_0^t p(t) \cdot d(t)$$

$$= [6 \times 5] + [\tfrac{1}{2} \times 10 \times 10] + [\tfrac{1}{2} \times 10 \times 7]$$

$$= [30 + 50 + 35] \times 60$$

$$= (115 \times 60)$$

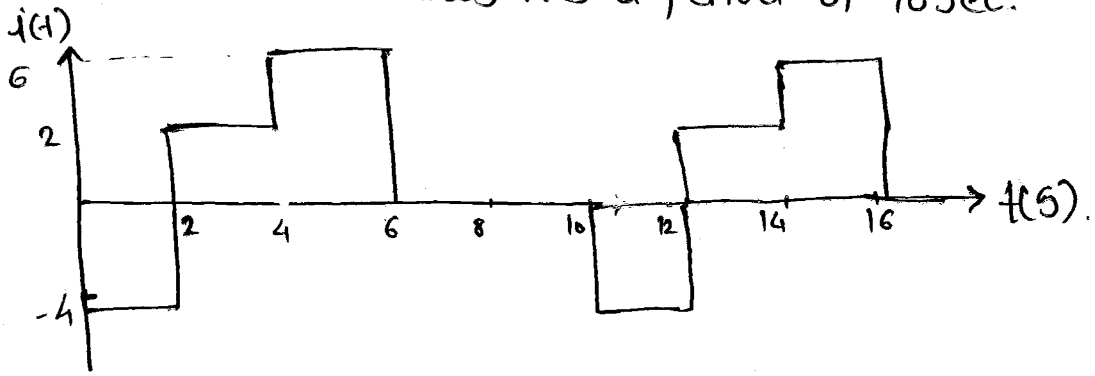
$$W = 6900\,J$$

(b) $$P_{av} = \frac{1}{T}\int_0^T p(t)\cdot d(t)$$

$$\frac{W}{T} = \frac{115 \times 60}{24 \times 60}$$

$$P_{av} = \frac{115}{24} = 4.79\ W$$

Que: The Waveform shows has a period of 10sec.



(a) What is the avg value of C/n over one period.

(b) How much charge is transfered in time interval 0 to 12 sec.

(c) If the initial charge is '0' then sketch q(t) for time interval 0 to 16 sec.

Sol^n: $$I_{avg.} = \frac{1}{T}\int_0^T i(t).dt$$

$$= \frac{1}{10}\left[[-4\times2]+[2\times2]+[2\times6]\right]$$

$$= \frac{1}{10}\times[-8+4+12]$$

$$= \frac{16-8}{10}$$

$$= \frac{8}{10}$$

$$I_{avg.} = 0.8\ A$$

(b) $q(t) = q(0) + \int_0^t i(t) \cdot dt.$

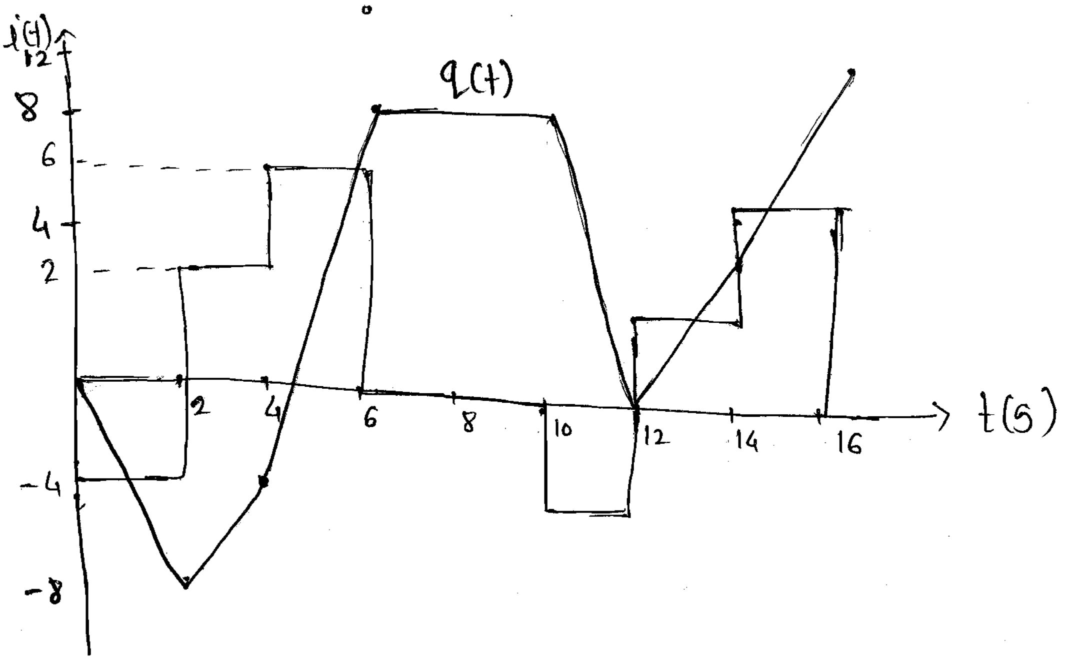
$= 0 + [-8 + 4 + 12 - 8]$

$q(t) = 0C$

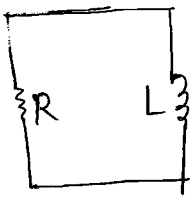
(c) step $\xrightarrow{\int}$ ramp

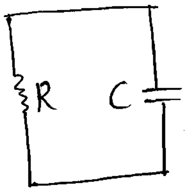
$\int a \cdot dt = at$ (slope)

$q(t) = 0 + \int_0^t i(t) dt$



Lec-4





$\tau = \frac{L}{R}$ $\tau = RC$

Interview:

In given ckts.

RL, Why T.C. $(\tau) \propto \frac{1}{R}$

RC, Why T.C. $(\tau) \propto R$

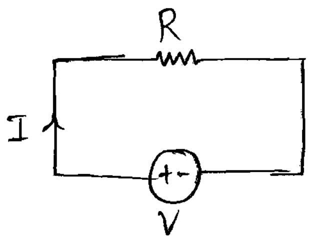
Circuit Elements:

Ckt elements can be completely characterised based on its V-I characteristics:

① Resistor:- If voltage across an element is linearly proportional to the current flowing through it, then that element is called as Resistor.

- Resistor is an element having a property of resistance.

Resistance can be described as that property of circuit element which offers the opposition to flow of the current & in doing so it converts the electrical energy into heat energy.



$P = V.I$

$P = (IR)I. = V.\frac{V}{R}$

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

$W = \int_0^t P.dt.$

$= \int_0^t I^2R.dt = \int_0^t \frac{V^2}{R}.dt$

$$\boxed{W = I^2R.t. = \frac{V^2}{R}.t}$$

$$\boxed{R = \frac{W}{I^2t}} \quad \boxed{W = \int_0^t (I^2)R.dt}$$