Lecture - 3

Voltage

(*) **Voltage:** একটা charge কে এক স্থান থেকে অন্য স্থানে স্থানান্তর করতে যে পরিমান কাজ হয় বা Energy ব্যয় হয় তাকে voltage বলে।

⇒ Voltage tells us how much Energy is available or (required) to move a unit charge from one point to another.

∴ Work = voltage × charge
∴ Energy = voltage × charge

⇒ To move the electron in a conductor in a particular direction requires some **work** or **Energy Transfer**.

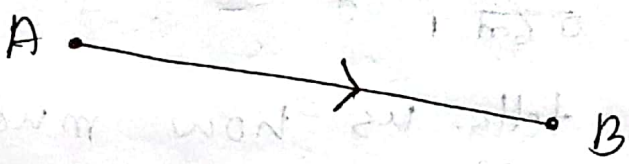
⇒ This work is performed by an external **electromotive force (emf)**, typically represented by battery.

Unit : একক Volt = V

$1\ V = 1\ J/C$

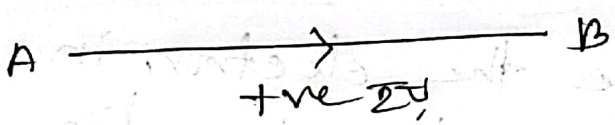
Polarity of voltage

(*) Charge কে A থেকে B তে move করালে:-

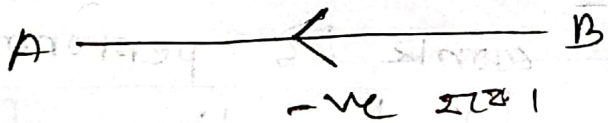


$\therefore V_{AB} = V_A - V_B$

যদি A to B move করাতে positive (+ve) বলা হয়:



তাহলে, B to A move করাতে negative (-ve) বলা হবে:-



So, $V_{AB} = V_A - V_B \Rightarrow V_{BA} = V_B - V_A$

$\Rightarrow V_{BA} = -(V_A - V_B)$

$= -V_{AB}$

(*) Current Always বড় voltage থেকে ছোট voltage এর দিকে যায়। অর্থাৎ ⊕ to ⊖ যায়।

$\therefore V_{AB} = -V_{BA}$ ⇒ এটাকেই polarity of voltage বলা হয়।

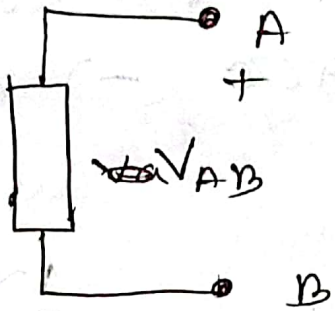
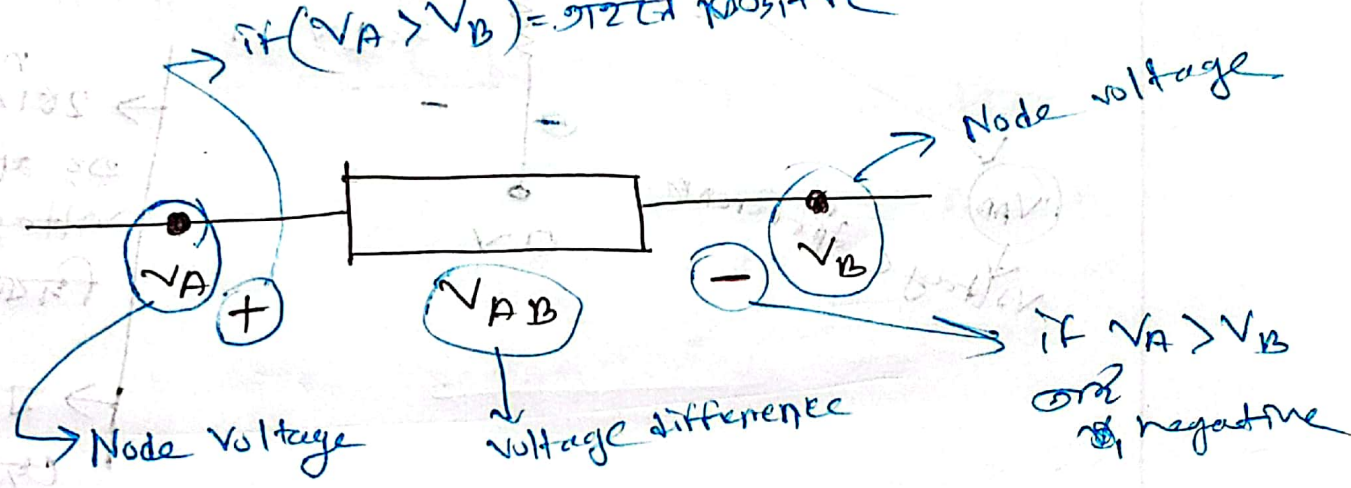


fig: Polarity of Voltage



(*) node voltage: কোনো একটা নির্দিষ্ট point এর voltage কে Node voltage বলে। ex: V_A এবং V_B

(*) Voltage difference: দুই node voltage এর difference থাকলে তাকে voltage difference বলে।

V_A এবং V_B এর মাঝের difference কে V_{AB}।

Mathmetical Eqn. for Voltage:

1 C চার্জকে V_A to V_B তে নিতে কাজ হয় W।

$dq \longrightarrow dw$

$1 \longrightarrow \frac{dw}{dq}$

So,

$$\boxed{V_{AB} = \frac{dw}{dq}}$$

Here,

W = কাজ or Energy এর equation

$\frac{dw}{dq}$ = change এর সাপেক্ষে differentiation।

V_{AB} = A to B তে Voltage.

So, for কাজ / Energy :-

$$V = \frac{dw}{dq}$$

$$\Rightarrow V \cdot dq = dw$$

$$\Rightarrow \int V\,dq = \int dw$$

$$\therefore W = \int V\,dq$$

Integration

- with limit → $W = \int_{q_1}^{q_2} V\,dq$ (Interval এর মাঝে কাজ করতে হলে with limit)
- without limit → $W = \int V\,dq$ (Specific point এর equation কাজ করতে হলে without limit)

Power

(*) কোনো কিছু 1 sec কাজ করার হারকে power বলে।

⇒ Power is the time rate of expending (supplying) or absorbing energy, measured in watts (W).

Unit: ~~Math~~ watt (W).

⇒ Mathmatical Equation for Power:

$$P = \frac{dw}{dt}$$

$$w = \int p\, dt$$ ↳ without limit

↳ used for equation of w.

$$w = \int_{t_0}^{t} p\, dt$$ ⇒ with limit integration between t and t_0 time interval.

* w = work/Energy eqn.

$\frac{d}{dt}$ = time এর সাপেক্ষে differentiation.

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = v \times i$$

So,

$$\boxed{p = vi} = i^2 R = \frac{v^2}{R}$$

$p = vi$ → for all elements এর জন্য এই eqn. use হবে

$i^2R = \frac{v^2}{R}$ → Resistance থাকলে এই eqn. গুলো use হবে।

Example: Find the power delivered to an element at $t = 3$ ms if the current entering its positive terminal is :-

$i = 5 \cos 60\pi t$ A and the voltage is : (a) $v = 3i$ (b) $v = 3\, di/dt$

Ans: Here, $t = 3\text{ms} = \boxed{3 \times 10^{-3}\, s}$

(Convert করার কারণ current 1s এ কত বার হয়? হিসাব করব।)

$i = 5 \cos 60\pi t$ A

(a) $v = 3i = 3 \times (5 \cos 60\pi \cdot t) = 15 \cos 60\pi t$

∴ [illegible]

b) $V = 3\frac{di}{dt} = 3 \times \frac{d}{dt}(5\cos 60\pi t)$

$= 3 \times (5 \cos 60\pi t \times 60\pi)$

So,

a) $p = V \times i$

$= 15 \cos 60\pi t \times 5 \cos 60\pi t$

$= 75 \cos^2 60\pi t$

$\therefore p(3) = 75 \times \cos^2 (60 \times \pi \times 3 \times 10^{-3})$

$= 75$ watt

b) $p = V \times i$

$= 3 \times (5 \cos 60\pi t \times 60\pi) \times 5 \cos 60\pi t$

$=$

$p(3) =$

Sign Convention for Power

(*) Circuit এ 2 type বিদ্যুৎ থাকে :-

→ Power Supplier (−)

→ Power Absorber (+)

negative → Power Supplier

positive → power Absorber / consumer

(*) Absorber হলে :- Current (i) ↑(+) দিয়ে ঢুকবে। (−) দিয়ে বের হবে।

(*) Supplier হলে :- Current(i) ↑(−) দিয়ে ঢুকবে। (+) দিয়ে বের হবে।

$P = VI$

↳ ~~positive~~ ও (+) sign দিয়ে Current ঢুকে। (+) দিয়ে ঢুকলে : $P = +VI$

(−) ও ও : $P = -VI$

এবার,

$P = \square VI = \oplus$ watt

↳ plus হলে Absorb করবে।

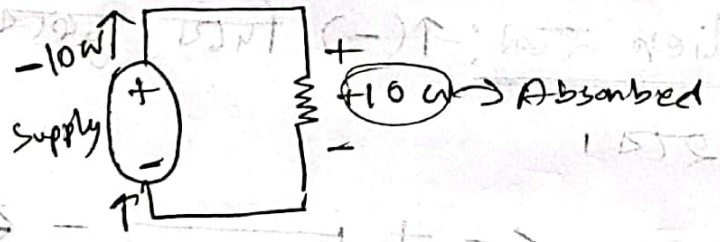
voltage এর যে side দিয়ে current ঢুকে

$P = \square VI = \ominus$ watt

↳ minus হলে supply করবে।

(*) কোনো Circuit এ total power এর যোগফল Always 0 হবে।

$$\sum P = 0$$



এখানে 10w supply হচ্ছে 10 w ই Absorb হয়।

So,

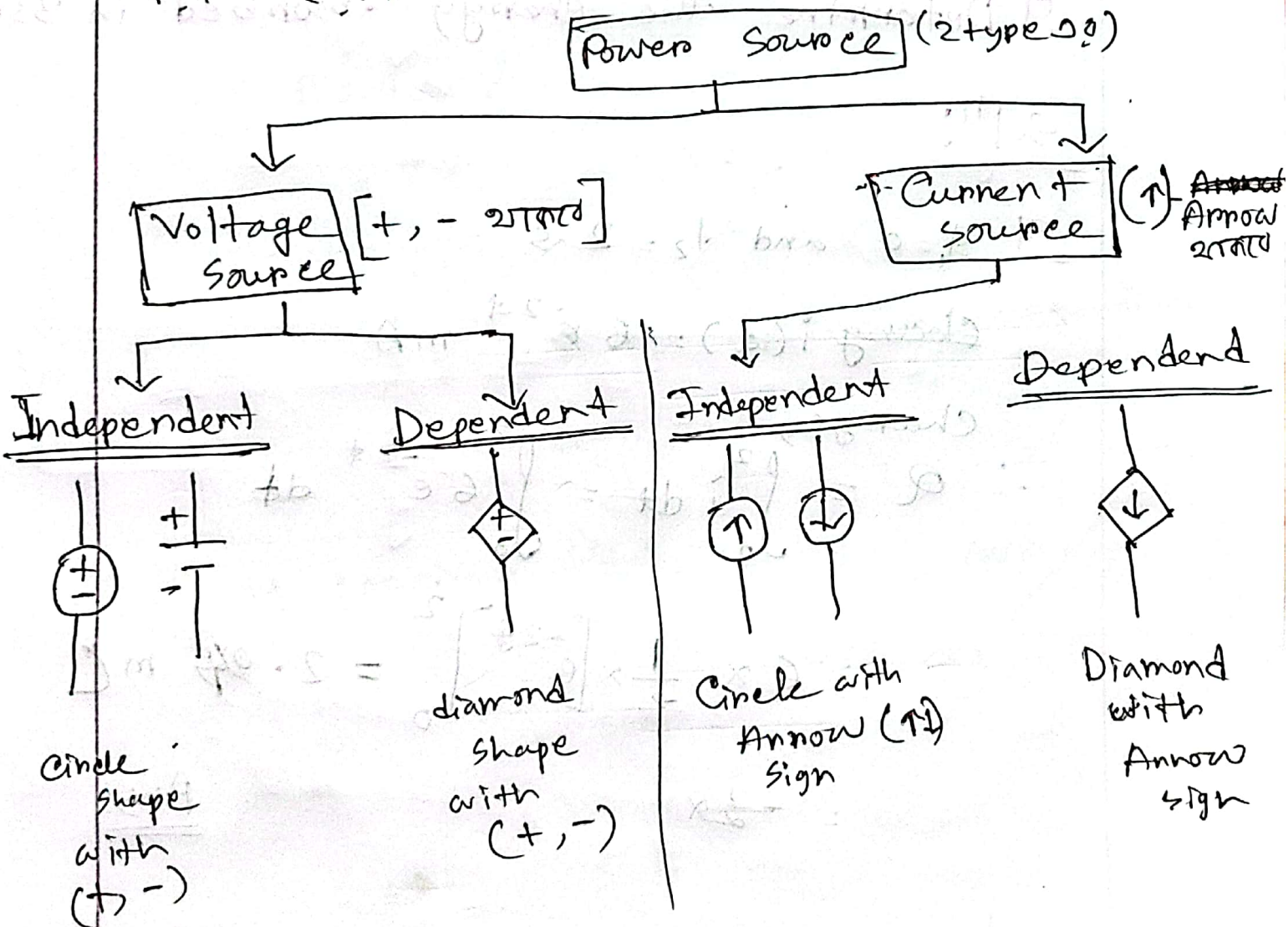
total Powers supplied. = - total powers Absorbed

(N) Series ১ থাকলে Current same।

(N) Parallel ১ ও Voltage same।

Lecture - 04

Power Source: যেখান থেকে power supply করা হয়।



1.15: The current entering the positive terminal of a device is $i(t) = 6e^{-2t}$ mA and the voltage across the device is, $V(t) = 10\, di/dt$ V

a) Find the change delivered to the device between $t = 0$ and $t = 2s$.

b) Calculate the power absorbed.

c) Determine the energy absorbed in 3s.

Soln:

a) $t_1 = 0$ and $t_2 = 2$ s

$i(t) = 6e^{-2t}$ mA

Charge,

$$\therefore Q = \int_0^2 i\, dt = \int_0^2 6e^{-2t}\, dt$$

$$= 6 \times \frac{1}{-2} \times \left[e^{-2t}\right]_0^2 = 2.95 \text{ mC}$$

$= -3x$

Ans:

b) absorbed means $p = +VI$

So, Here, ~~$p = +VI$~~ $\quad i = 6e^{-2t}\ mA$

$$V = 10\frac{di}{dt} = 10 \times \frac{d}{dt}(6e^{-2t})$$

$$= 10 \times 6 \times e^{-2t} \times -2 = -120\, e^{-2t}\ V$$

So, $p = +VI$

$$= -120\, e^{-2t} \times 6e^{-2t}$$

$$= -720 \times e^{-4t}\ \mu W$$

power is actually negative

So it supplies power.

c) at specific time, $t = 3s$; energy, $w = ?$

$$w = \int p\, dt = \int -720 \times e^{-4t}$$

$$= -720 \times \frac{1}{-4} \times e^{-4t} = 180 \times e^{-4t}$$

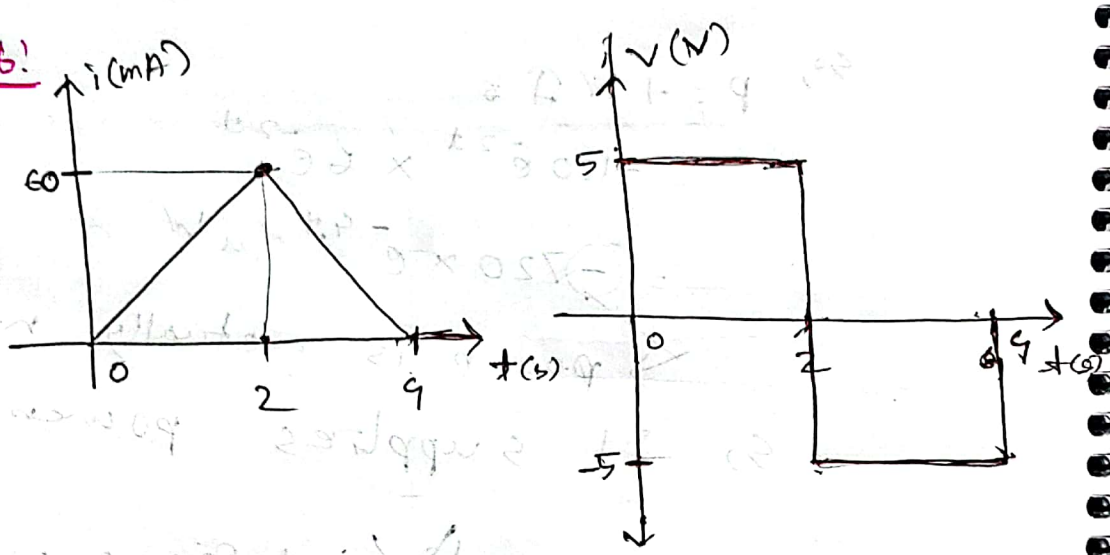
$$\therefore w(3) = 180 \times e^{-4 \times 3} =$$

q $t_1 = 0$; $t_2 = 3$ [energy থেকে total absorbed energy খুঁজে lower limit $t_0 = 0$ নেবে।]

$$w = \int_0^3 -720 \times (e^{-4t})$$

$$= -179.99 \approx -180 \ \mu J$$

1.16)



Figures shows the current through and the voltage across an element.

a) Sketch the power delivered to the element for $t > 0$.

b) find the total energy absorbed by the element for the period of $0 < t < 4s$.

Soln:

a) এখানে 2টি গ্রাফ। একটি I vs t এবং আরেকটি V vs t graph।

এবং আমাদের p vs t Graph আঁকতে হবে।

So,

$p = vi$ use করে প্রতি t এর মানের p vs t graph বানাবো।

at, $t = 0 \Rightarrow i = 0$ and $v = 5$

So, $p = vi = 5 \times 0 = 0$

$t = 2 : \Rightarrow i = 60$ and $V = \pm 5$

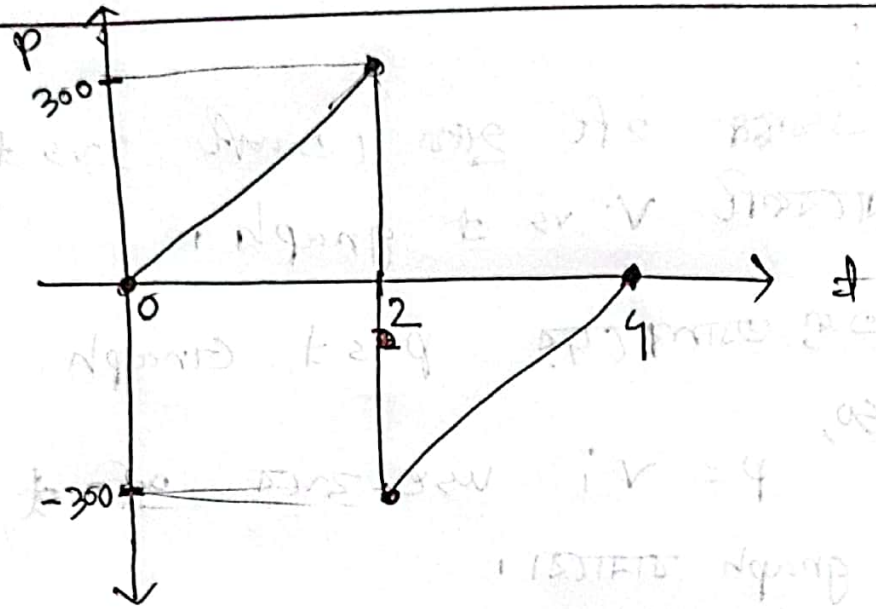
So, $P_1 = vi = 60 \times 5 = 300$

$P_2 = vi = 60 \times -5 = -300$

$t = 1 : \Rightarrow i = 0 \; ; \; v = -5$

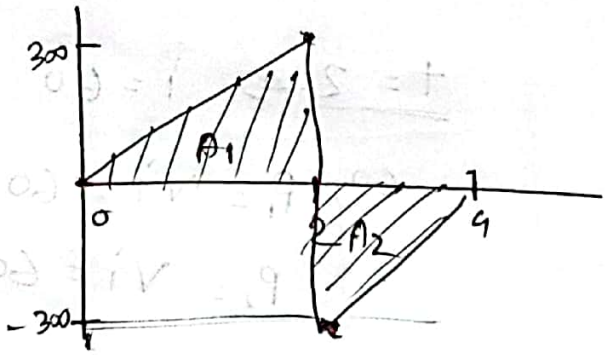
$\therefore p = 0 \times -5 = 0$

So the p vs t graph is:-



b) Total energy in period of:

$0 < t < 4$



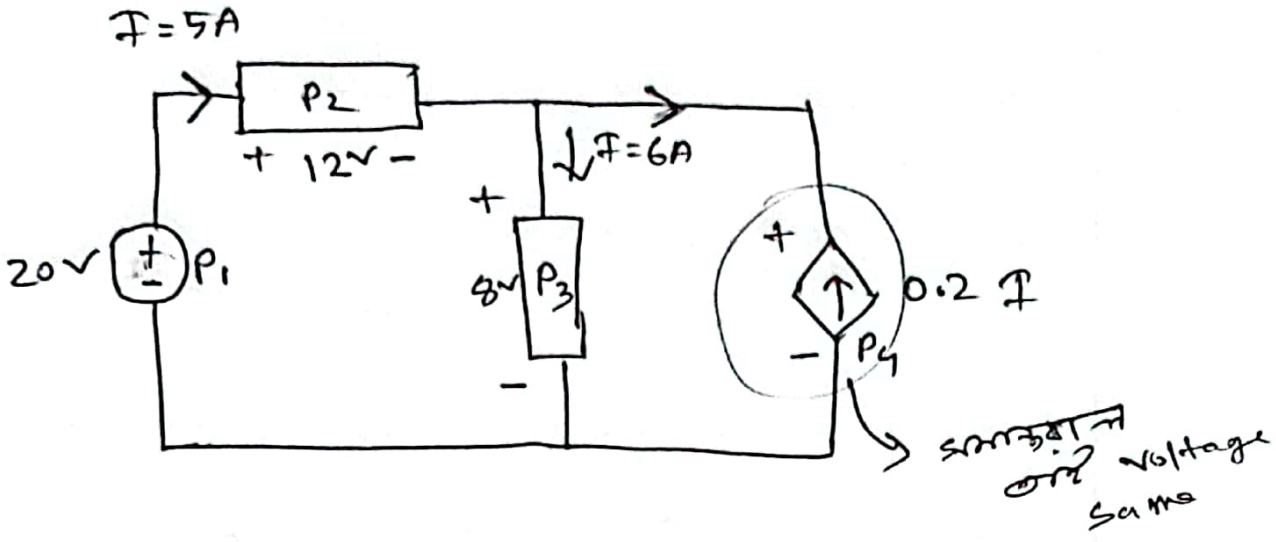
$$w_1 = \frac{1}{2} \times a \times b = \frac{1}{2} \times 2 \times 300 = 300$$

$$w_2 = \frac{1}{2} \times a \times b = \frac{1}{2} \times 2 \times -300 = -300$$

$$\therefore w = w_1 + w_2$$

$$= 300 - 300 = 0 \text{ J}$$

ex: Calculate the power supplied or absorbed by each element:



P_1 = + দিয়ে ঢোকে তাই supplied

$= -VI = -20 \times 5 = -100$ Watt

P_2 = + দিয়ে ঢুকে তাই Absorben

$= +VI = +12 \times 5 = +60$ watt

P_3 = + দিয়ে ঢুকে মানে Absorben

$= +VI = +8 \times 6 = +48$ watt

P_4 = + দিয়ে বের হয়, ∴ supplied

$= -(V)I = -8 \times (0.2 \times 5) =$ -8 watt

↳ যেহেতু 8V এর সমান্তরাল তাই এর voltage 8V