$$\boxed{v_d = \frac{eE}{m_e}\tau}$$

Relaxation Time

Random Motion + Organized Motion.

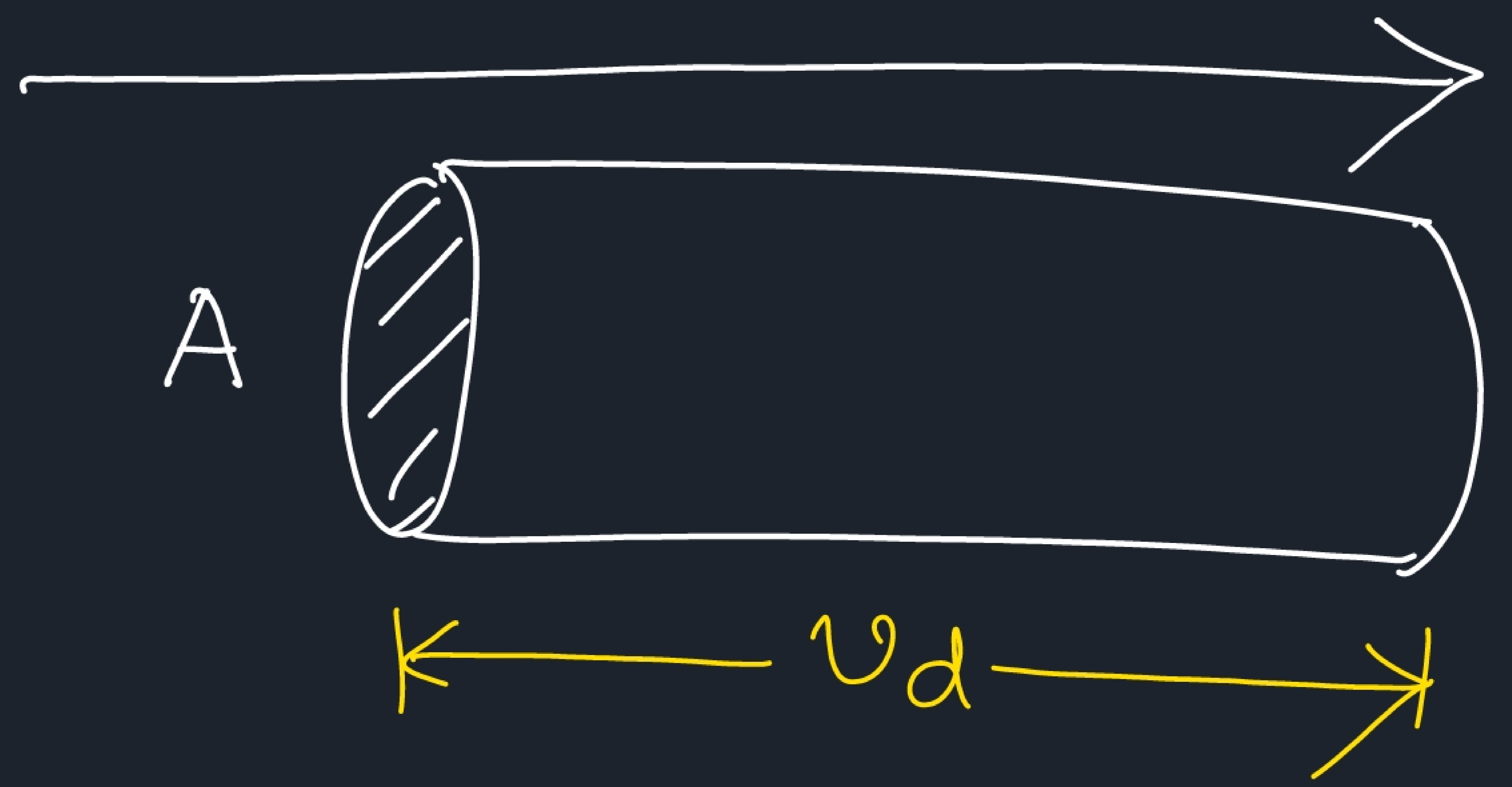
N_e

$$\boxed{\vec{J} = \sigma \vec{E}} \Rightarrow \text{OHM's law.}$$

$$E = -\frac{dV}{dx}$$

$$\left|E\right| = \left|\frac{V}{l}\right|$$

$$\frac{I}{A} = \sigma \frac{V}{l} \qquad I = \frac{A}{l}\frac{1}{\rho}V$$



$$e N_e A v_d = Q = I$$

$$I = e N_e A \frac{eE}{m_e}\tau$$

$$\frac{I}{A} = \underbrace{\left\{\frac{e^2 N_e}{m_e}\tau\right\}}_{\sigma} E = J$$

$$V = \frac{\rho l}{A} I$$

$$\boxed{V = RI}$$

Problem:-

Cu wire

$A = 4\,mm^2$

$l = 4\,m$

$I = 10\,A$

$N_e = 8 \times 10^{28}\,m^{-3}$

$v_d = ?$

$I = N_e e A v_d$

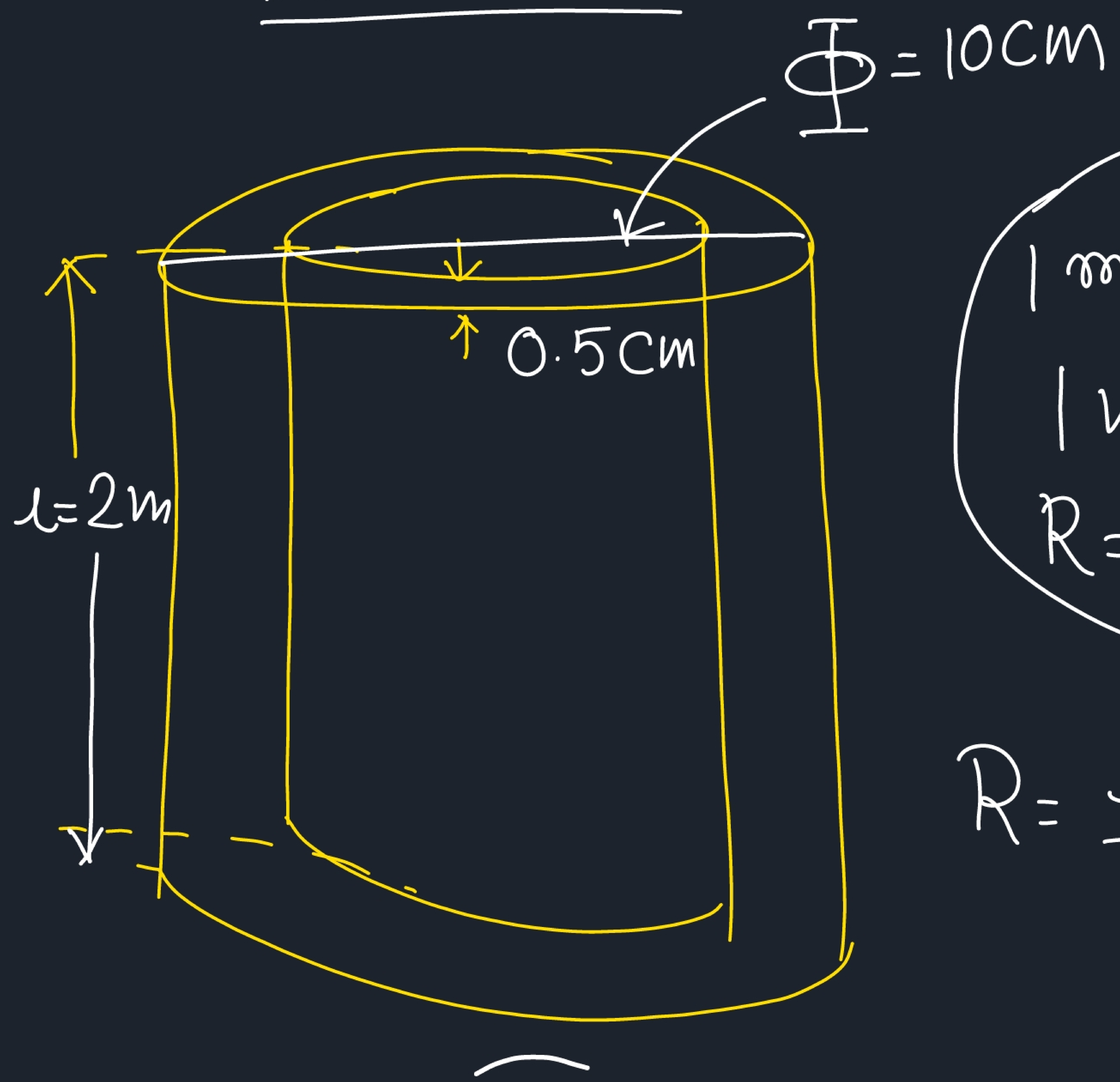
$$v_d = \frac{I}{N_e e A}$$

$$= \frac{10}{8 \times 10^{28} \times 1.602 \times 10^{-19} \times 4 \times 10^{-6}} \; m/sec$$

$$= 1.95 \times 10^{-4} \; m/sec$$

0.000195

Problem:-



$\rho_{cu} = ?$

1m length of
1mm² of cu tube
R = 0.015 Ω

$R = \frac{\rho l}{A}$

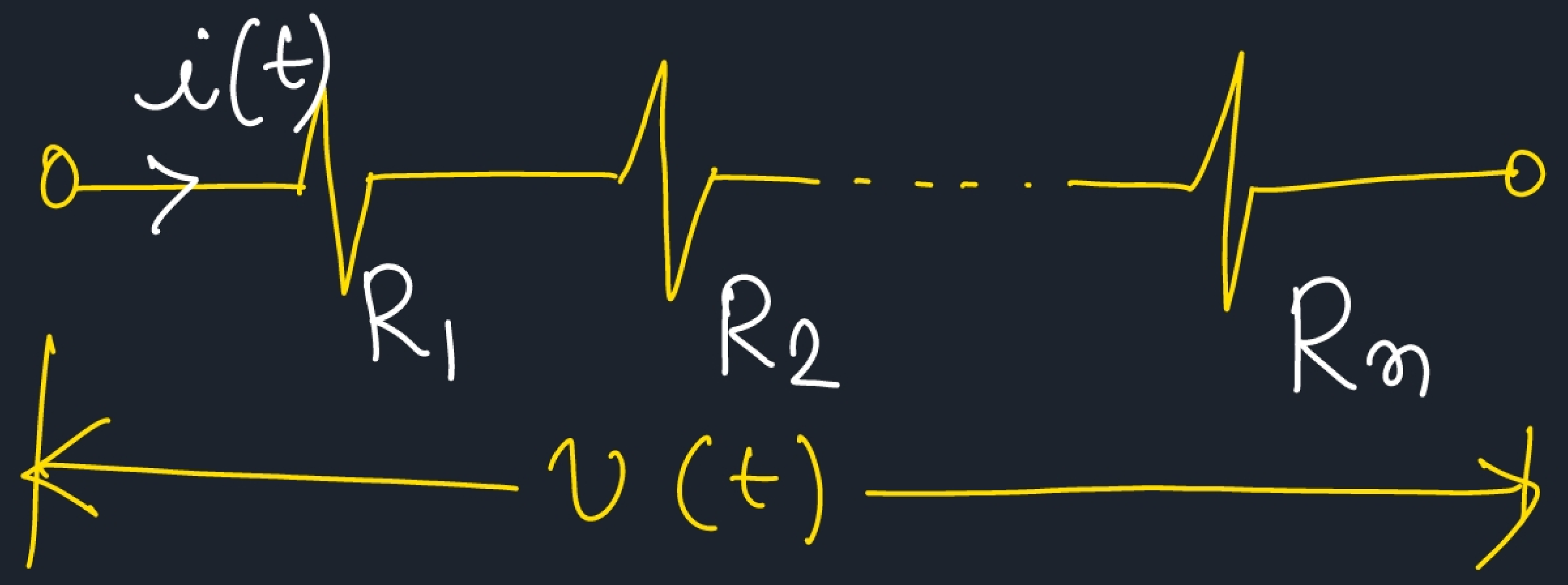
$\rho = \frac{RA}{l}$

$= \frac{0.015 \times 1 \times 10^{-6}}{1}$

$R = \frac{\rho l}{A}$

$A = \pi\{r_{ext}^2 - \underbrace{r_{int}^2}_{} \} = ?$ (above r_{int}^2: $= ?$)

$20.1038 \times 10^{-6}\ \Omega$



$$v(t) = v_1(t) + v_2(t) + \dots + v_n(t)$$

$$= i(t)R_1 + i(t)R_2 + \dots + i(t)R_n$$

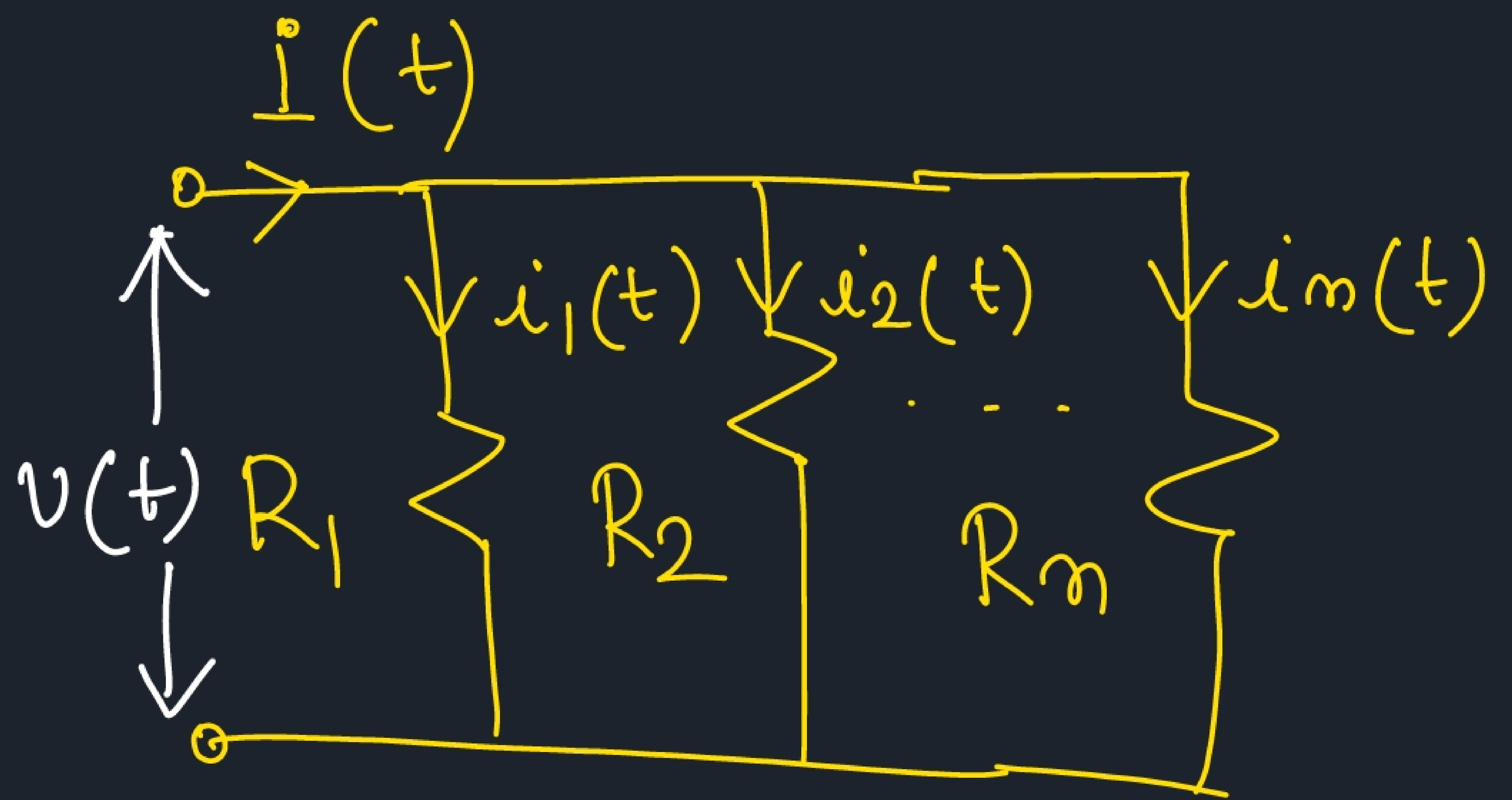
$$= \underbrace{\left(\sum_{j=1}^{n} R_j\right)}_{R_{eq}^{S}} i(t)$$

$$v_1(t) : v_2(t) : \dots : v_n(t) = R_1 : R_2 : \dots : R_n$$

$$v_m(t) = \frac{R_m}{\sum_{j=1}^{n} R_j} v(t)$$

$$p_1(t) : p_2(t) \dots p_n(t) = R_1 : R_2 : \dots : R_n$$

$$p_m(t) = \frac{R_m}{\sum_{j=1}^{n} R_j} p(t)$$



$$i(t) = i_1(t) + i_2(t) + \dots + i_n(t)$$

$$= \frac{v(t)}{R_1} + \frac{v(t)}{R_2} + \dots + \frac{v(t)}{R_n}$$

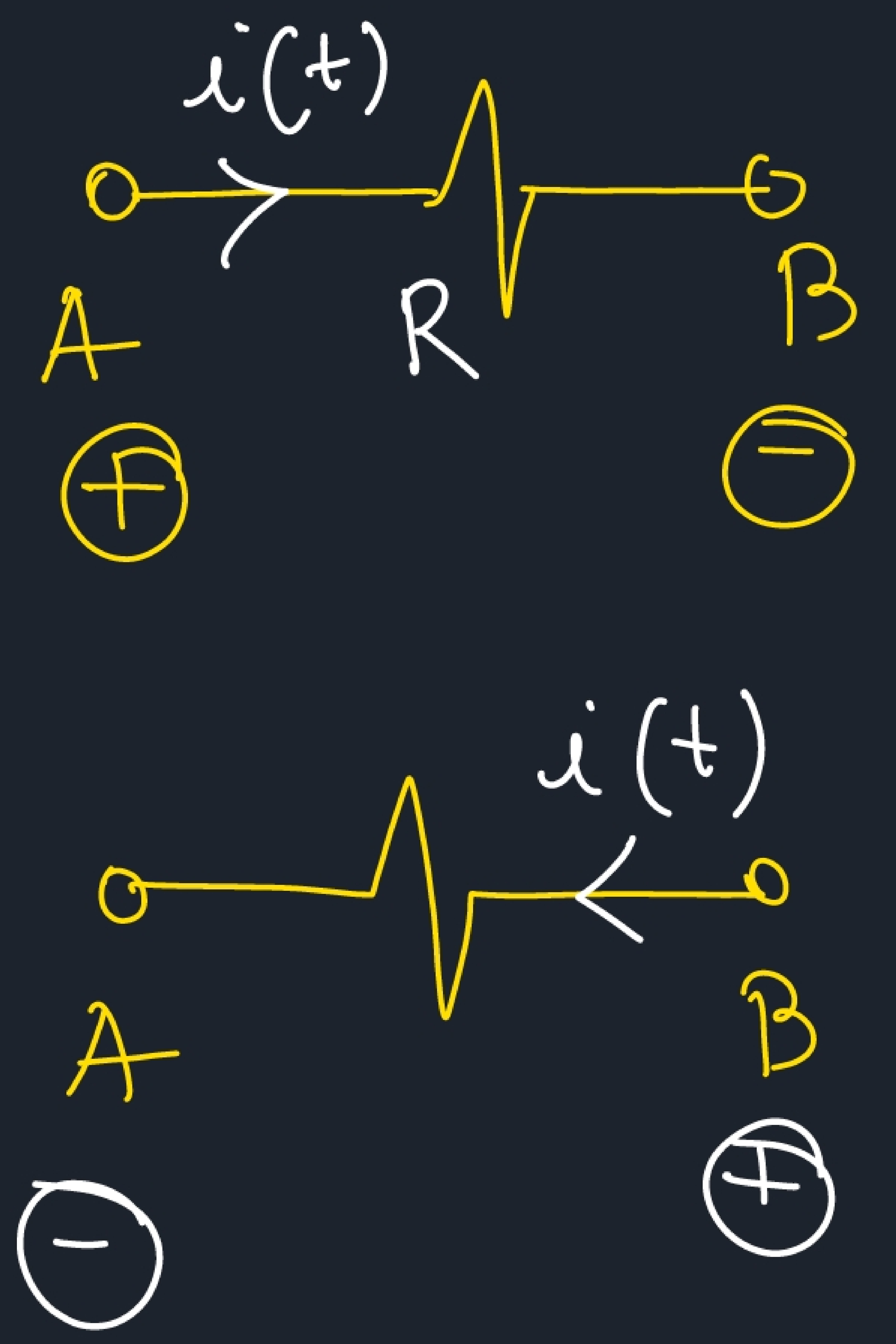
$$= v(t) \sum_{j=1}^{n} \frac{1}{R_j} \rightarrow R_{eq}^{P}$$

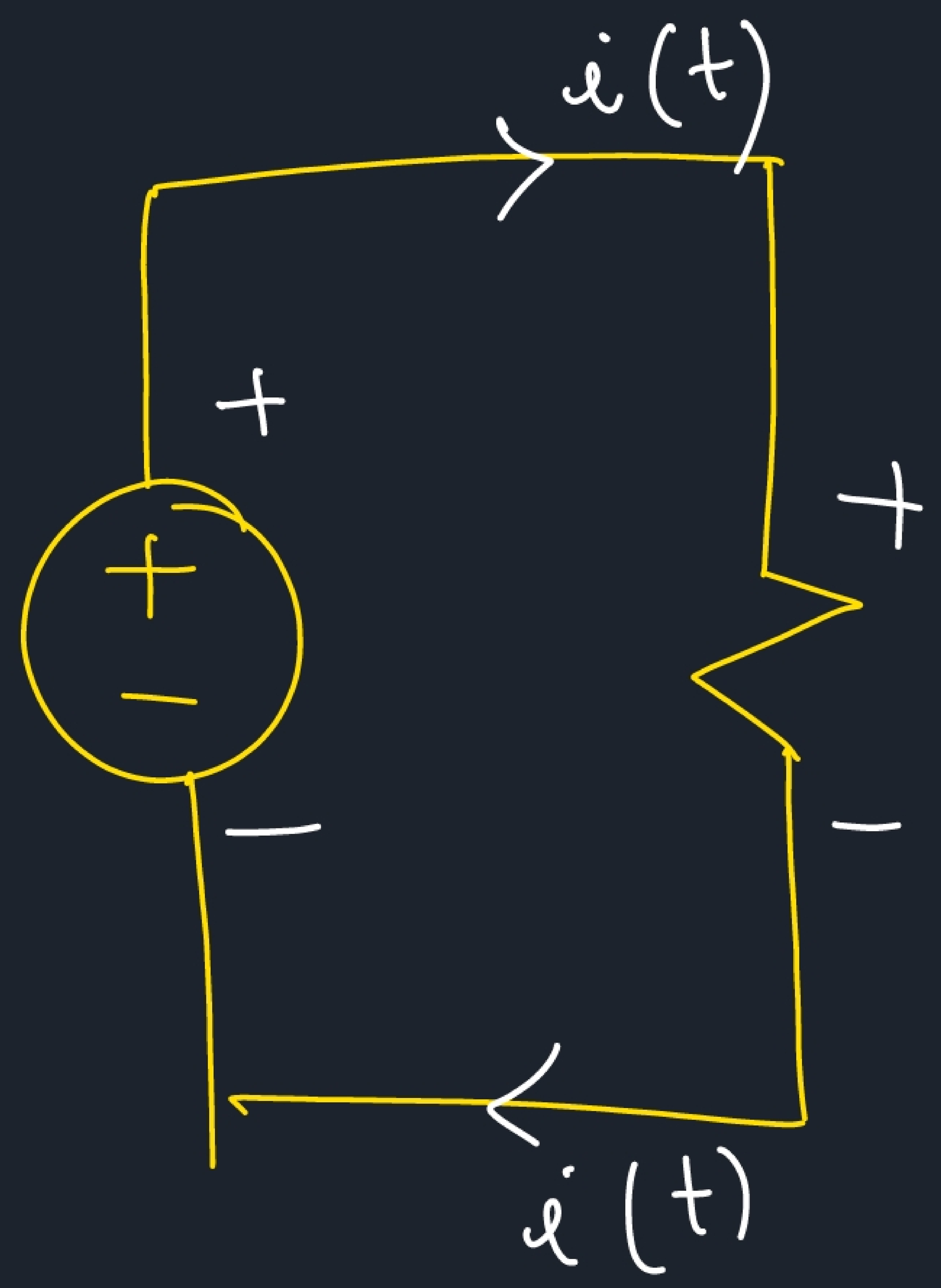
$$i_1(t) : i_2(t) \dots i_n(t)$$
$$= G_1 : G_2 \dots : G_n$$

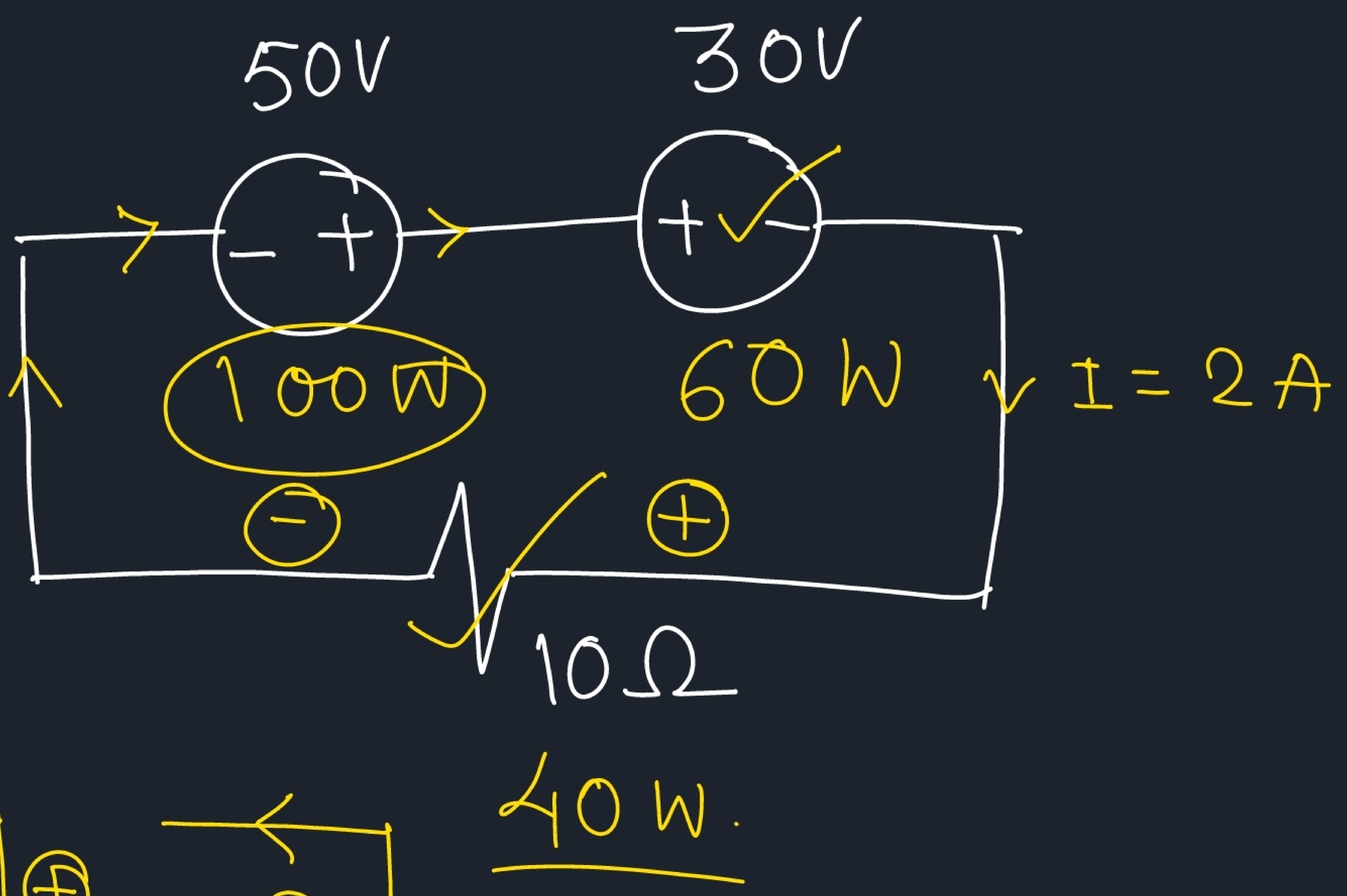
$$\boxed{i_m(t) = \frac{G_m}{\sum_{j=1}^{n} G_j} i(t)}$$

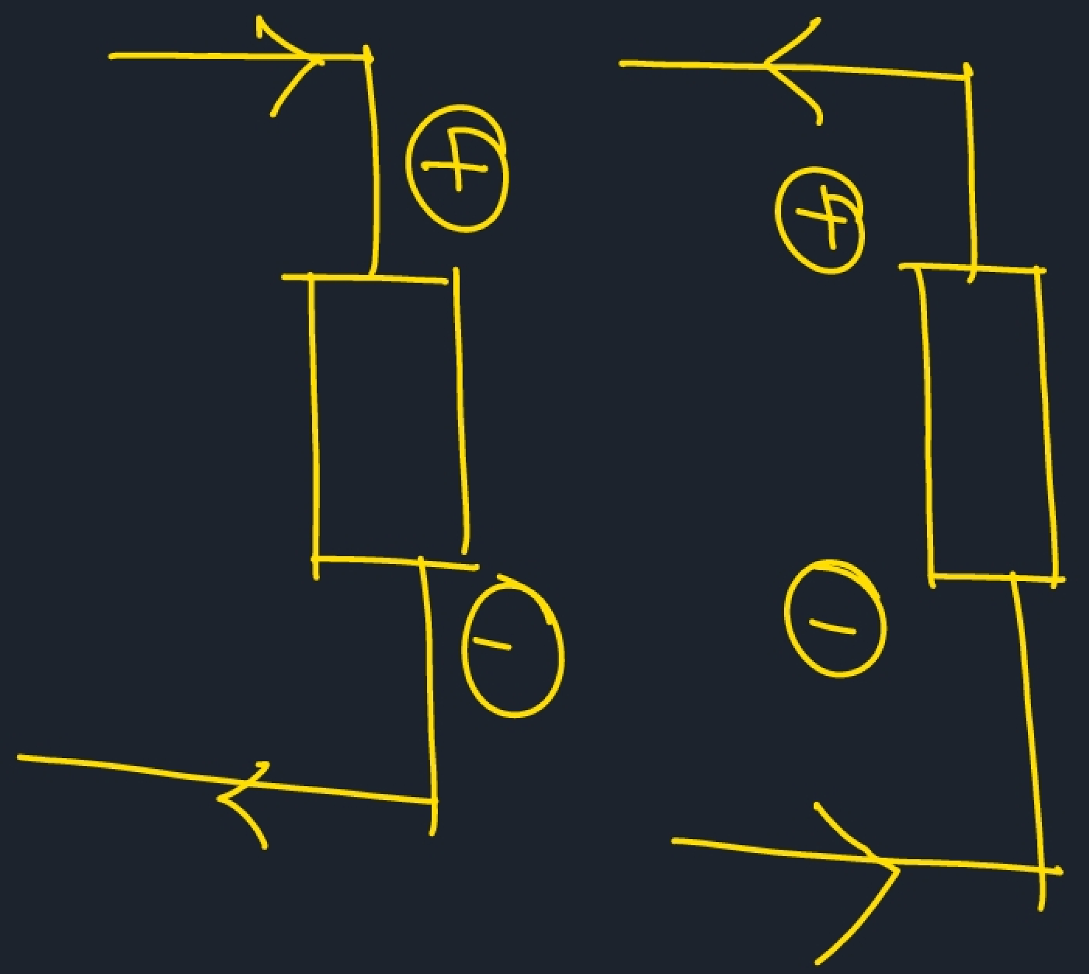
$$p_1(t) : p_2(t) \dots p_n(t)$$
$$= G_1 : G_2 \dots : G_n$$

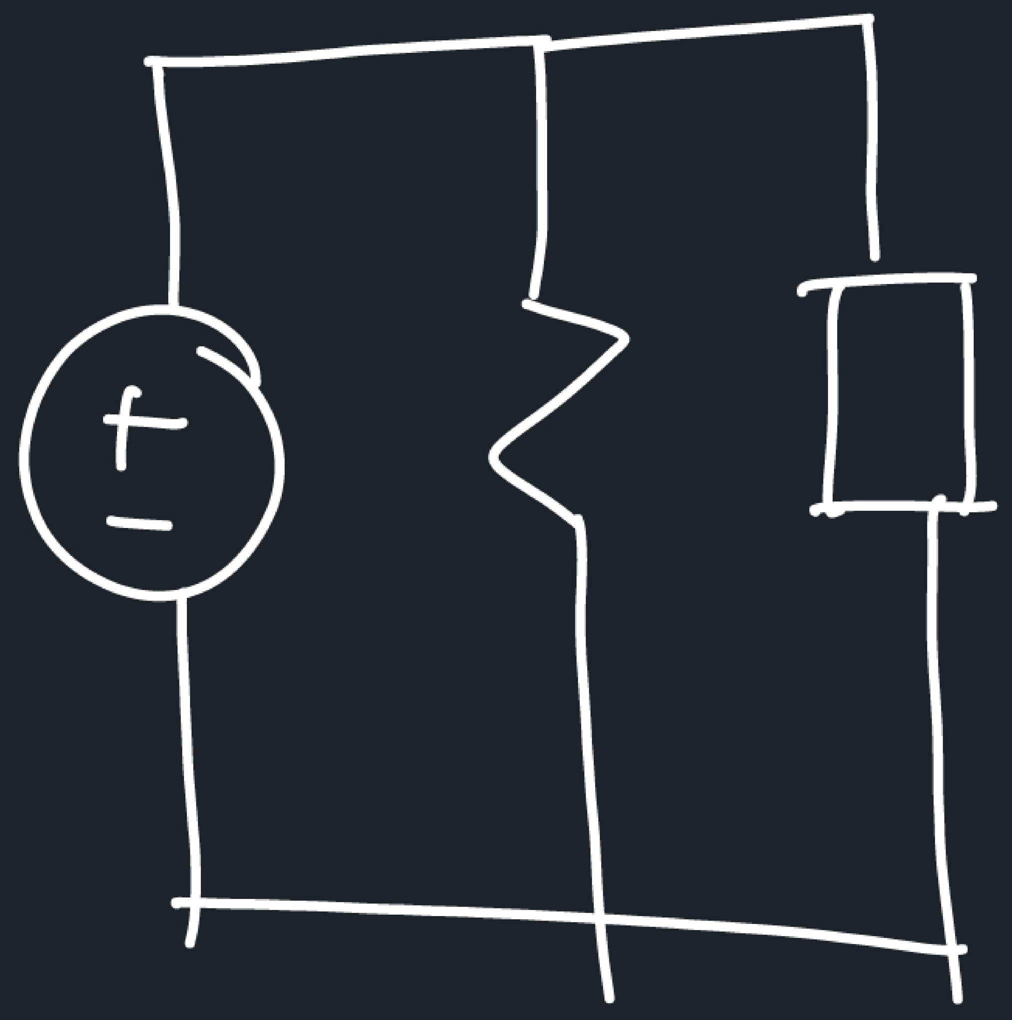
$$p_m(t) = \frac{G_m}{\sum_{j=1}^{n} G_j} p(t)$$

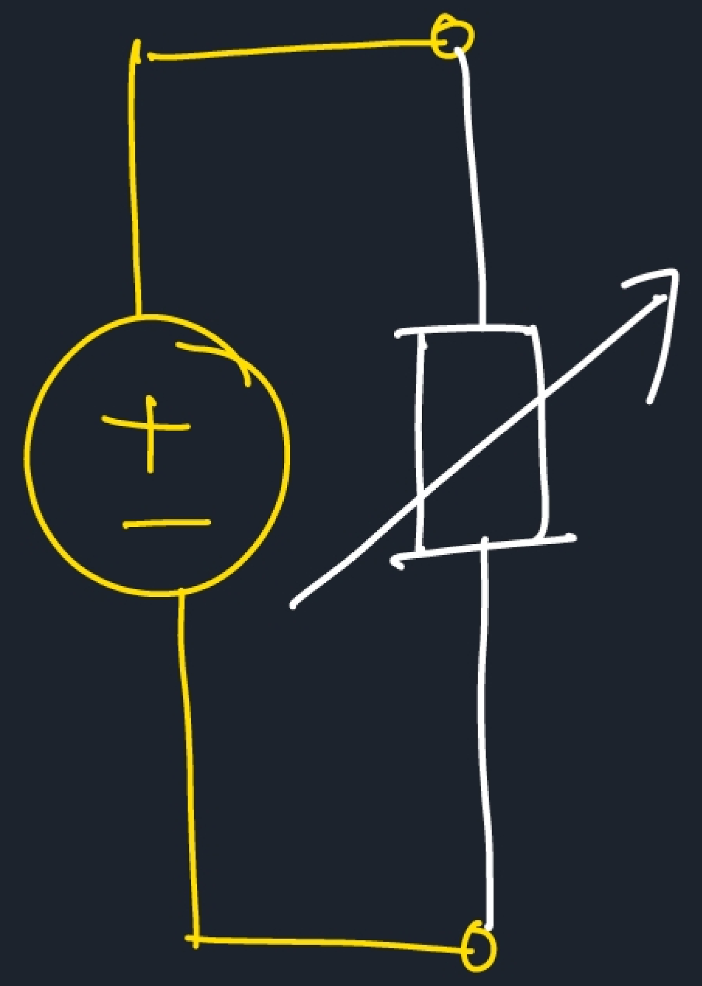

i(t)
R
A
B
+
−
i(t)
A
B
−
+

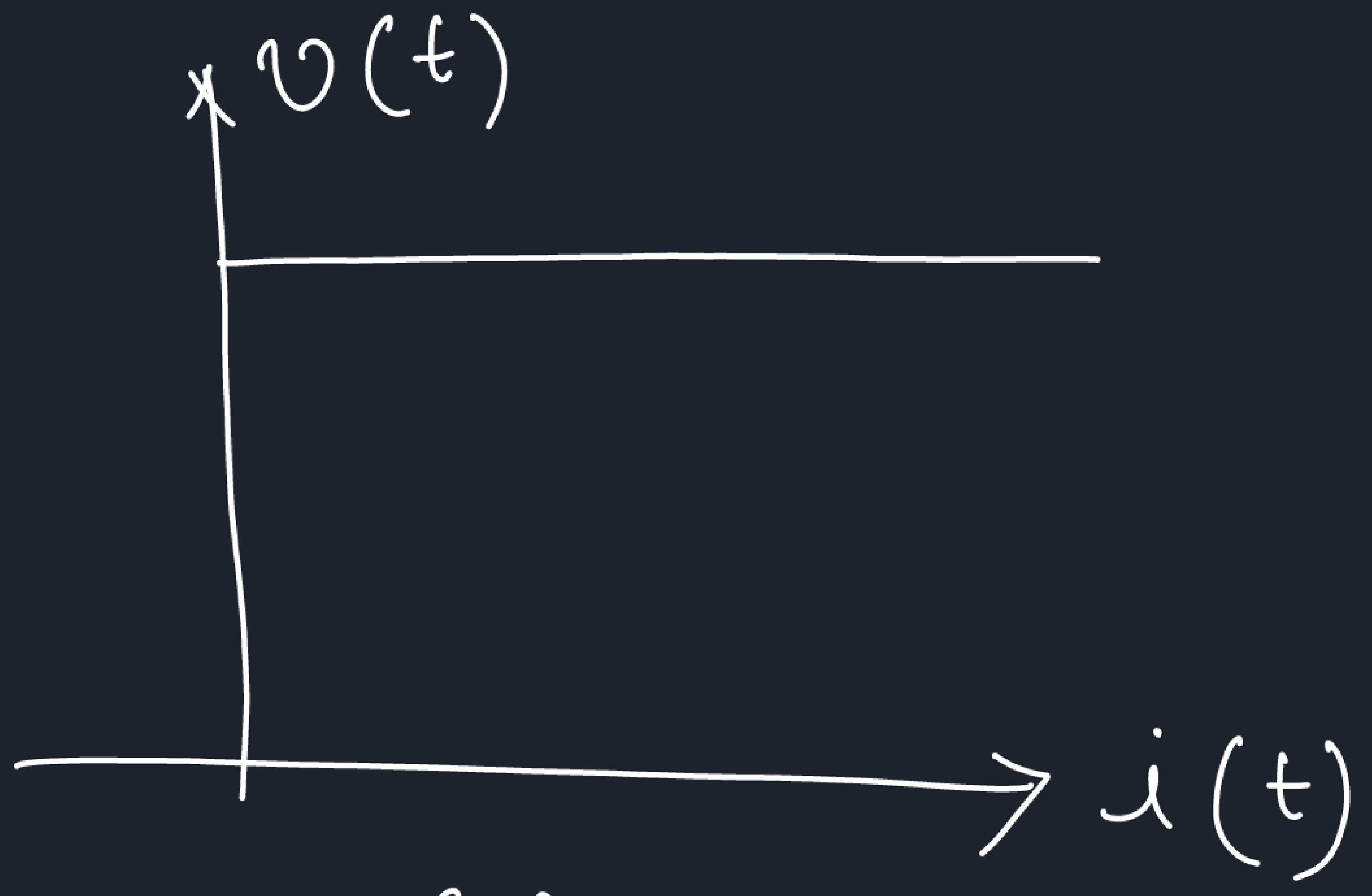

i(t)
+
+
−
+
−
−
i(t)

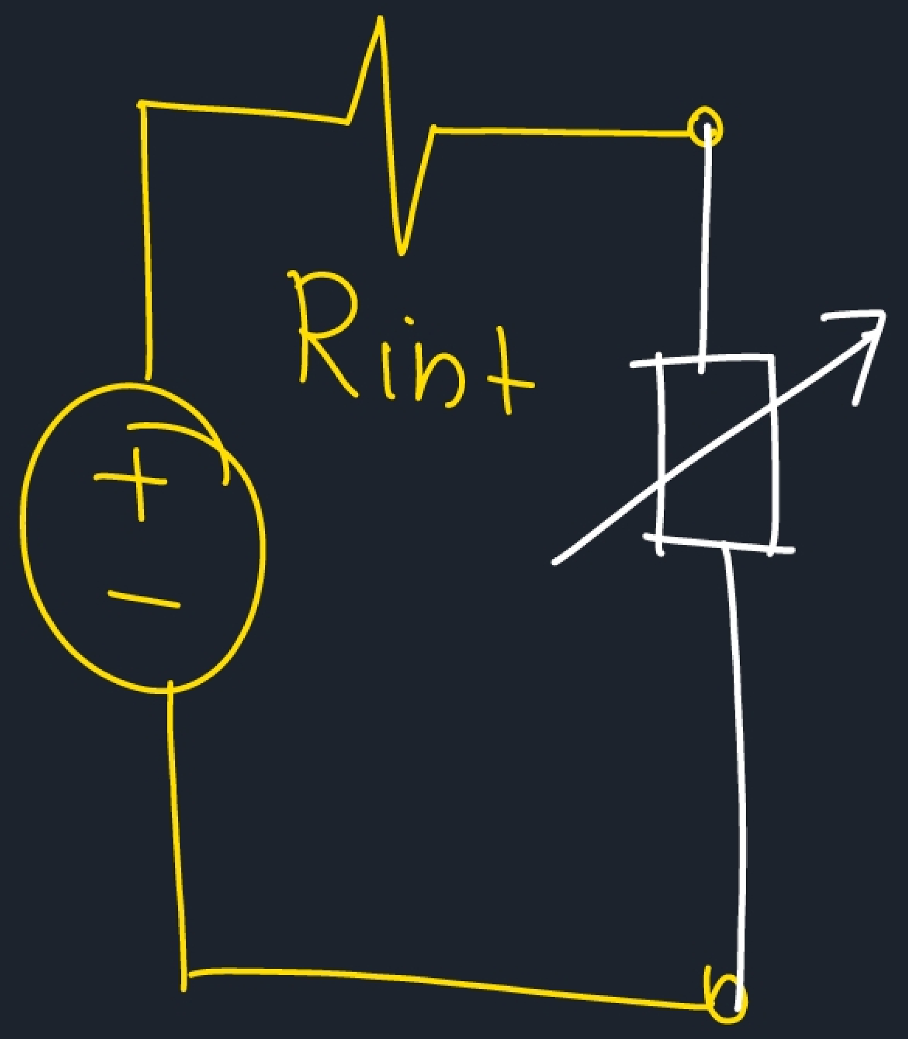

50V
30V
− +
+ −
100W
60W
I = 2A
−
+
10Ω
40W.

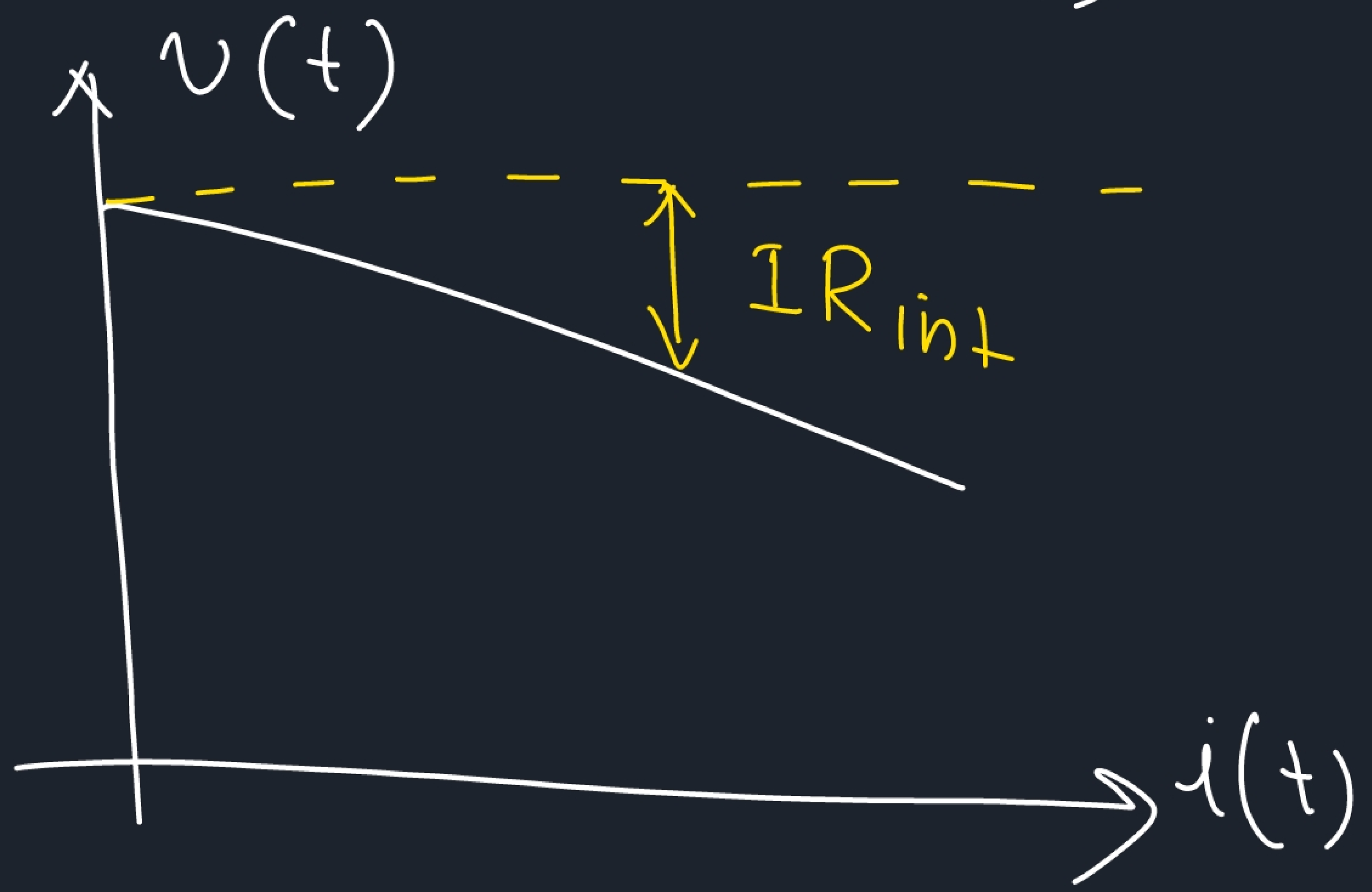

+
−
+
−





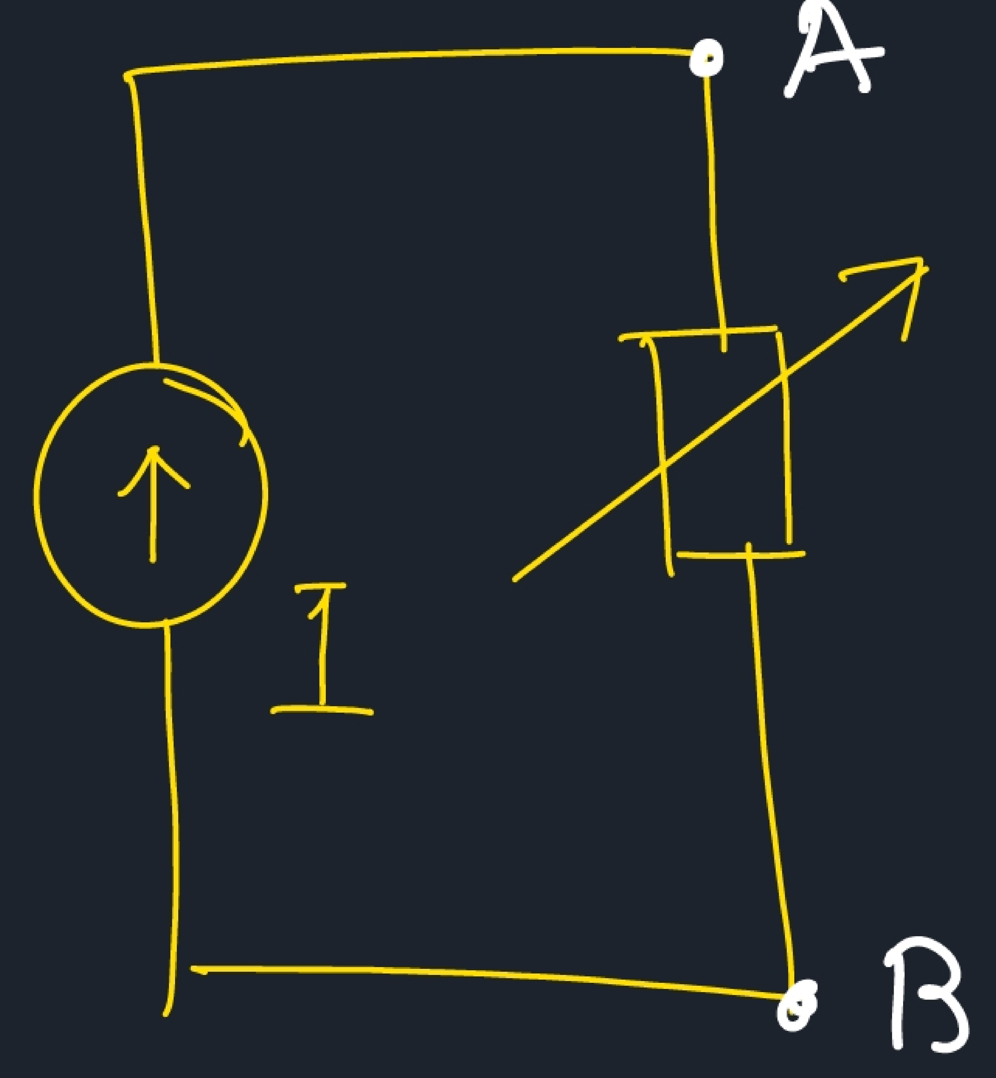

v(t)
i(t)

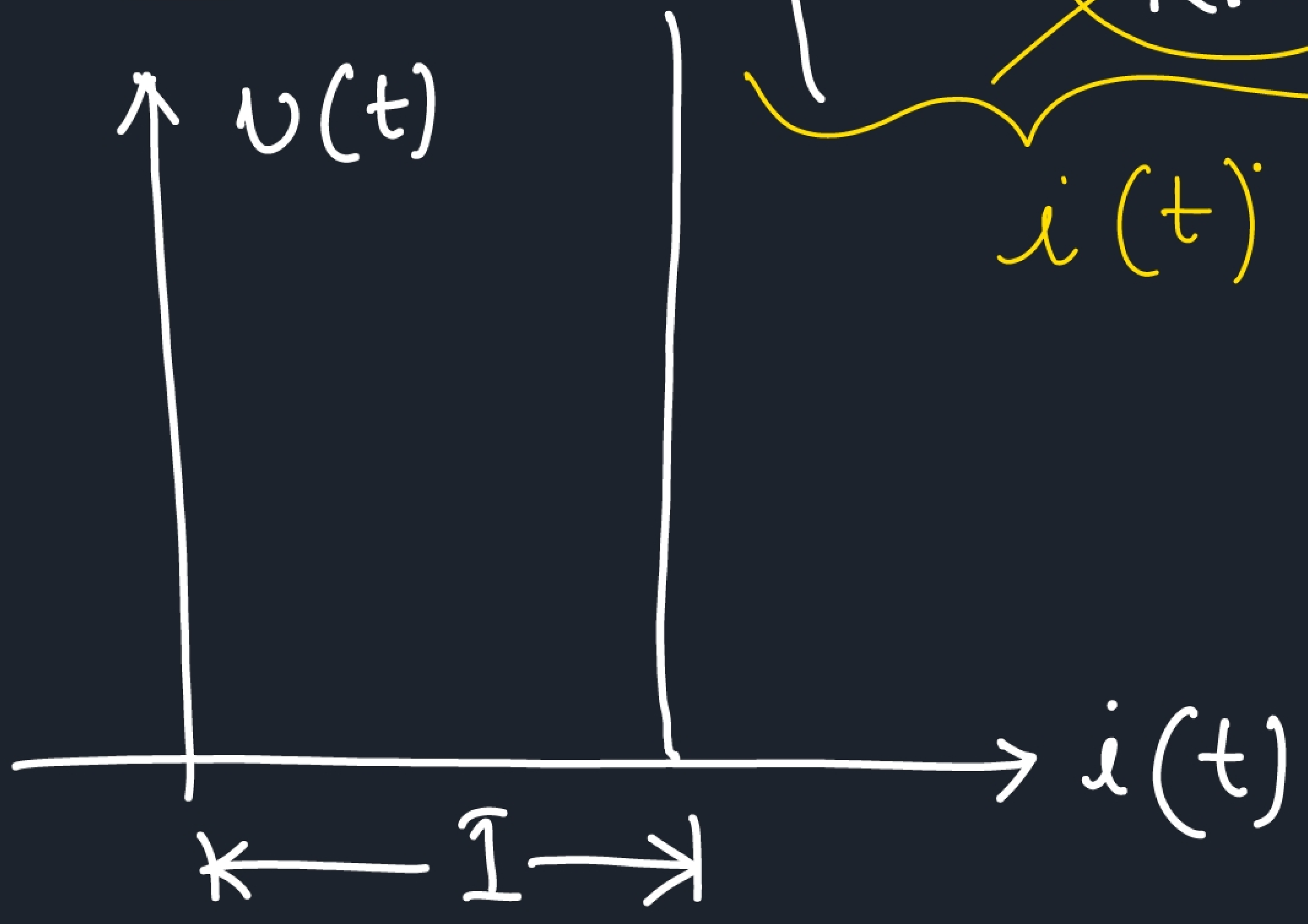

Rint

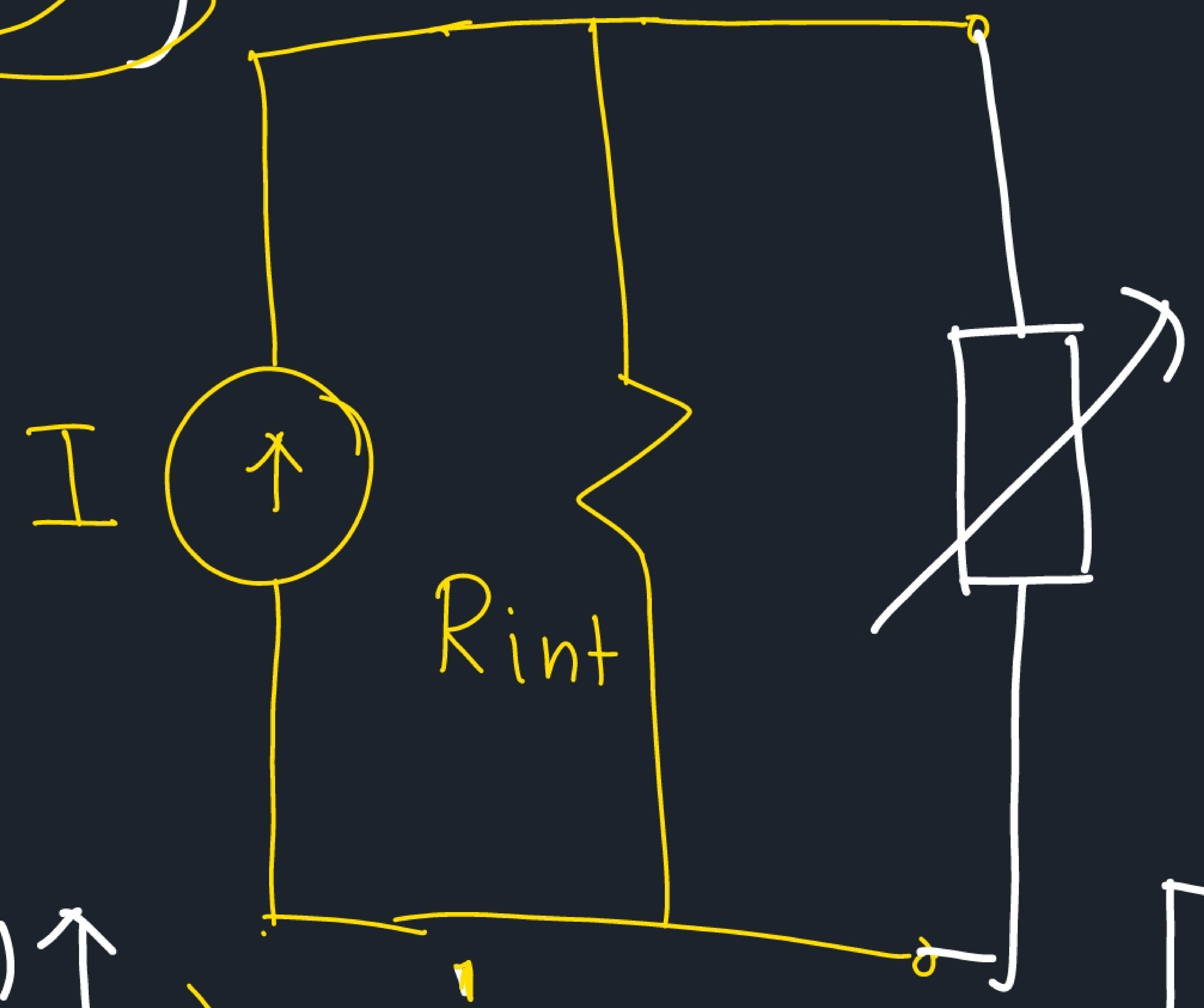

v(t)
IRint
i(t)

Current Source:-

$$\underbrace{I - \cancel{\frac{v(t)}{R_{int}}}^{\approx 0}}_{i(t)} \qquad R_{load} = v(t)$$

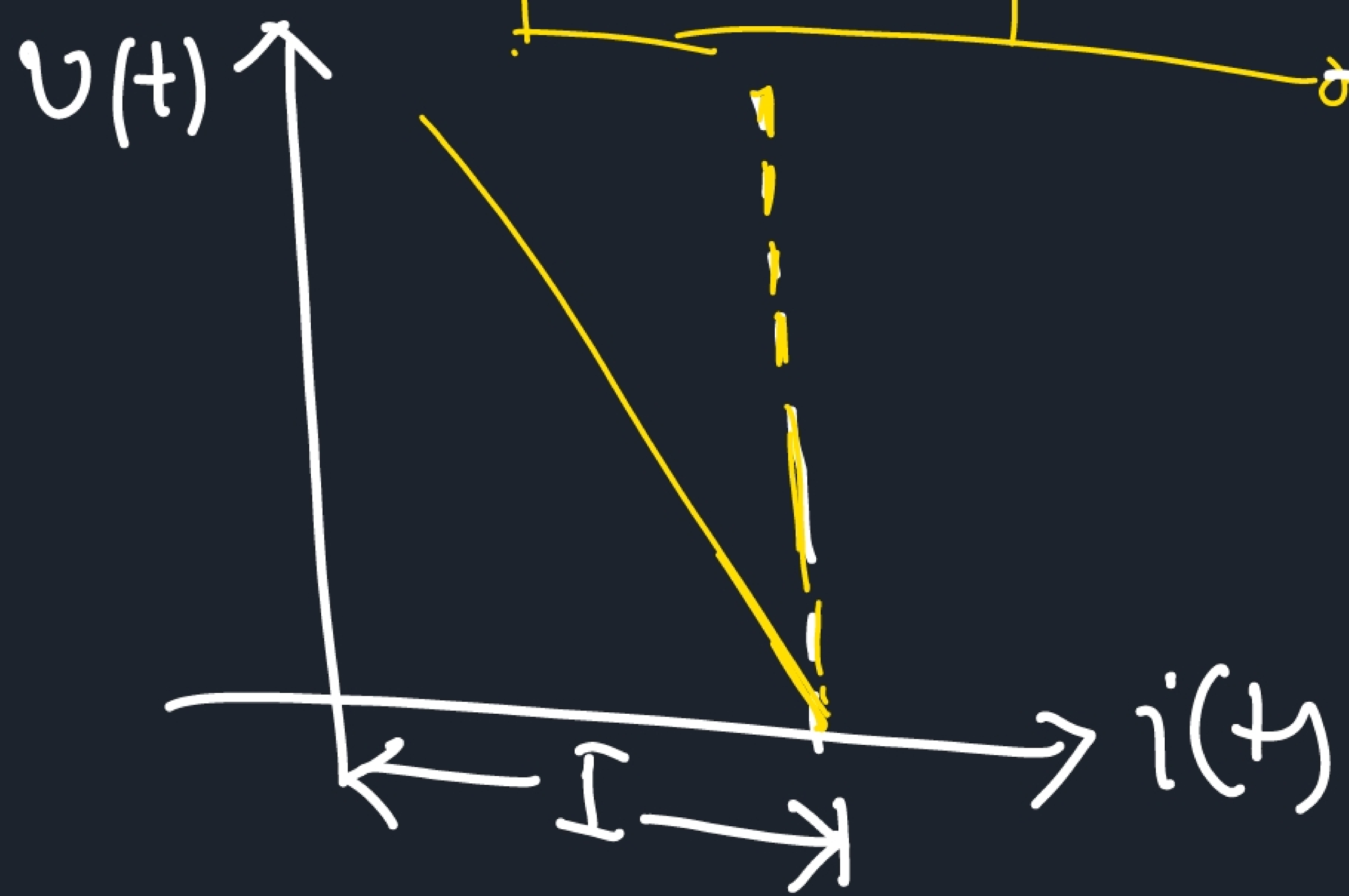


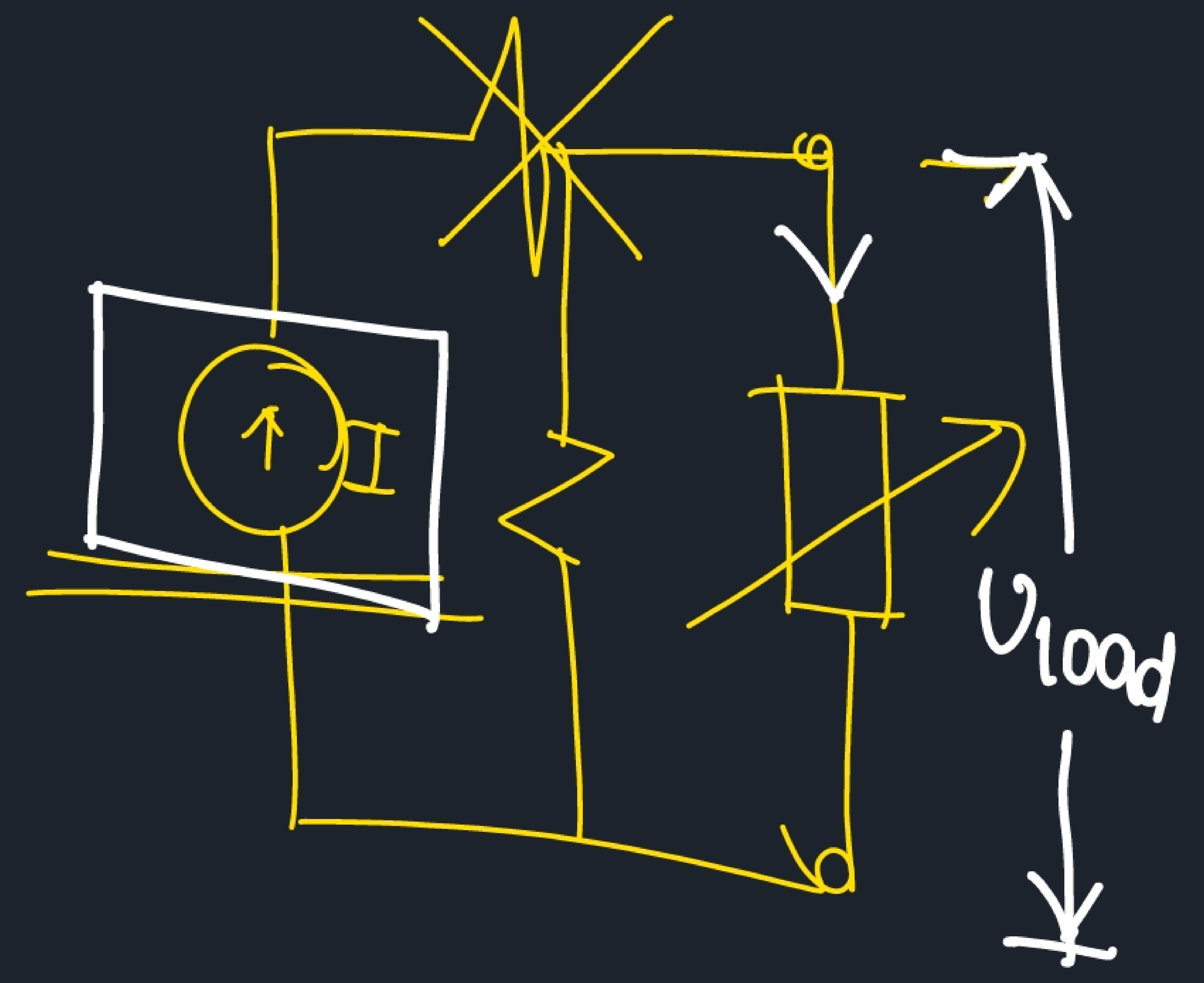


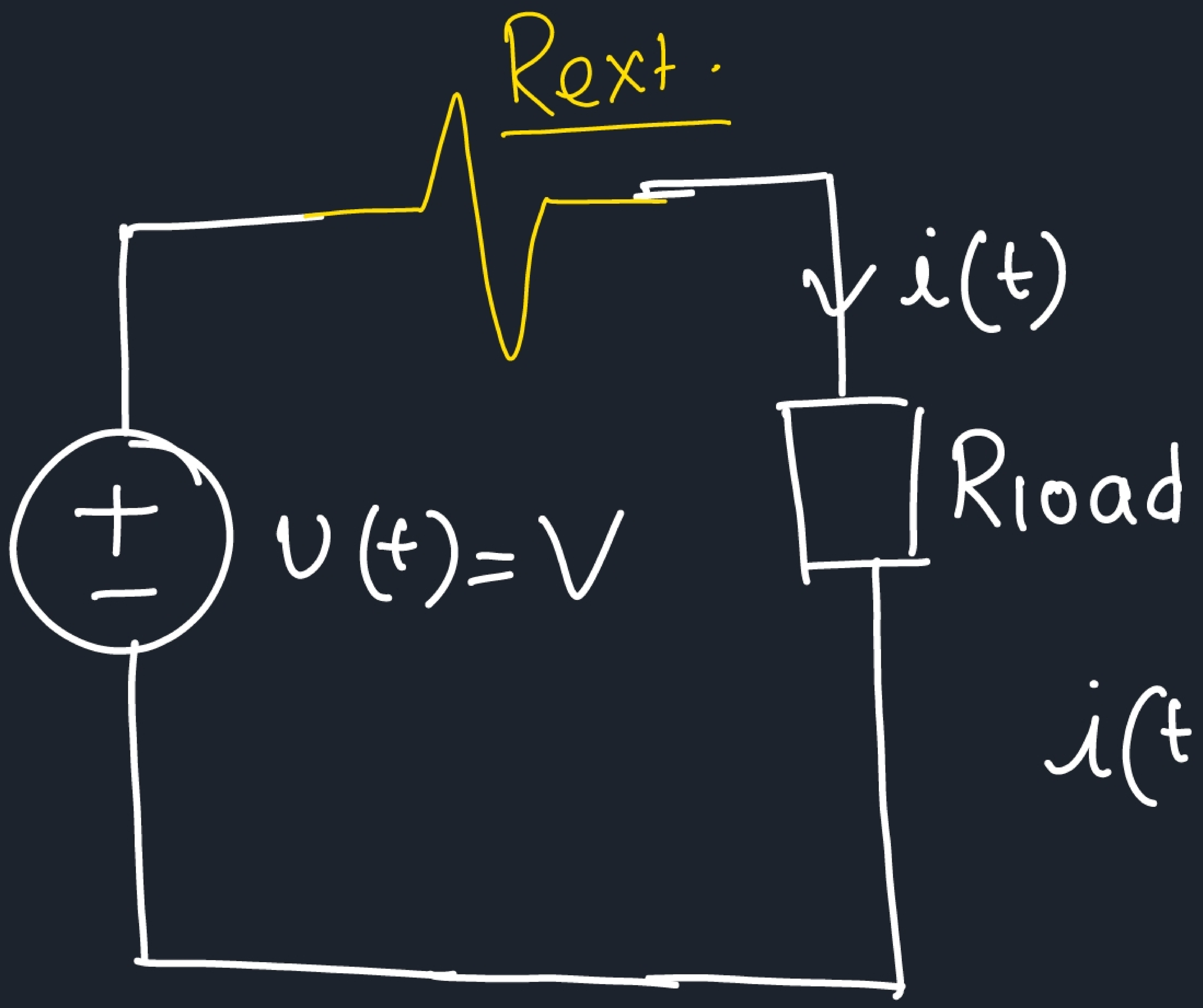


Ideal Current Source.

$$i(t) = I - \frac{v(t)}{R_{int}}.$$

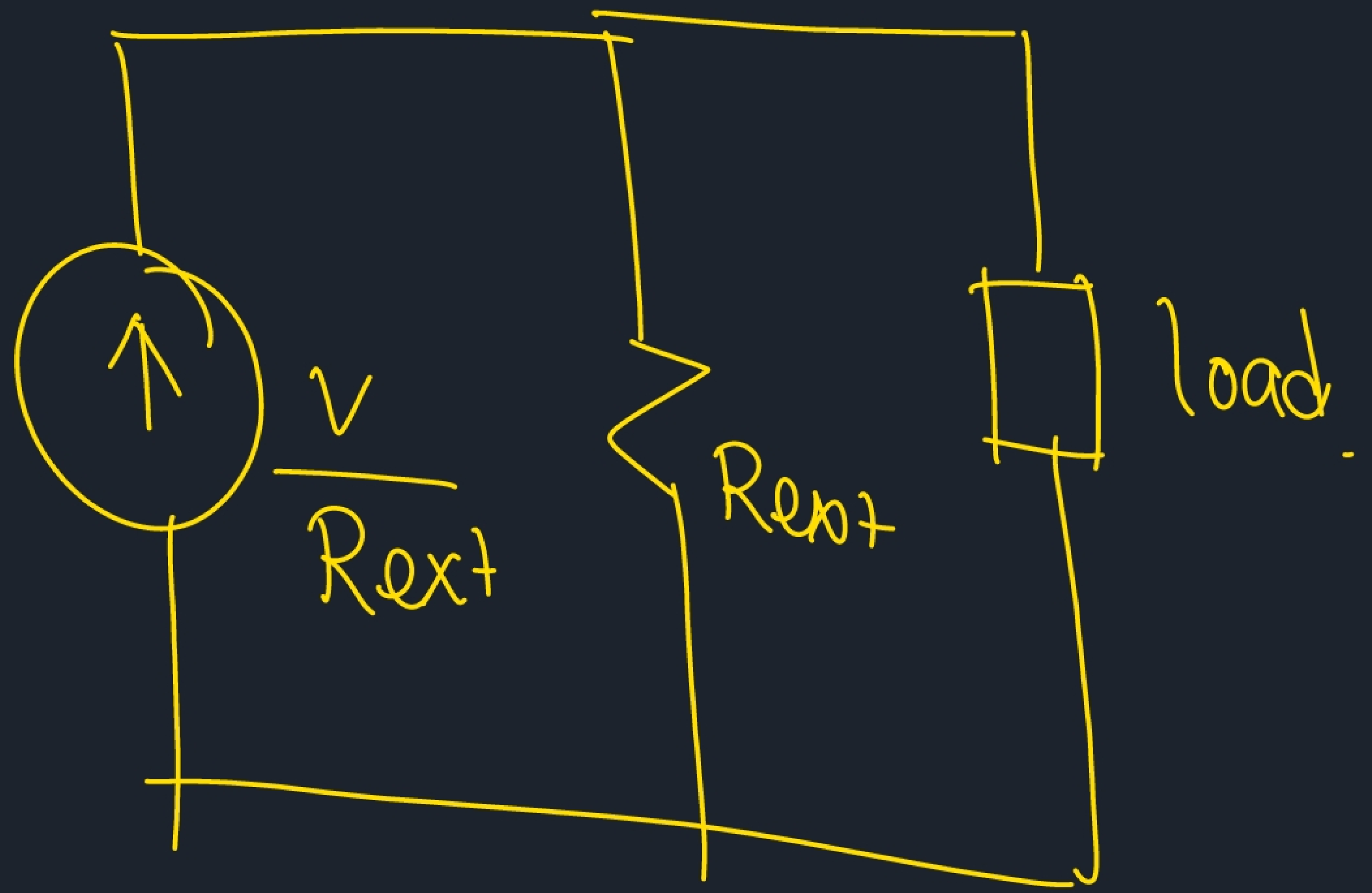




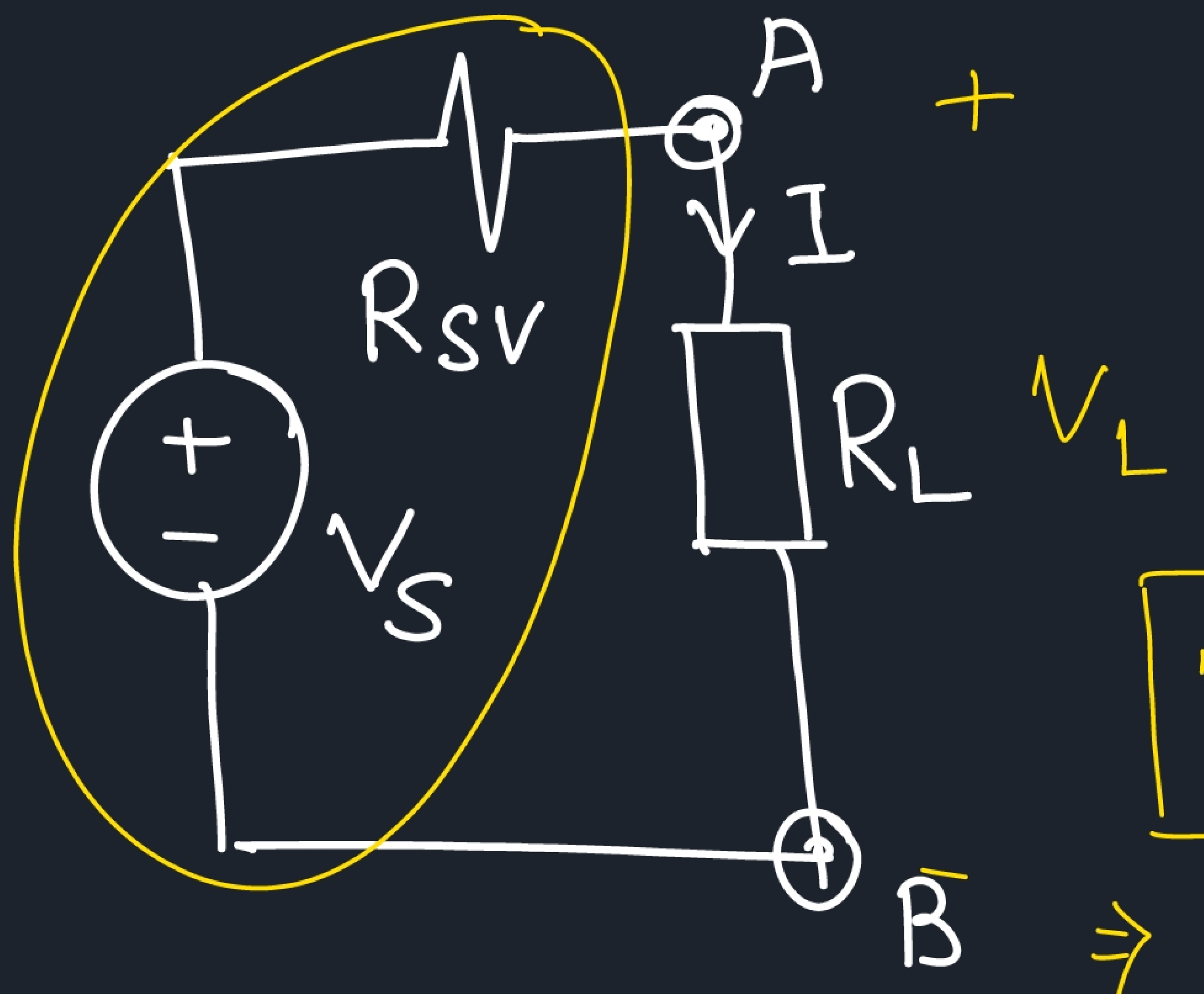


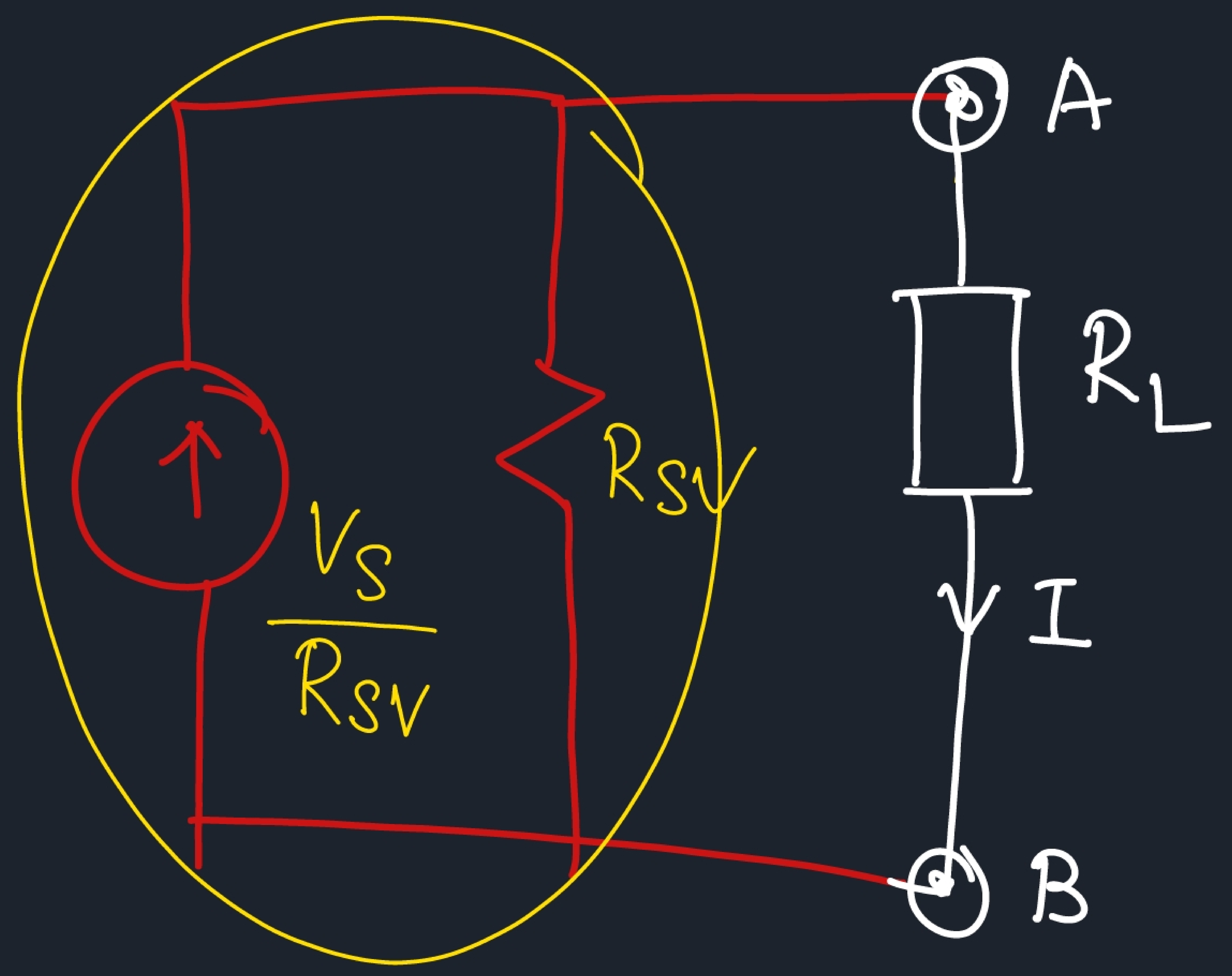
$$i(t) = \frac{v(t)}{R_{load} + R_{ext}}.$$

$$R_{ext} \gg R_{load}$$



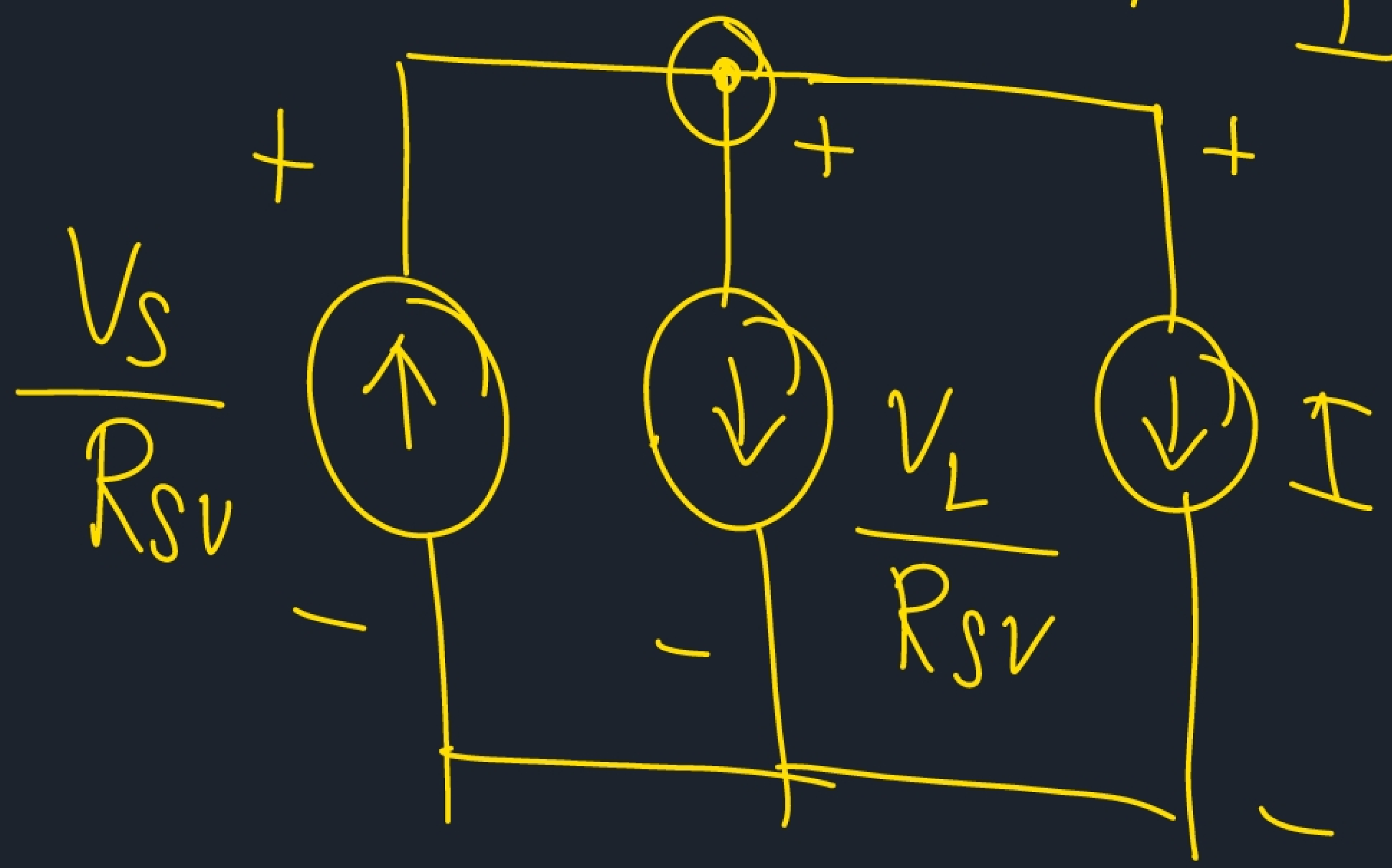
Source Transformation:-



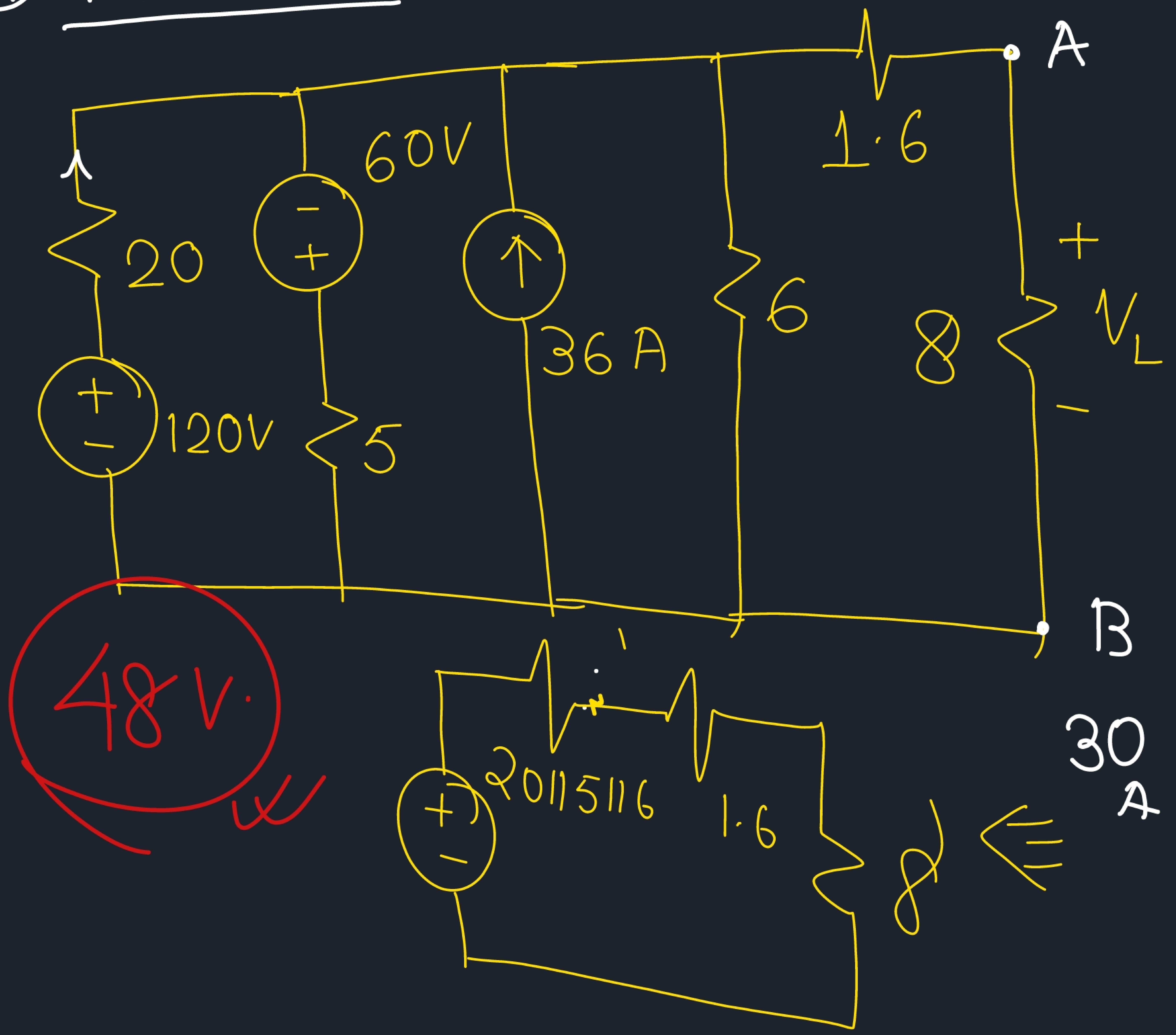


$$\boxed{V_L = V_S - R_{SV} I}$$

$$\Rightarrow I = -\frac{V_L}{R_{SV}} + \frac{V_S}{R_{SV}}$$

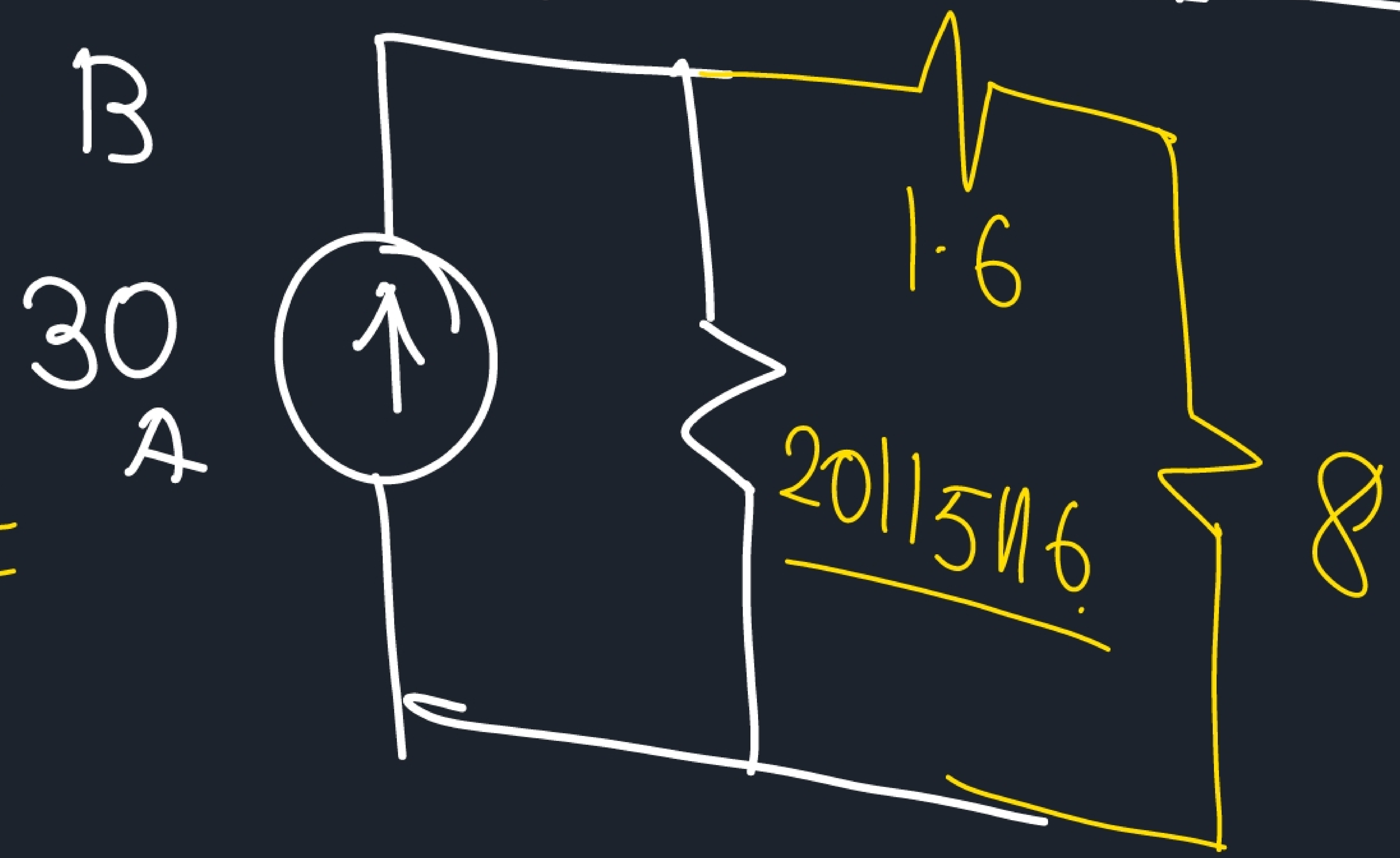


Problem :-



A
B
20
120V
60V
36 A
6
1.6
8
V_L
48V.
20115116
1.6
8

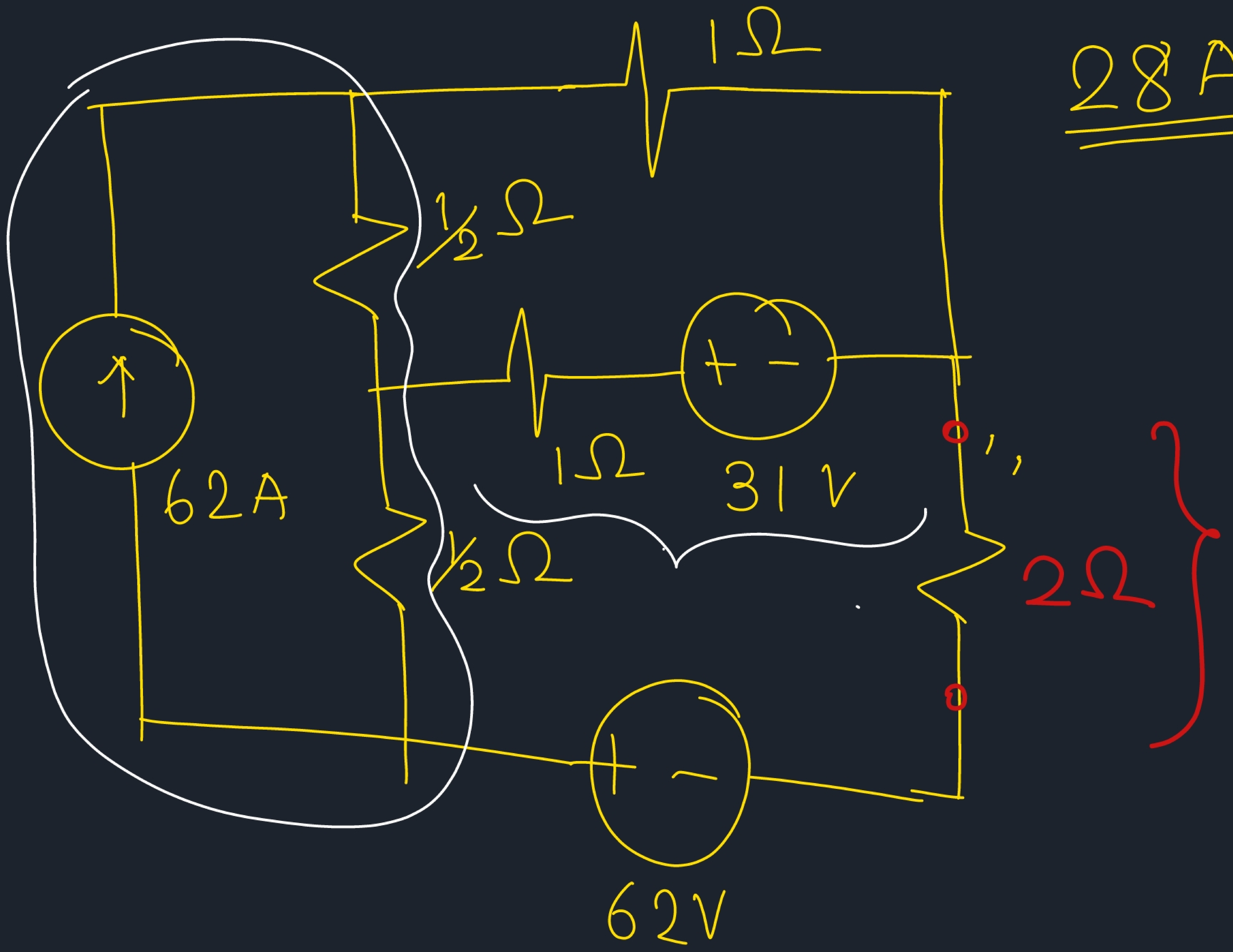
6A
20
12A
5Ω
36 A

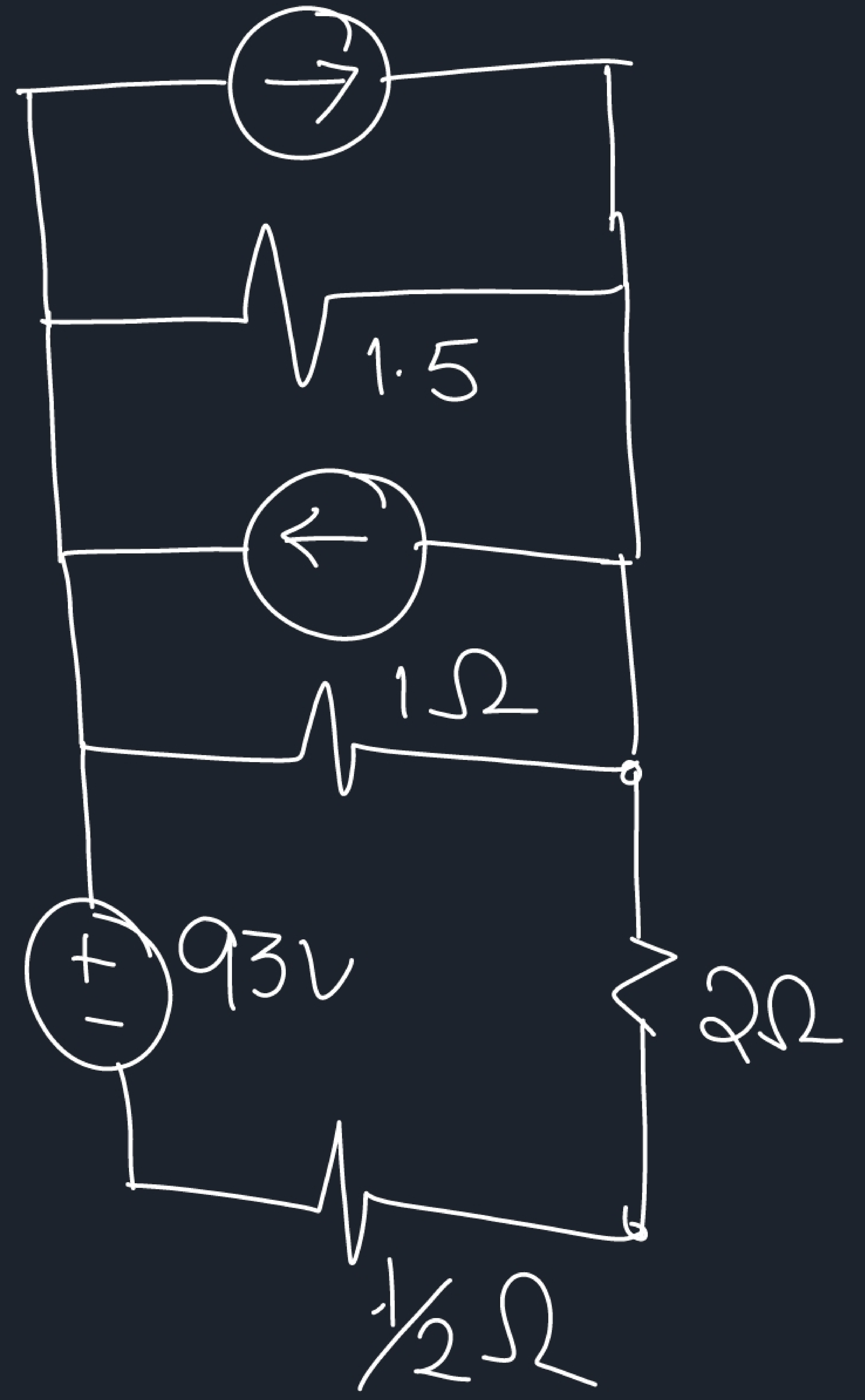


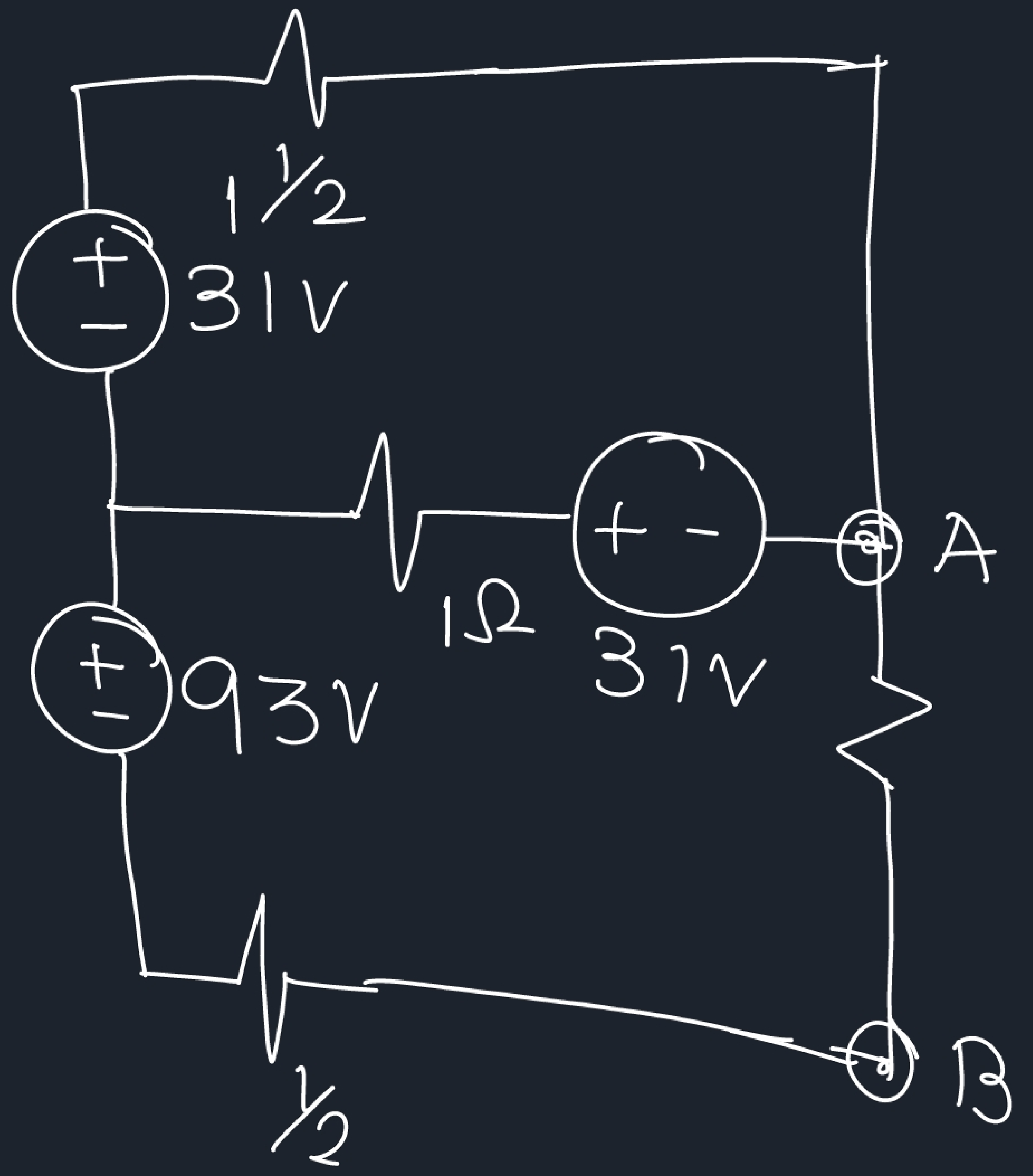
30 A
1.6
20115116
8

28 Amps.

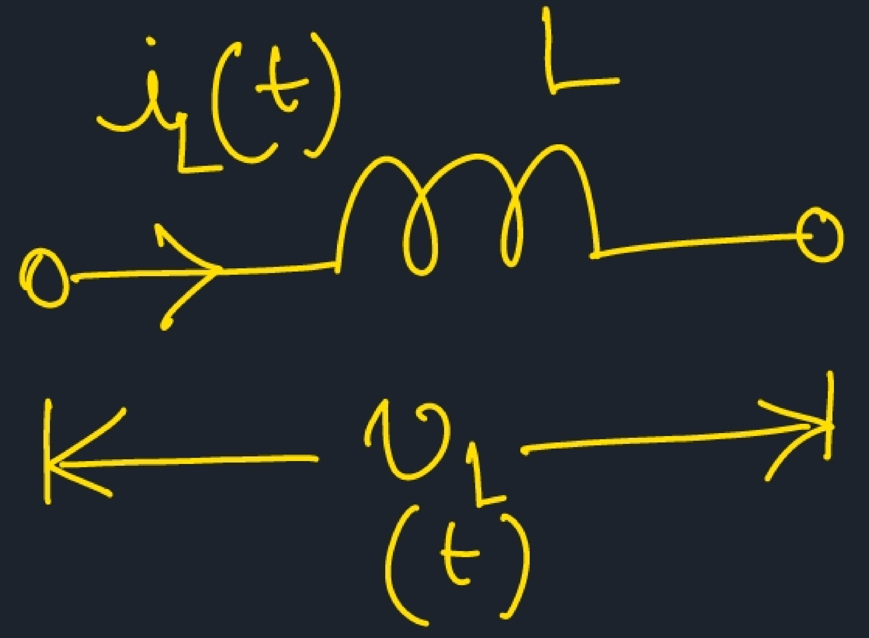
7546







Inductor:-



$$v_L(t) = L\frac{di_L(t)}{dt}$$

$$i_L(t) = \frac{1}{L}\int_{-\infty}^{t} v_L(t)\,dt = \underbrace{\frac{1}{L}\int_{-\infty}^{0} v_L(t)\,dt}_{I_0} + \frac{1}{L}\int_{0}^{t} v_L(t)\,dt$$

$$i_L(t) = I_0 + \frac{1}{L}\underbrace{\int_0^t v_L(t)\,dt}$$

Volt-Sec.

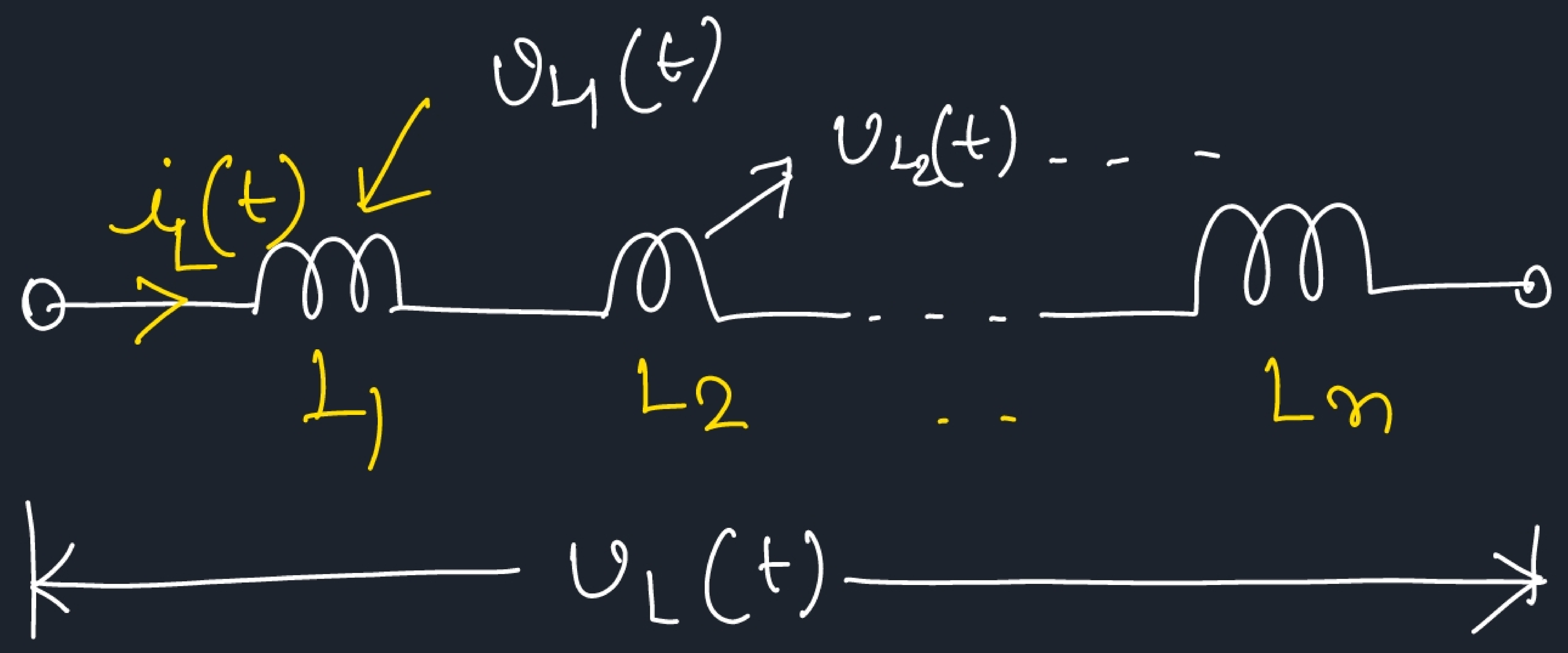
↳ Area of $v_L(t)$ plot.

$$\boxed{N\phi = LI}$$

Ψ = flux linkage

$$V = -N\frac{d\phi}{dt}$$

$$= -L\frac{di}{dt}$$



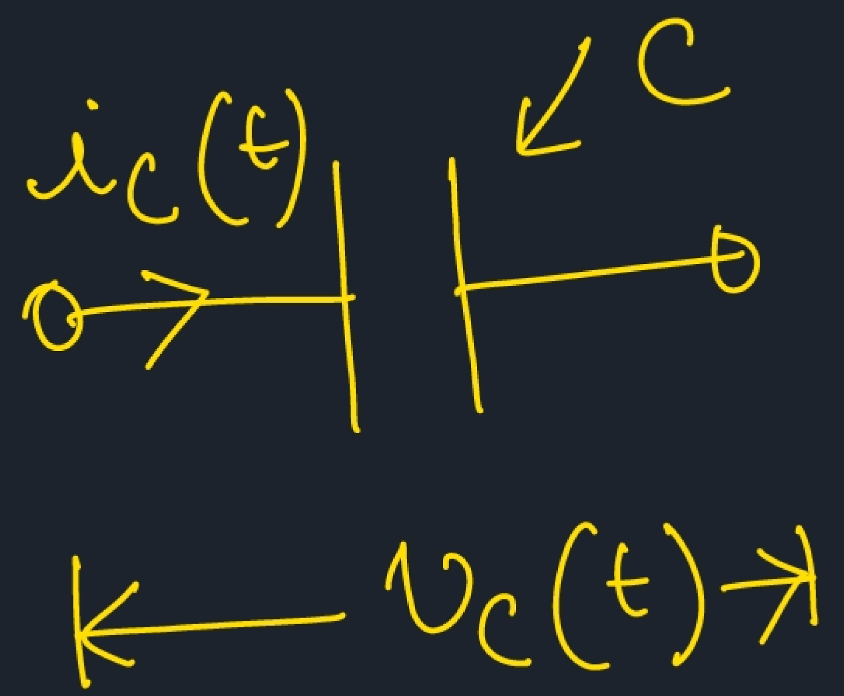
$$v_{L_1}(t) : v_{L_2}(t) \cdots : v_{L_n}(t)$$
$$= L_1 : L_2 : \cdots : L_n$$

$$v_L(t) = v_{L_1}(t) + v_{L_2}(t) + \cdots + v_{L_n}(t)$$
$$= L_1 \frac{di_L(t)}{dt} + L_2 \frac{di_L(t)}{dt} + \cdots + L_n \frac{di_L(t)}{dt}$$
$$= L_{eq}^{S} \frac{di_L(t)}{dt}.$$

$$v_{L_n} = \frac{L_n}{\sum_{j=1}^{n} L_j} v_L(t)$$

$$L_{eq}^{P} = \frac{1}{1/L_1 + 1/L_2 + \cdots + 1/L_n}$$

Capacitor :-



$$\boxed{i_c(t) = C\,\frac{dv_c(t)}{dt}}$$

$$\boxed{v_c(t) = V_c(0) + \frac{1}{C}\int_0^t i_c(t)\,dt}$$

$$v_c(t) = \frac{1}{C}\underbrace{\int_{-\infty}^{t} i_c(t)\,dt}_{\text{Amp-Sec.}} = \underbrace{\frac{1}{C}\int_{-\infty}^{0} i_c(t)\,dt}_{V_c(0)} + \frac{1}{C}\int_0^t i_c(t)\,dt$$

$$C_{eq}^{S} = \frac{1}{1/C_1 + 1/C_2 + \dots + 1/C_n}$$

$$C_{eq}^{P} = C_1 + C_2 + \dots + C_n$$

$$\boxed{v_R(t) = R\, i_R(t)}$$

$$v_L(t) = L \frac{di_L(t)}{dt}$$

$$v_C(t) = \frac{1}{C}\int_{-\infty}^{t} i_C(t)\,dt$$

Linear & Nonlinear Element.

$y = mx$

1. Additivity
2. Homogeneity

$\Rightarrow$ Superposition.

$y = f(x)$

$y_1 = f(x_1)$

$y_2 = f(x_2)$

$y_1 + y_2 = f(x_1 + x_2)$

$ay = f(ax)$

$i_{R_1}(t) \rightarrow v_{R1}(t)$

$i_{R_2}(t) \rightarrow v_{R2}(t)$

$a\, i_R(t) \rightarrow a\, v_R(t)$

$y = mx + c$ $\to 0$

x_1, x_2 Non linear

ax_1

ay_1

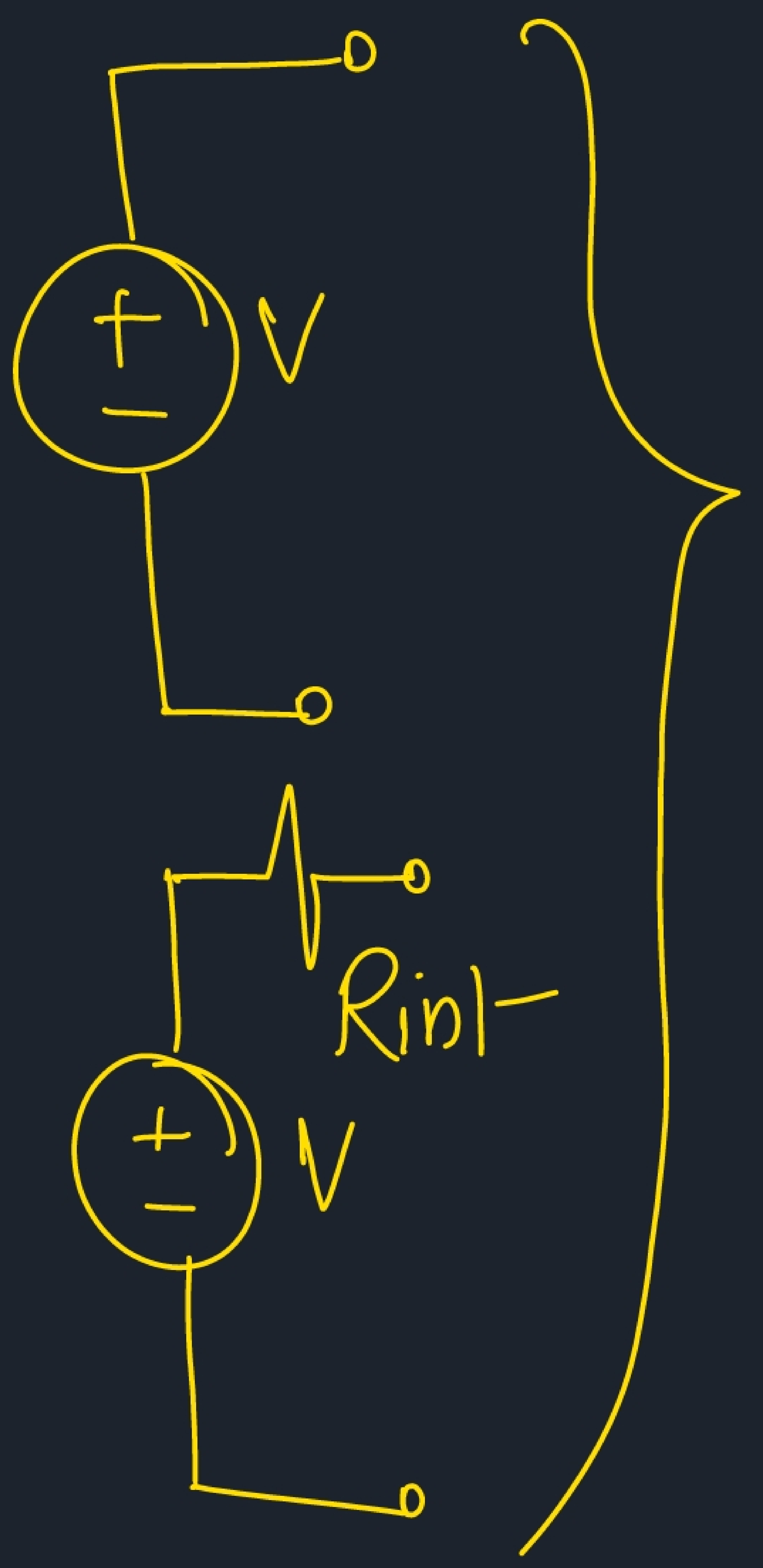
$$\boxed{v_L(t) = L\,\frac{di_L(t)}{dt}}$$

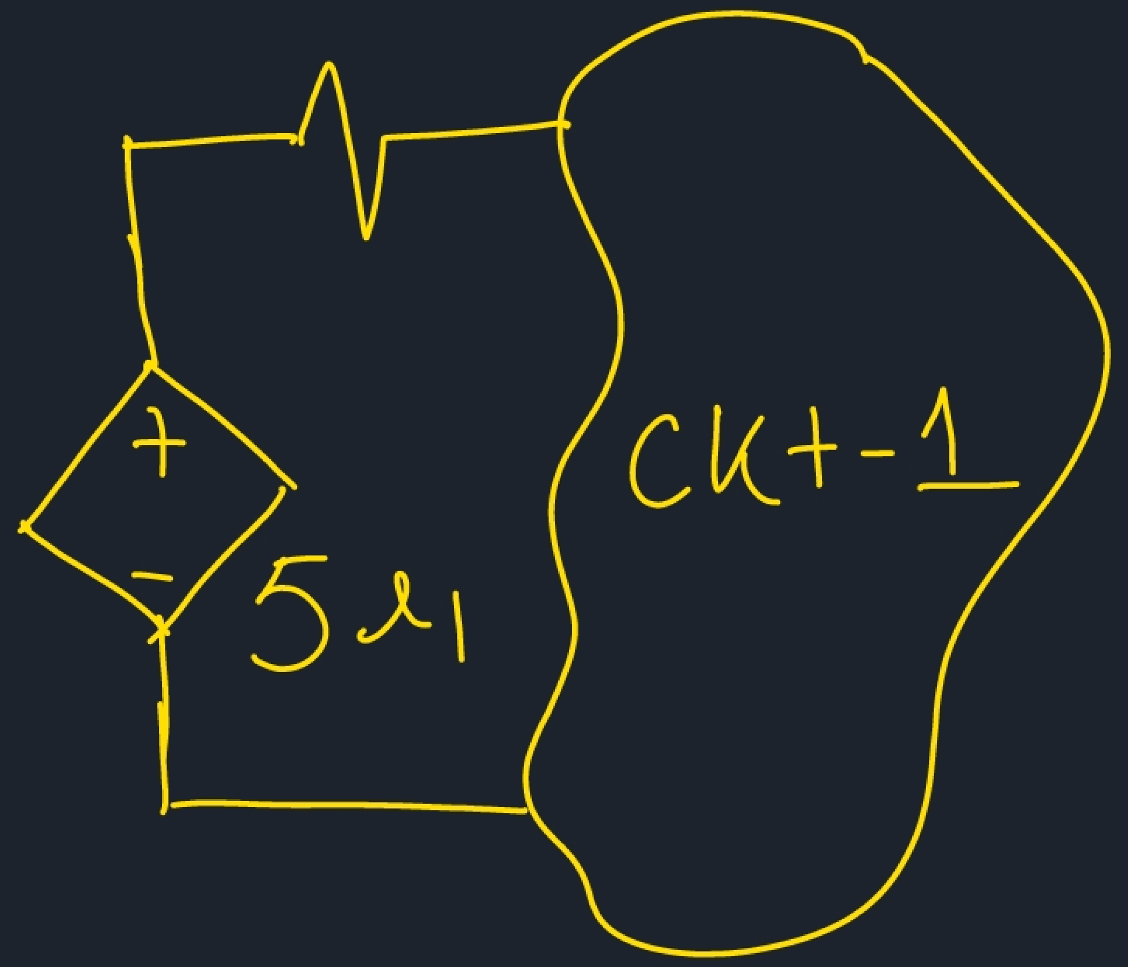
$$i_L(t) = I_0 + \int_0^t v_L(t)\,dt$$

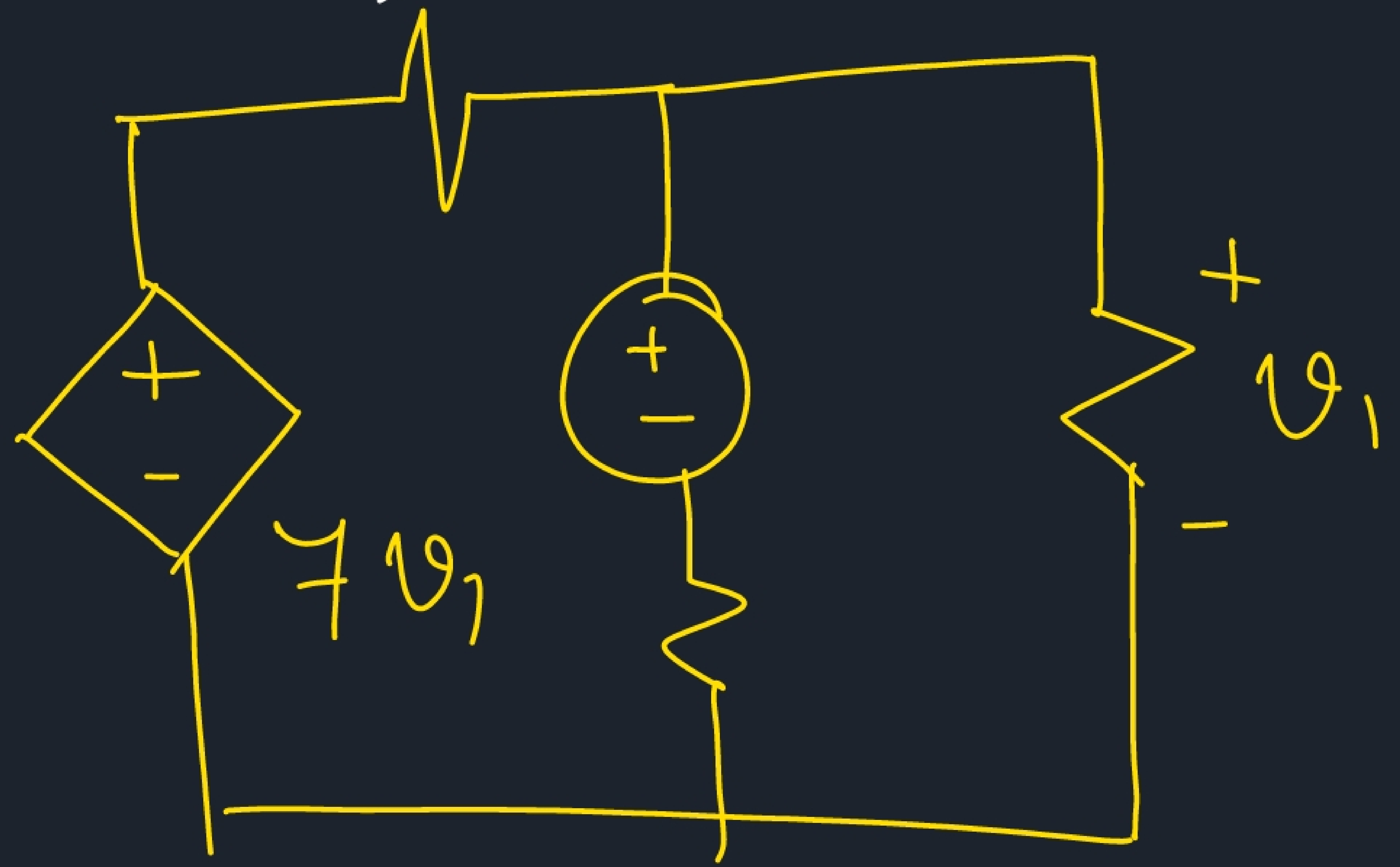
$$v_L(t) = L\,\frac{d\{i_L + k\}}{dt}$$

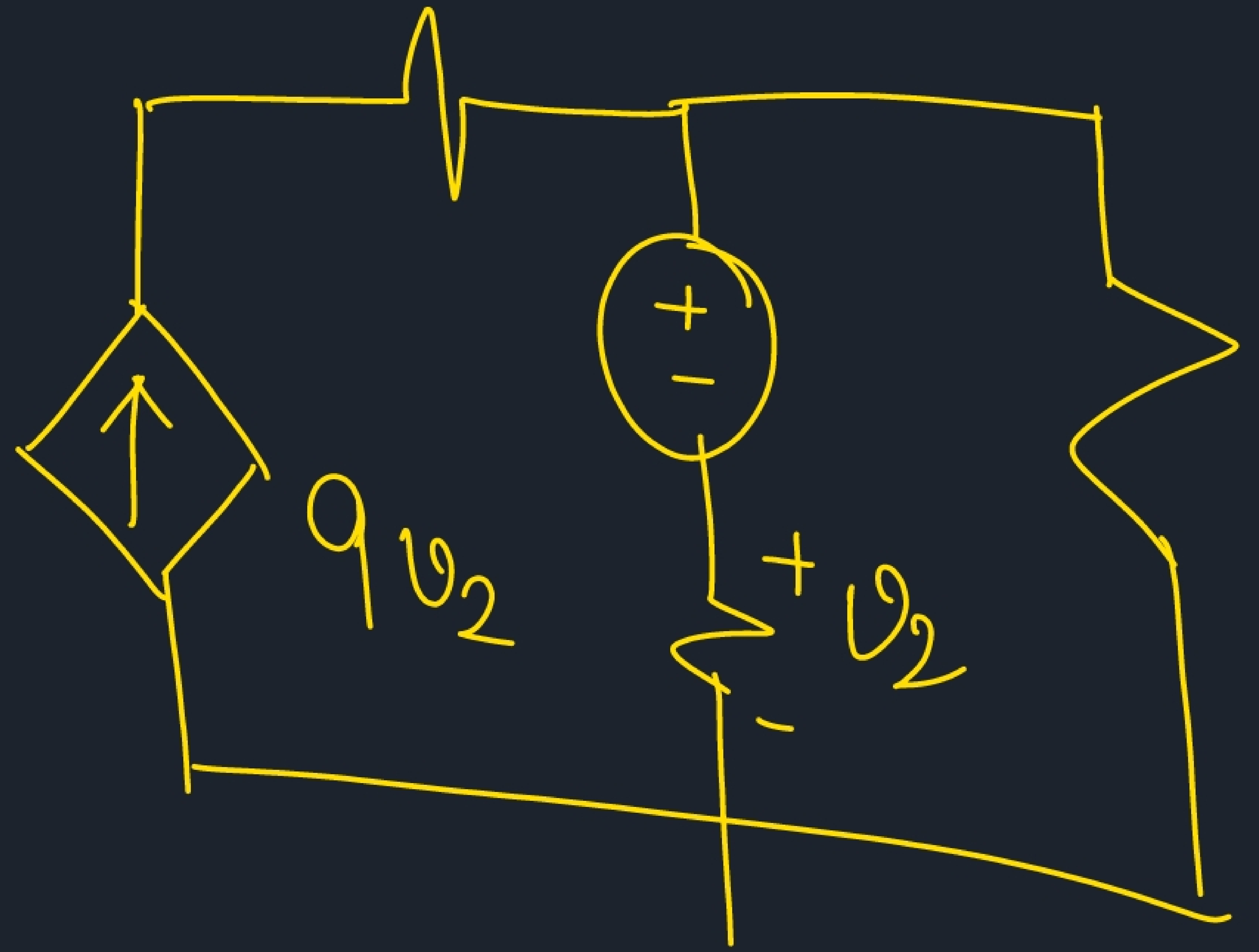
$$i_c(t) = C\,\frac{dv_c(t)}{dt}$$

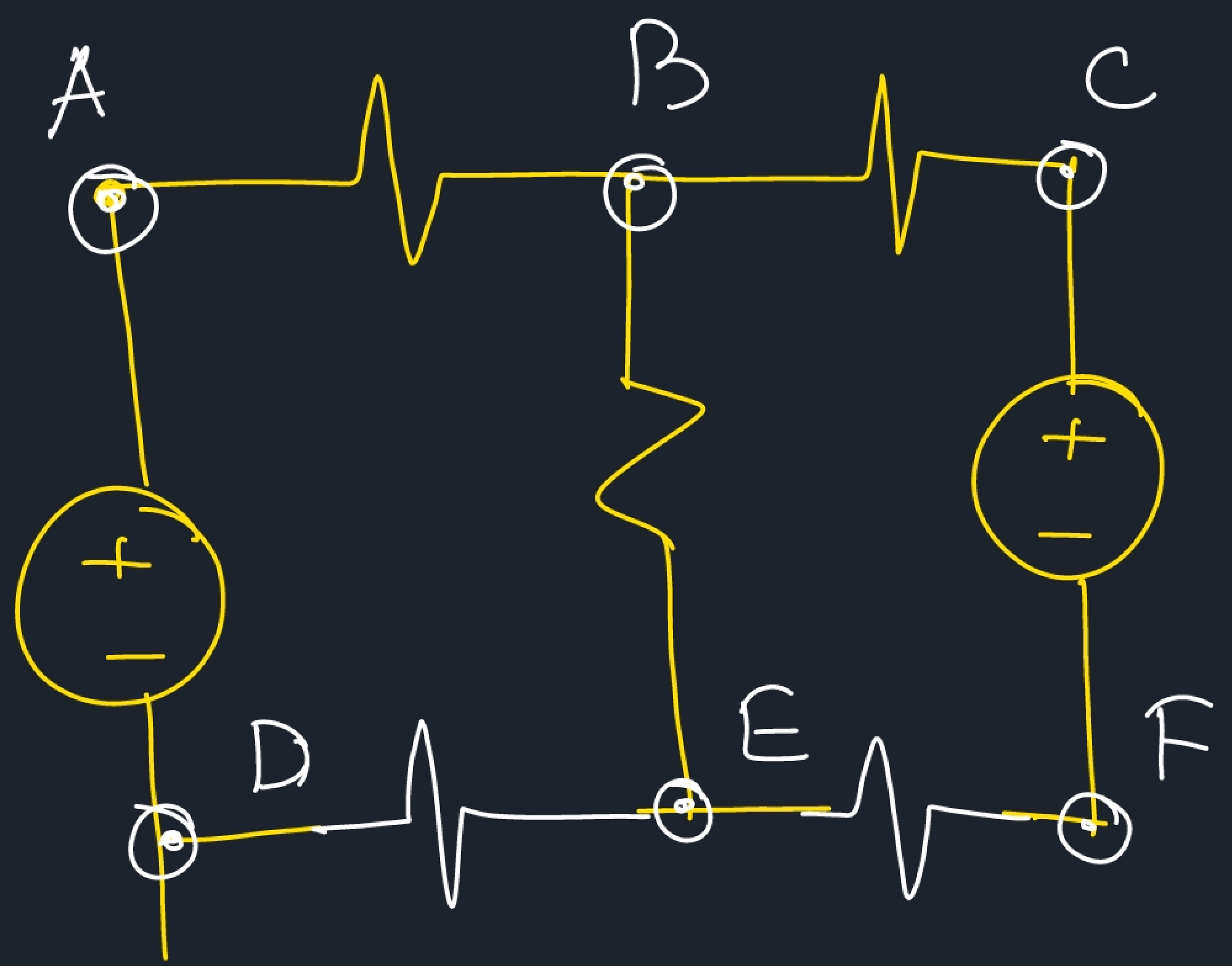
Dependent & Independent :- (Sources)











NODE

JUNCTION ⇒ B, E

BRANCH ⇒

LOOP ⇒

MESH ⇒

NETWORK ANALYSIS.

DIRECT

MESH ANALYSIS

NODAL "

SUPERPOSITION

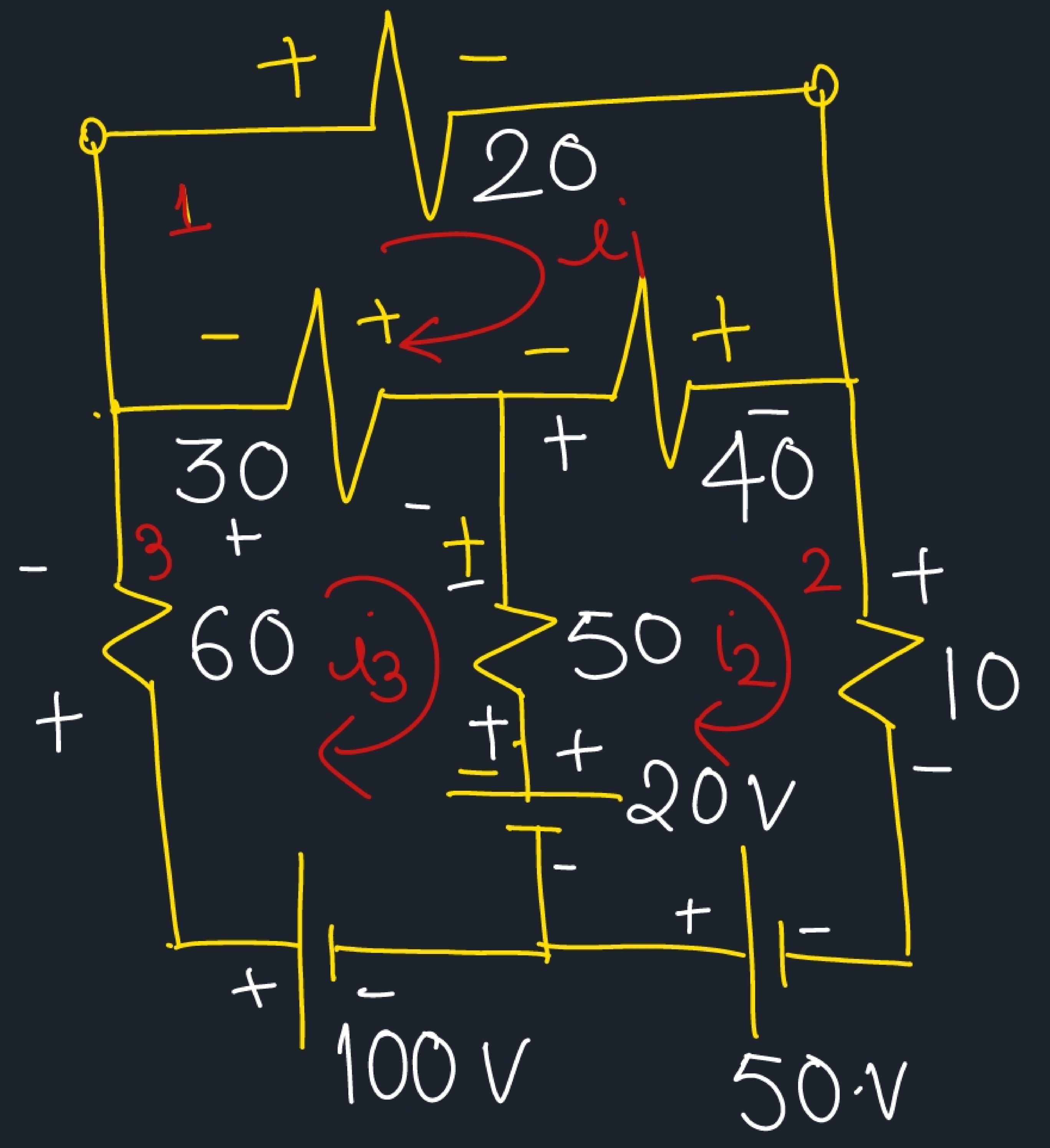
INDIRECT

THEVENIN'S

NORTON'S

Y-Δ Transform.

MESH ANALYSIS:-



$$I = f(i_1, i_2, i_3)$$

MESH-1.

$$-20i_1 - 40(i_1 - i_2) - 30(i_1 - i_3) = 0 \quad \text{....(i)}$$

$$\Rightarrow i_1(20+40+30) - i_2(40) - i_3(30) = 0$$

MESH-2

$$-40(i_2 - i_1) - 10i_2 + 50 + 20 - 50(i_2 - i_3) = 0 \quad \text{— (ii)}$$

MESH-3.

$$-60i_3 - 30(i_3 - i_1) - 50(i_3 - i_2) - 20 + 100 = 0 \quad \text{...(iii)}$$