CSE 251: Electronic Devices and Circuits

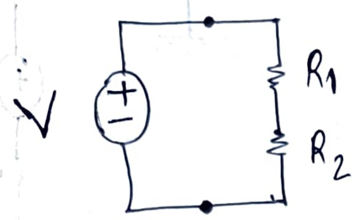
Summer 24

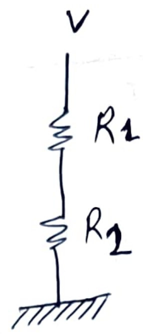
(Before Mid)

CSE - 251

Date: 02·06·24
Lecture - 01

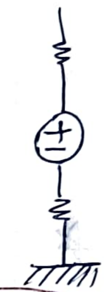
Loop Representation





Rules of Line representation:

Non-floating (Grounded)



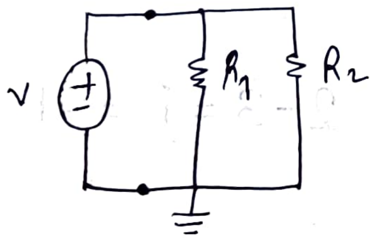
floating

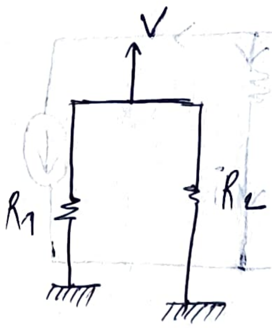
(i) Decide ground

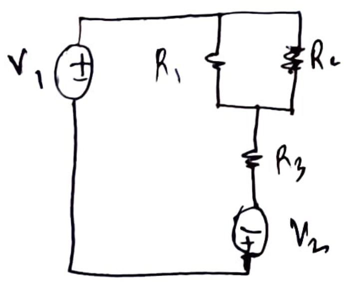
(ii) floating voltage sources should be minimized

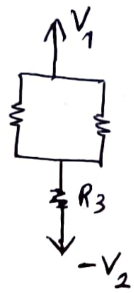
(iii) There is no way to replace a floating voltage source

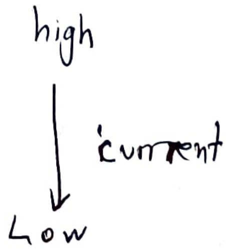
Line Representation

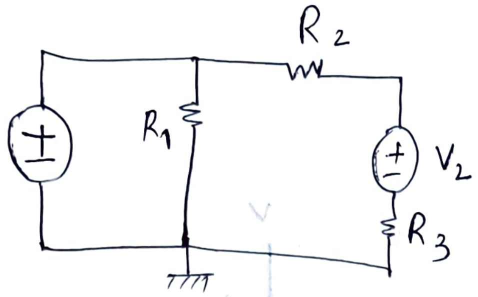


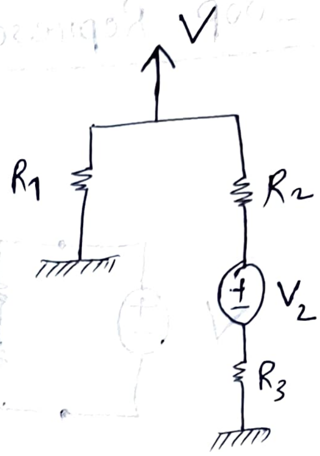


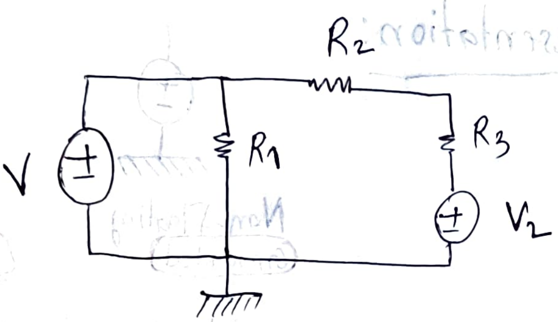


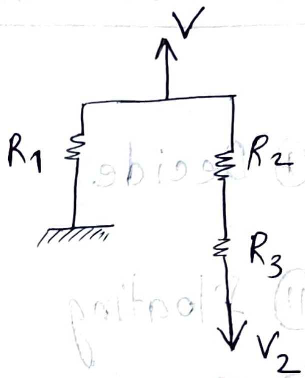


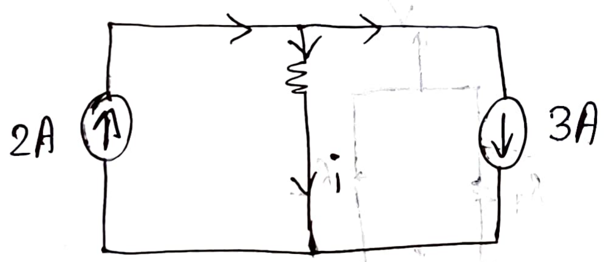




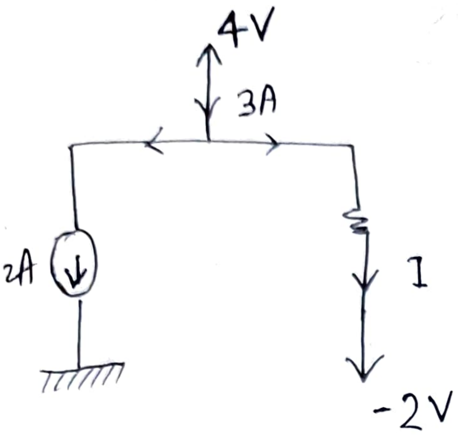








$\Rightarrow \; 2 - 3 = i = -1$

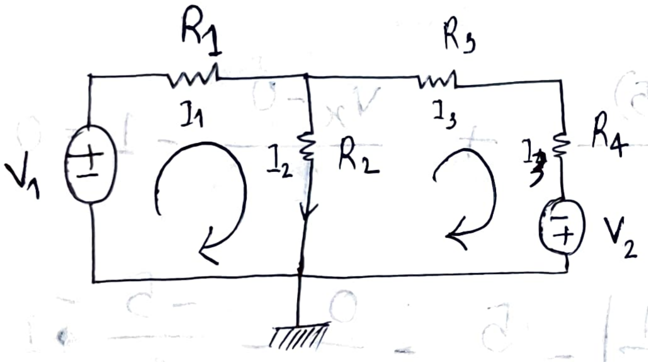


$\boxed{-\text{entering} + \text{exiting} = 0}$

$-3 + 2 + I = 0$

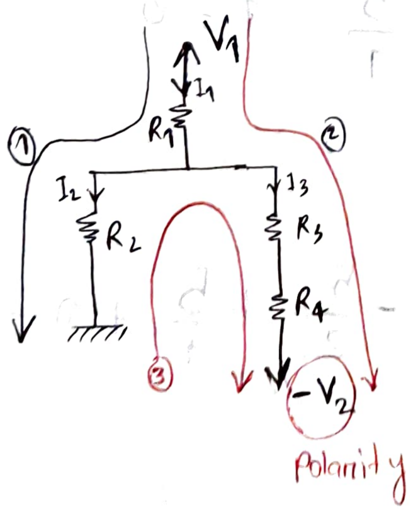
$\Rightarrow I = 1$

KVL



$$\begin{cases} ① (I) & I_1 R_1 + I_2 R_2 - V = 0 \\ ③ (II) & I_3 R_3 + I_3 R_4 - V - I_2 R_2 = 0 \\ ② (III) & -V + I_1 R_1 + I_3 R_3 + I_3 R_4 - V_2 = 0 \end{cases}$$

$\Downarrow$



(I) ① $V_1 - 0 = I_1 R_1 + I_2 R_2$

$\Rightarrow I_1 R_1 + I_2 R_2 - V_1 = 0$

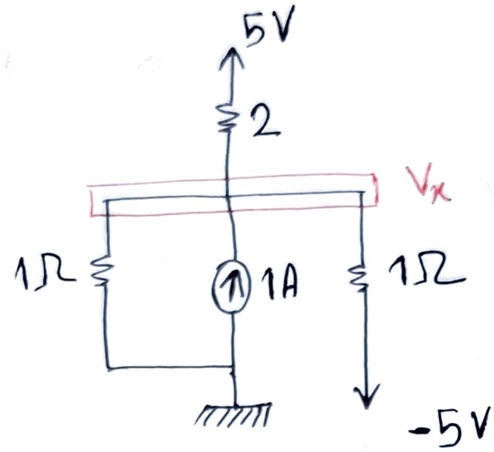
(III) ② $V_1 - (-V_2) = I_1 R_1 + I_3 R_3 + I_3 R_4$

$\Rightarrow I_1 R_1 + I_3 R_3 + I_3 R_4 - V_1 - V_2 = 0$

(II) ③ $0 - (-V_2) = -I_2 R_2 + I_3 R_3 + I_3 R_4 = 0$

$\Rightarrow I_3 R_3 + I_3 R_4 - I_2 R_2 - V_2 = 0$

Nodal Analysis



$$\frac{V_x-5}{2} + \frac{V_x-(-5)}{1} + \frac{V_x-0}{1} - 1 = 0$$

$$V_x\left(\frac{1}{2}+\frac{1}{1}+\frac{1}{1}\right) - \frac{5}{2} - \frac{0}{1} - \frac{-5}{1} - 1 =$$

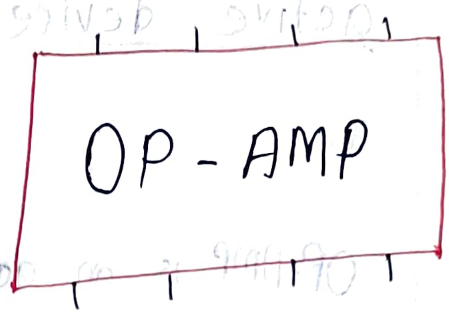
$$\Rightarrow V_x\left(\frac{1}{2}+1+1\right) - \frac{5}{2} + \frac{5}{1} - 1 = 0$$

$$\frac{V_x}{2} + \frac{V_x}{1} + \frac{V_x}{1} - \frac{5}{2} + \frac{5}{1} + 0 - 1 = 0$$

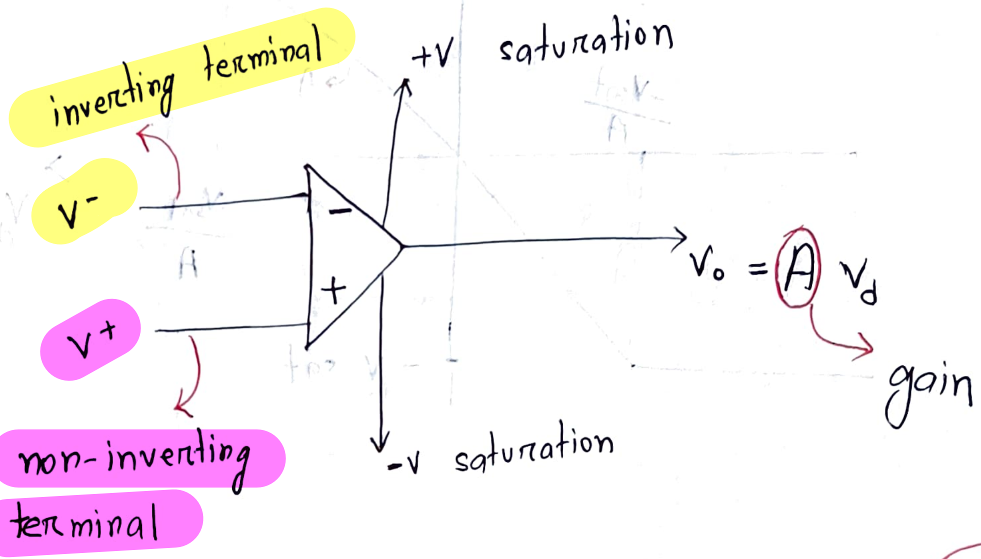
CSE - 251

Date: 04·06·24
Lecture: 2

OP-AMP



Operational	Amplifier
Performs mathematical Operation	amplifies the input signal



V_d = (non-inverting - inverting)

$\Rightarrow V_d = V^+ - V^-$

difference amplifier

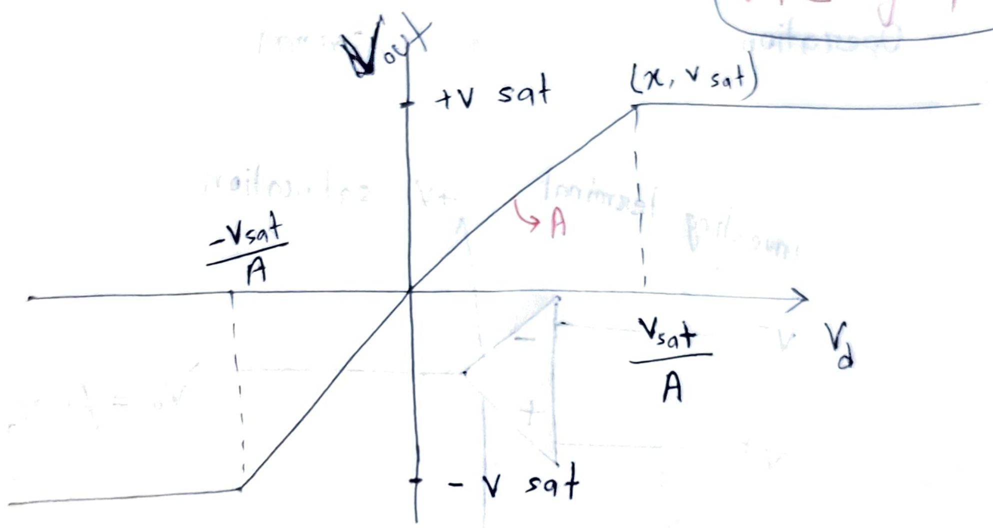
difference কে A গুণ করে output দেখায়।

active device (we need a sertain power to turn it on)

OP-AMP is an active device.

Voltage Transform Characteristic graph

VTC graph



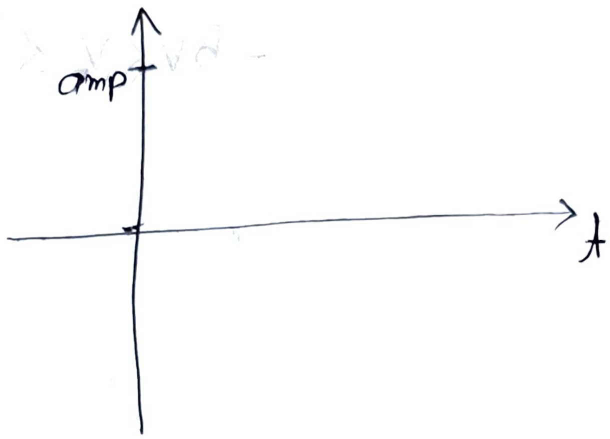
$V_o = A V_d$

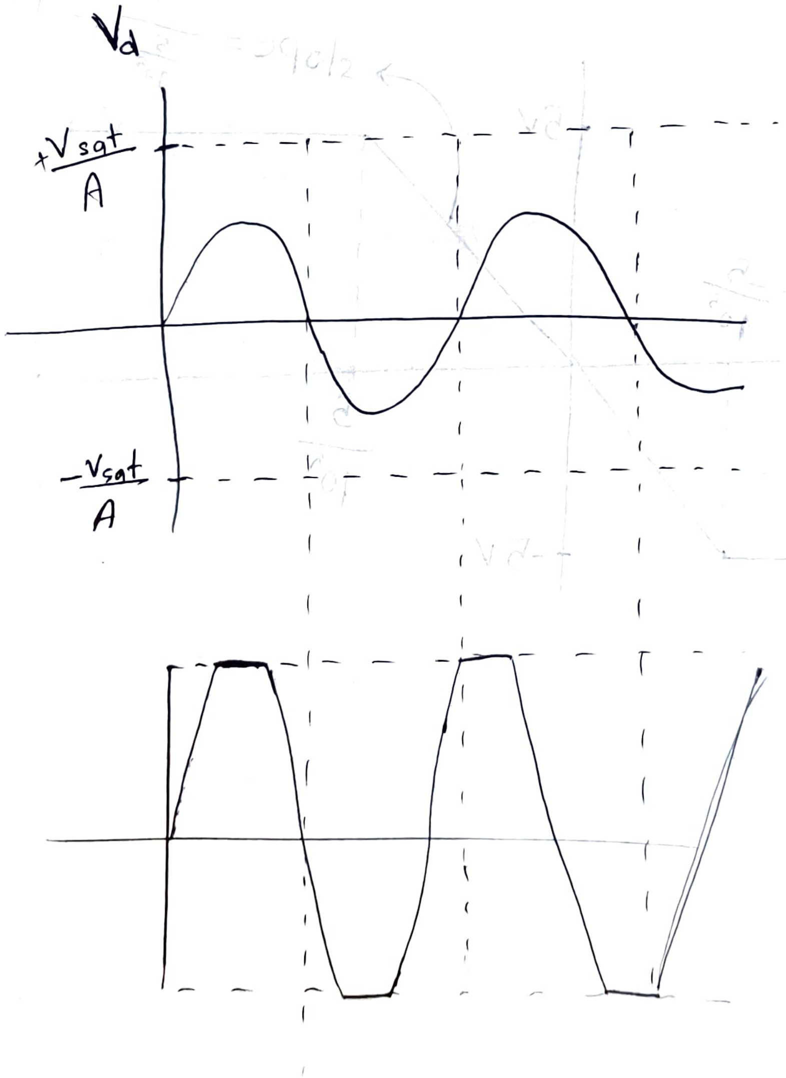
$\Rightarrow y = m x$

$\Rightarrow x = \frac{y}{m}$

$= \frac{V_{sat}}{A}$

Wave form (V/I)





phase is not correct
It's just a demo

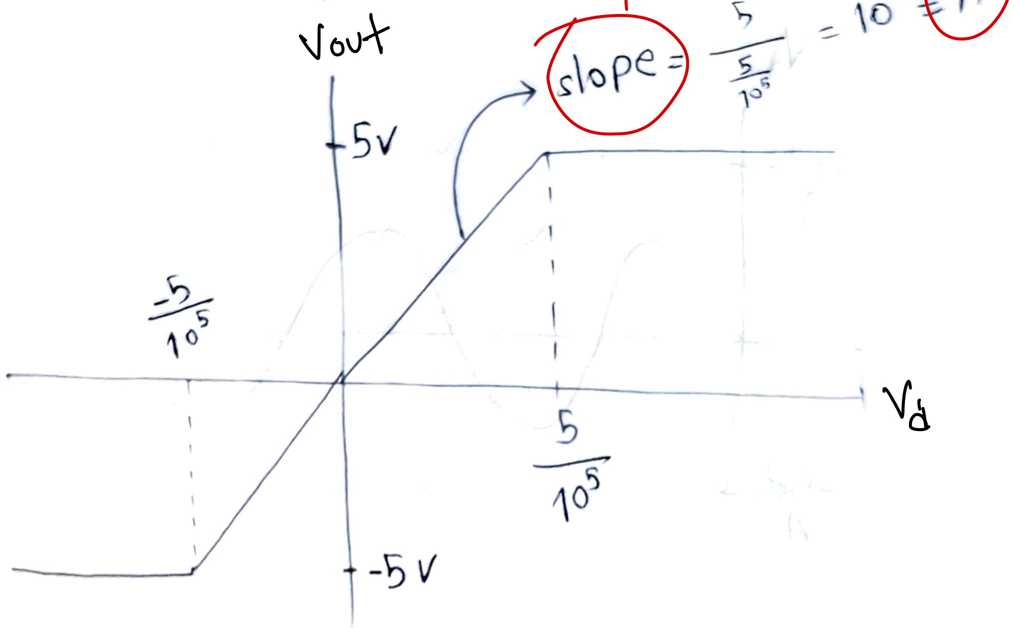
Ex 1

$V_o = A v_{in}$ $\qquad -5V \leq V_o \leq 5V$

Given,

$A = 10^5$

Draw the VTC graph.

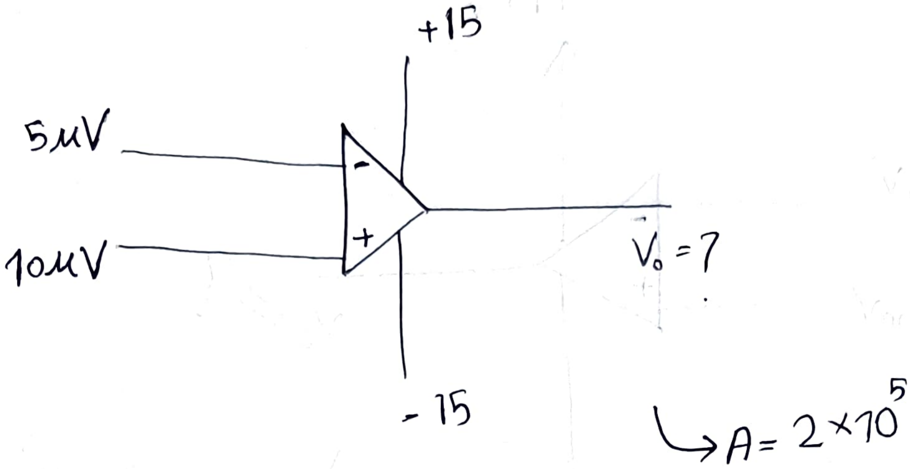


$V_{out} = A V_d$

$\Rightarrow y = mx \Rightarrow \boxed{x = \frac{y}{m}} = \frac{5}{10^5}$

$\Rightarrow \boxed{m = \frac{y}{x}} = \frac{5}{\frac{5}{10^5}} = 10^5$

Ex 2



$$V_o = A\,V_d$$

$$= A(V_+ - V_-)$$

$$= 2\times10^5(10\mu - 5\mu)$$

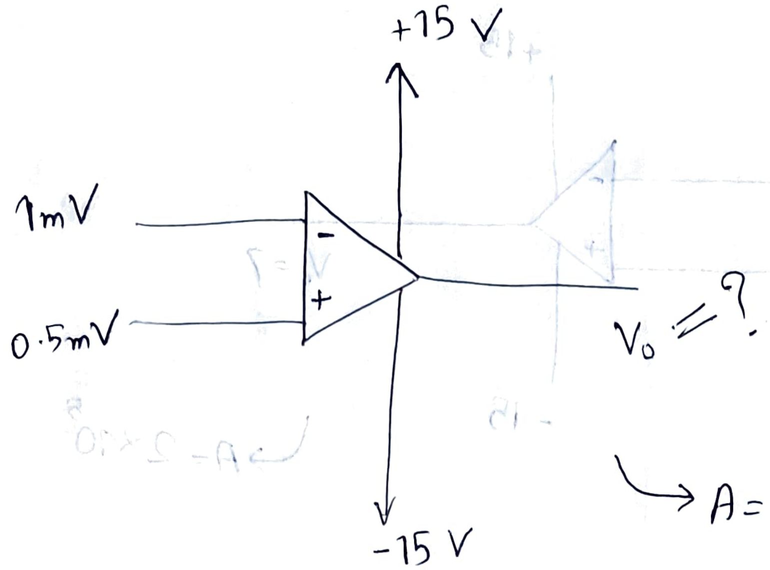
$$= 2\times10^5 \times 5\times10^{-6}$$

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

$$= 1\,V$$

(Ans)

Ex 3 :



$\hookrightarrow A = 2 \times 10^5$

$V_d = V^+ - V^-$

$= (0.5 - 1)$ mV

$= -0.5$ mV

$= -0.5 \times 10^{-3}$ V

$\therefore V_o = A \, V_d$

$= 2 \times 10^5 \times (-0.5 \times 10^{-3})$

$= 2 \times (-0.5) \times 10^2$

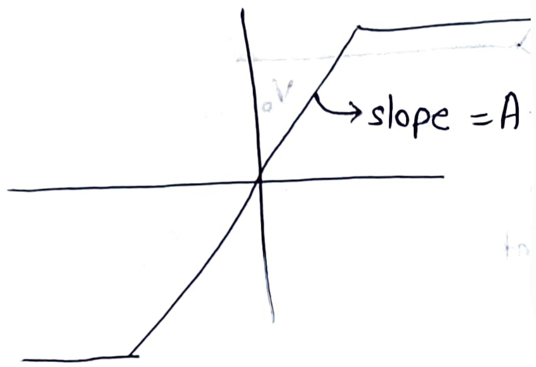
$= -1 \times 100$

$= -100$

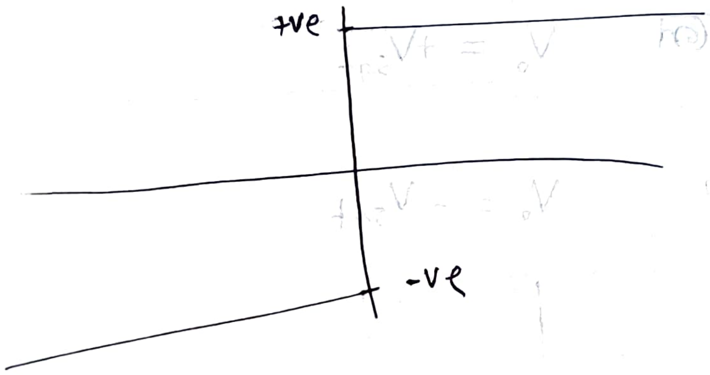
$\boxed{\text{for } -V \text{ saturation, } V_o = -15}$

parameter	Typical range	Ideal
gain value $= A$	$10^5 \sim 10^8$	$A = \infty$ $R_{in} = \infty$

Practical OP-AMP



Ideal OP-AMP



$V_d = +ve$ হলে result হবে $+V_{sat}$

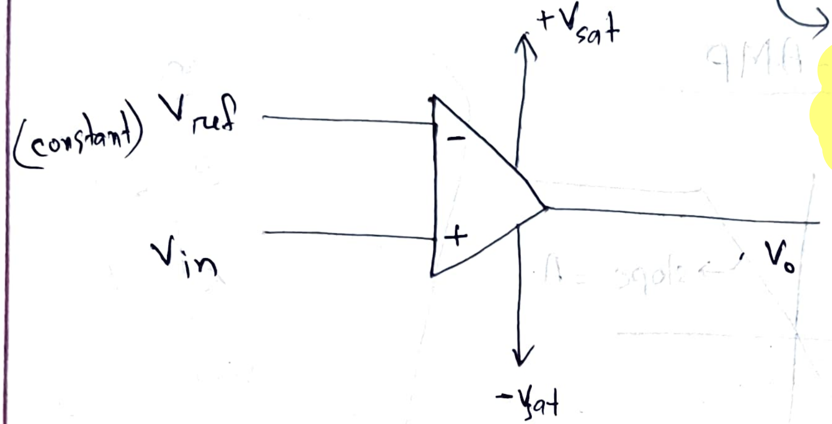
$V_d = -ve$ " " " $-V_{sat}$

Comparator

It compares two voltage.

Non-inverting comparator

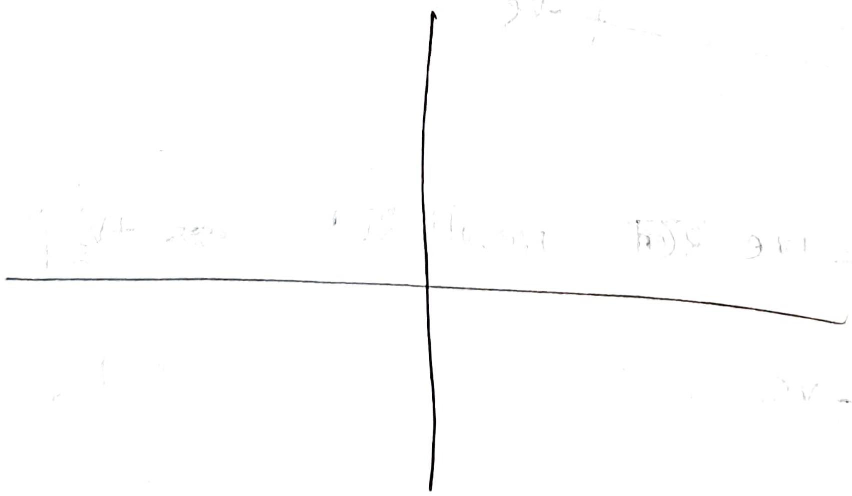
V_{in} যে জায়গায় সেই অনুযায়ী নাম।



$$V_d = V_{in} - V_{ref}$$

$V_d > 0$ হলে $\quad V_o = +V_{sat}$

$V_d < 0$ " $\quad V_o = -V_{sat}$



$V_d > 0$

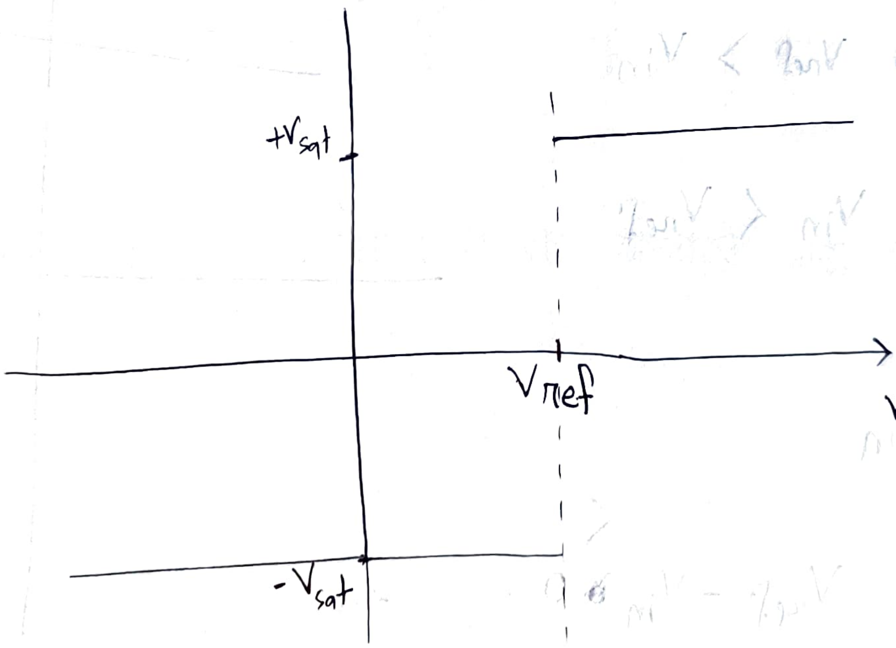
$V_{in} - V_{ref} > 0$

$\therefore V_{in} > V_{ref}$ $\boxed{V_o = +V_{sat}}$

$V_d < 0$

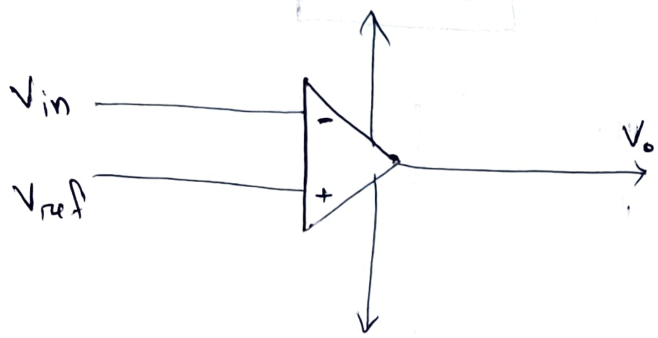
$\Rightarrow V_{in} - V_{ref} < 0$

$\Rightarrow V_{in} < V_{ref}$ $\boxed{V_o = -V_{sat}}$



জায়গা swap

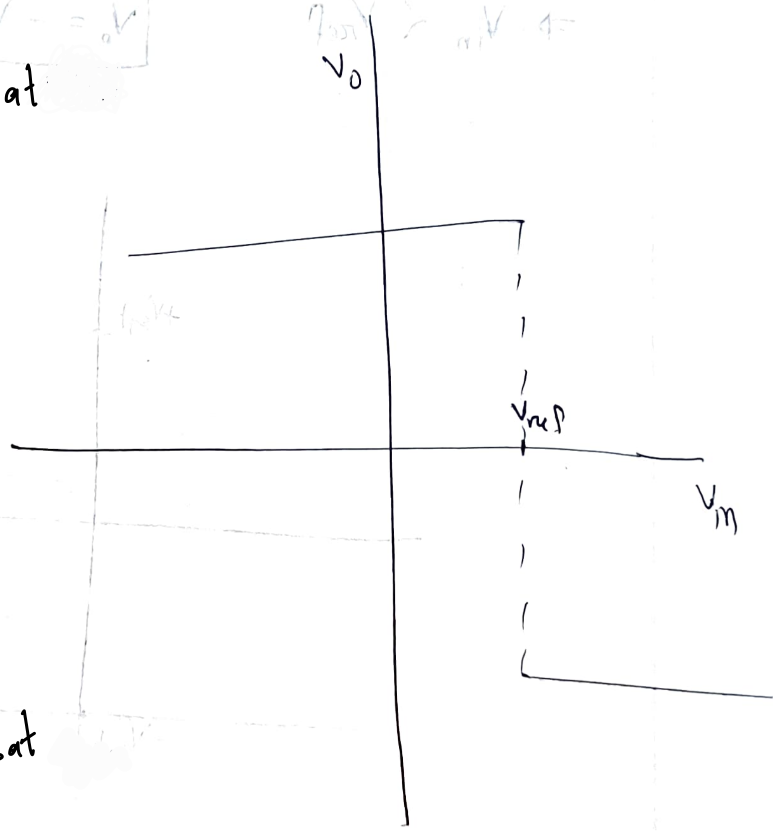
Inverting Comparator



$V_{ref} - V_{in} > 0, +V_{sat}$

$\Rightarrow V_{ref} > V_{in}$

$V_{in} < V_{ref}$



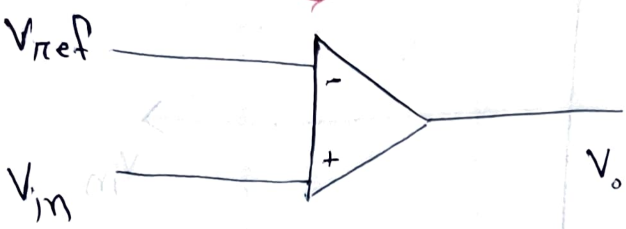
Again,

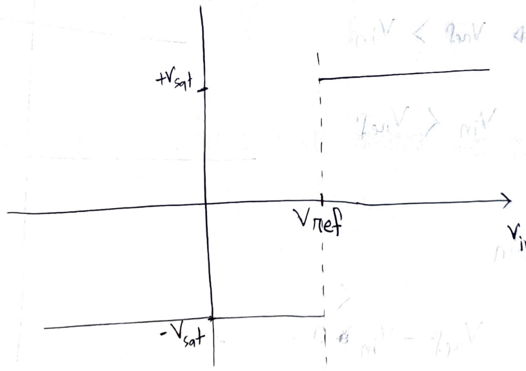
$V_{ref} - V_{in} < 0, -V_{sat}$

$\Rightarrow V_{ref} < V_{in}$

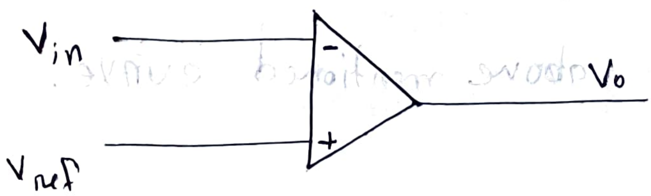
$\Rightarrow V_{in} > V_{ref}$

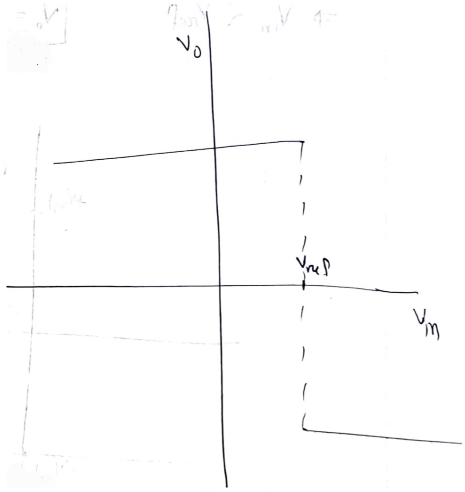
Non-inverting Comparator



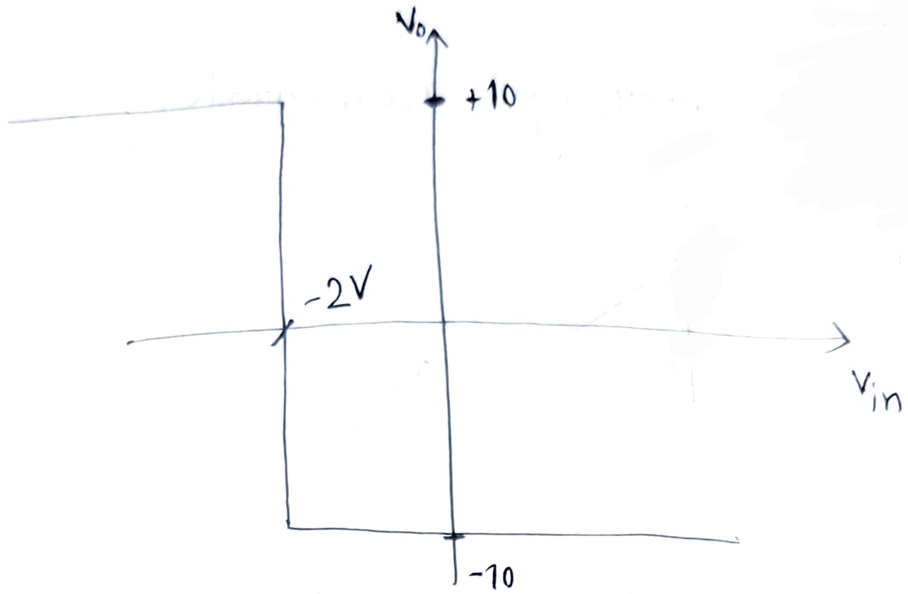


Inverting Comparator

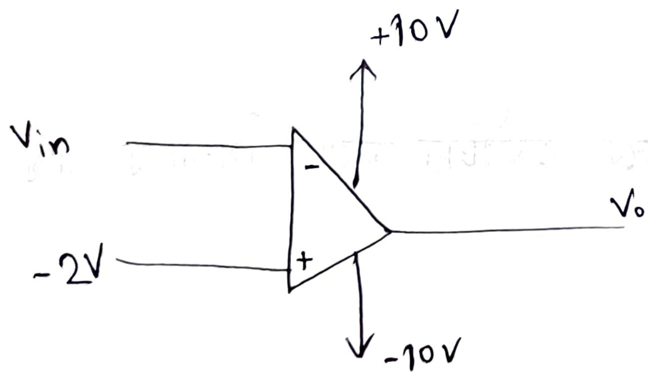




V_{in} যেটাতে থাকবে সেইটার সাথে মিলায়ে নাম হবে।



① Design an op-amp circuit so that the VTC curve is the above mentioned curve.



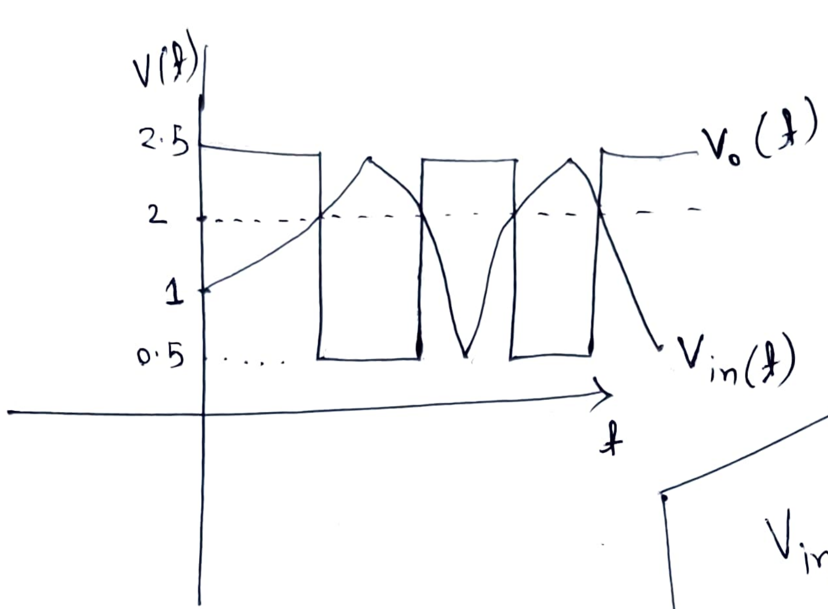
Inverting নাকি non-inverting সেইটা বুঝাতে হবে graph দেখে।

Inverting ⇒ একটা point এর পর কমে গেলে। 

non-inverting ⇒ " " " " বেড়ে " । 

+V_{sat} and $-V_{sat}$ অবশ্যই symetric নাও হতে পারে।

$V_{in} > V_{ref}$ $-V_{sat}$



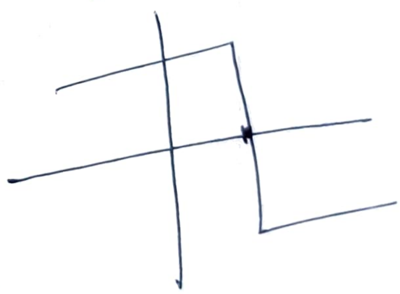
$V_{in} > ref$ ⇒ $-V_{sat}$

⇒ +sat

$V_d > 0$

⇒ ~~V_{in}~~ $V_{in} > V_{ref}$ +sat

inverting comparator



Non inverting

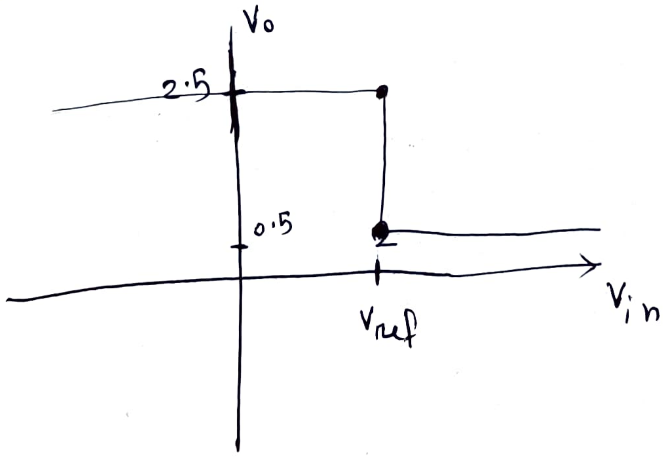
$V_d > 0$ $+V_{sat}$

$V_{in} > V_{ref}$

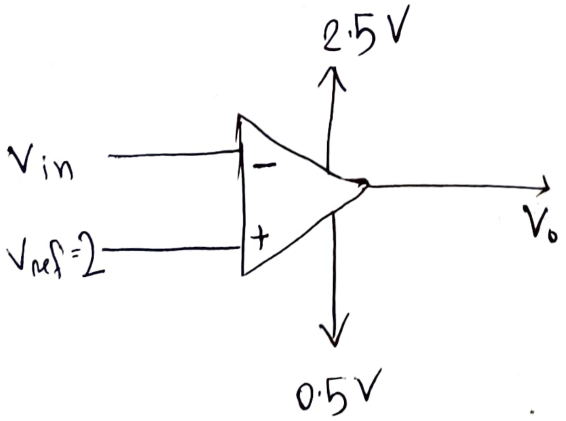
(i) Draw the VTC cure

(ii) Design the OP-AMP circuit.

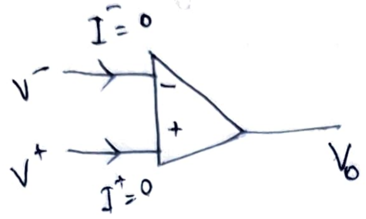
(i)



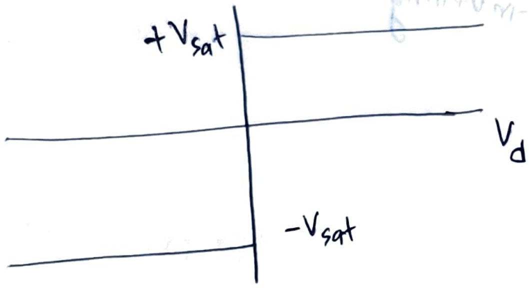
(ii)



Lecture 3



$$V_d = v^+ - v^-$$



Ideal OP-AMP

$\boxed{A = \infty \quad R_{in} = \infty}$ → characteristics of an ideal OP-AMP

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

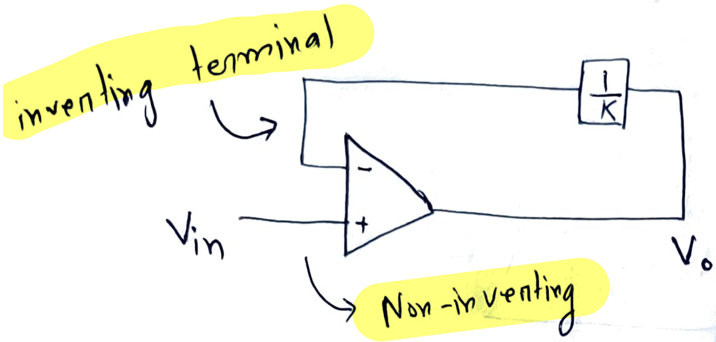
$$= \frac{V}{\infty}$$

$$I = 0$$

$\therefore R_o = 0$ ⟶ output resistance

* Output এ কোনো drop হবে না।

Closed Loop Configuration



$v^+ = V_{in}$

$V^- = \frac{V_o}{K}$

$V_d = V_{in} - \frac{V_o}{K}$

$= v^+ - v^-$

$\therefore V_o = A(v^+ - v^-)$

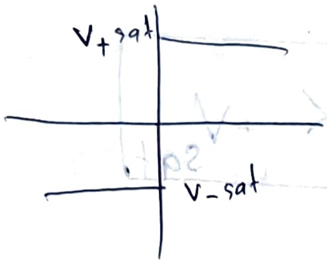
$\Rightarrow V_o = A\left(V_{in} - \frac{V_o}{K}\right)$

$\Rightarrow V_o + \frac{AV_o}{K} = A\,V_{in}$

$\therefore V_o\left(1 + \frac{A}{K}\right) = A\,V_{in}$

$$\Rightarrow V_o = \frac{A}{\left(1+\frac{A}{K}\right)} V_{in}$$

for an ideal OP-AMP:



Unstable system

* After closing with a negative feedback, we will get a stable output.

$$V_o = \frac{A}{\left(1+\frac{A}{K}\right)} V_{in}$$

$$\Rightarrow V_o = \frac{1}{\left(\frac{1}{A}+\frac{A}{K.A}\right)} V_{in}$$

$$= \frac{1}{\left(\frac{1}{A}+\frac{1}{K}\right)} V_{in}$$

$$= \frac{1}{\left(\frac{1}{\infty} + \frac{1}{K}\right)} V_{in}$$

$$\Rightarrow V_o = K V_{in}$$

[$A = \infty$
in ideal OP-AMP]

$$\boxed{-V_{sat} < V_o < +V_{sat}}$$

$$V_o = A V_d$$

$$\Rightarrow V_d = \frac{V_o}{A}$$

$$\Rightarrow V_d = \frac{V_o}{\infty} = 0$$

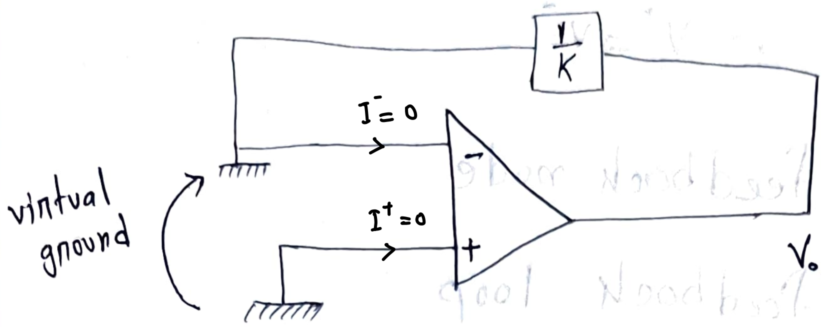
$$\Rightarrow V^+ - V^- = 0$$

$$\Rightarrow V^+ = V^-$$

(i) $I^+ = I^- = 0$ $\boxed{\text{সব সময়}}$

(ii) Closed Loop,

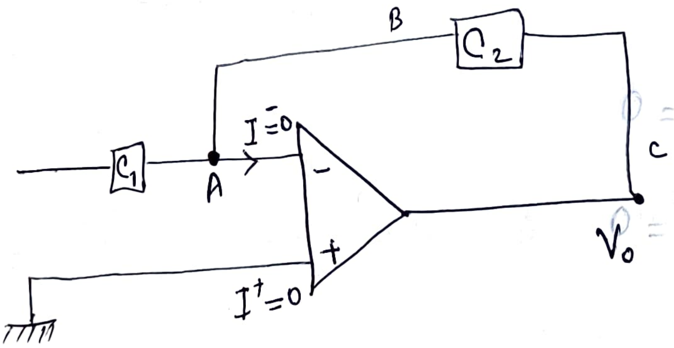
$V^+ = V^-$ [যেটা জানা থাকবে অন্যটা তার সমান হবে]



$V^+ = V^- = 0$

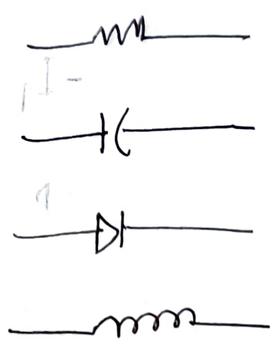
তাই auto V^- এ 0V হয়ে যাবে।

Math operation using OP-AMP



A = feed back node
ABC = feedback loop

C_1 and C_2 can be

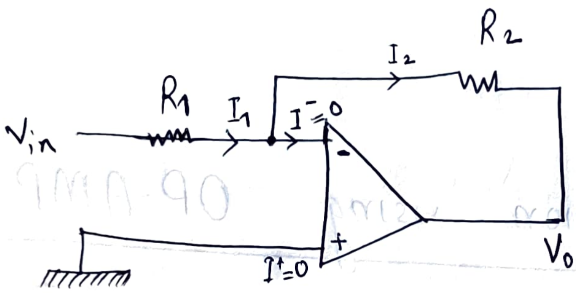


(i) $I^+ = I^- = 0$, $V^+ = V^-$

(ii) KCL at feedback node

(iii) KVL at feedback loop

Inverting Amplifier



(i) $I^+ = I^- = 0$

$V^+ = V^- = 0$.

(ii) KCL at feedback node.

$$-I_1 + I^- + I_2 = 0$$

$$\Rightarrow I_2 = I_1$$

$$I_1 = \frac{V_{in} - 0}{R_1}$$

$$\Rightarrow I_1 = \frac{V_{in}}{R_1}$$

$$I_2 = \frac{0 - V_o}{R_2}$$

$$\Rightarrow I_2 = \frac{-V_o}{R_2}$$

$\therefore \quad I_1 = I_2$

$$\Rightarrow \frac{V_{in}}{R_1} = -\frac{V_o}{R_2}$$

$$\Rightarrow \frac{-V_{in}}{R_1} = +\frac{V_o}{R_2}$$

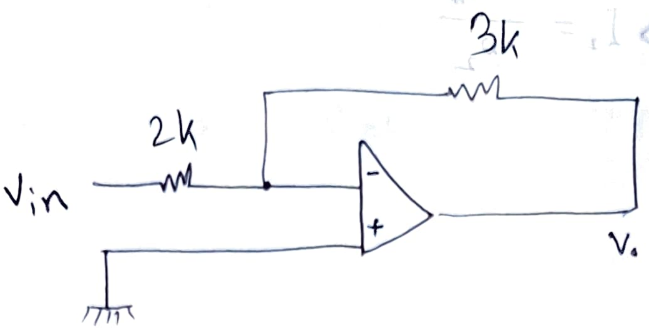
$\Rightarrow$

$$\Rightarrow V_o = \underbrace{-\left(\frac{R_2}{R_1}\right)}_{gain < 0} V_{in}$$

This amplifier amplifies V_{in} voltage to $\left(-\frac{R_2}{R_1}\right)$ times.

Note that: ~~this~~ inverting amplifier always amplifies with a minus sign.

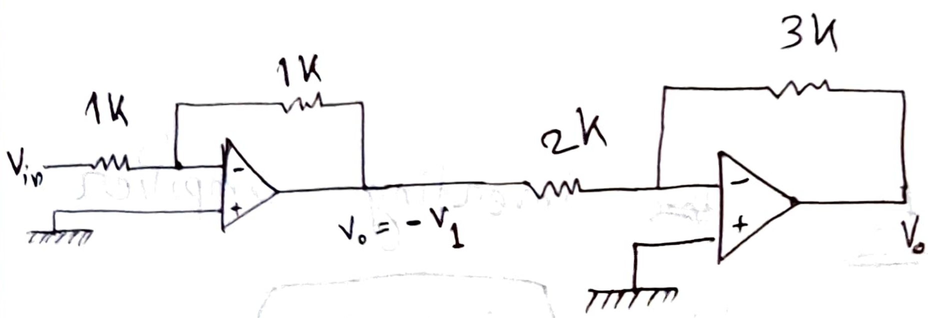
★ Design a OP-AMP where $V_o = -2.5 V_{in}$



$$\therefore V_o = \frac{3}{2} V_{in}$$

$$= 1.5 V_{in}$$

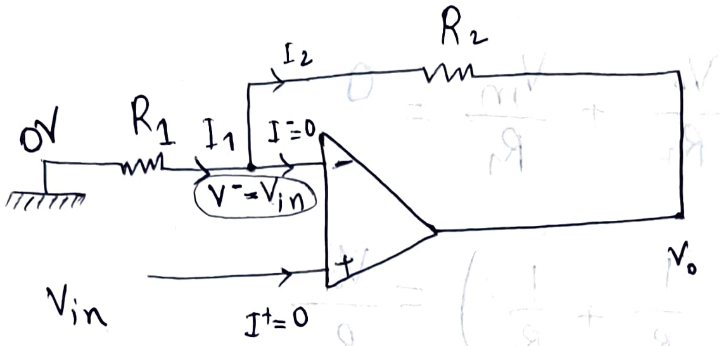
★ Design a OP-AMP where $V_o = 2.5 V_{in}$



$$\therefore V_o = \left(\frac{3}{2}\right)(-V_{in})$$

$$V_o = -2.5 V_{in}$$ (Ans)

Non-inverting amplifier



$$V^{+} = V^{-} = V_{in}$$

$$I^{+} = I^{-} = 0$$

(11) $$I_1 = \frac{0 - V_{in}}{R_1} = -\frac{V_{in}}{R_1}$$

$$I_2 = \frac{V_{in} - V_o}{R_2}$$

KCL at the feedback point,

$$-I_1 + I^{-} + I_2 = 0$$

$$\Rightarrow -I_1 + 0 + I_2 = 0$$

$$\Rightarrow I_2 = I_1$$

$$\Rightarrow \frac{V_{in} - V_o}{R_2} = -\frac{V_{in}}{R_1}$$

$$\Rightarrow \frac{V_{in}}{R_2} - \frac{V_o}{R_2} + \frac{V_{in}}{R_1} = 0$$

$$\Rightarrow V_{in}\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V_o}{R_2}$$

$$\Rightarrow V_{in}\left(\frac{R_1 + R_2}{R_1 R_2}\right) = \frac{V_o}{R_2}$$

$$\Rightarrow V_{in}\left(\frac{R_1 + R_2}{R_1}\right) = V_o$$

$$\Rightarrow V_o = \underbrace{\left(1 + \frac{R_2}{R_1}\right)}_{\text{gain} > 1} V_{in}$$

$$y = 2.5x$$

$$\Rightarrow \left(1 + \frac{R_2}{R_1}\right) = 2.5$$

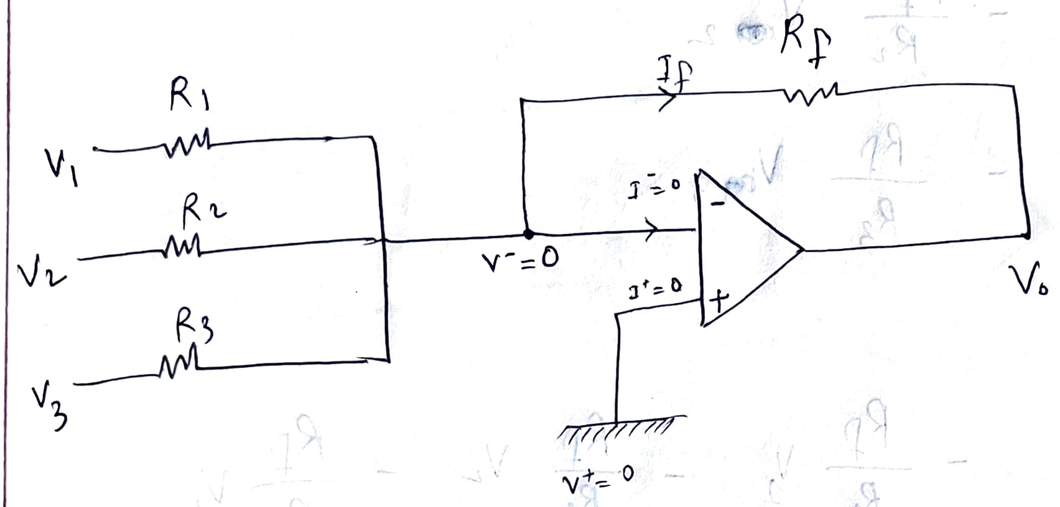
$$\Rightarrow \frac{R_2}{R_1} = 1.5$$

$\therefore$ It can be $\quad R_2 = 15, 3$
$\quad R_1 = 10, 2$

$y = -2x \rightarrow$ inverting amplifier

$y = 4x \rightarrow$ non-inverting amplifier

Inverting Adder



$$I_1 = \frac{V_1 - V^-}{R_1} = \frac{V_1 - 0}{R_1} = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_2 - 0}{R_2} = \frac{V_2}{R_2}$$

$$I_3 = \frac{V_3 - 0}{R_3} = \frac{V_3}{R_3}$$

KCL at feedback point,

$$-(I_1 + I_2 + I_3) + I_f + I^- = 0$$

$$\Rightarrow I_f = (I_1 + I_2 + I_3)$$

$$I_f = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

Super-position

$$V_o = -\frac{R_f}{R_1} V_{1}$$

$$V_o = -\frac{R_f}{R_2} V_{2}$$

$$V_o = -\frac{R_f}{R_3} V_{3}$$

$$\therefore V_o = -\frac{R_f}{R_1} V_1 - \frac{R_f}{R_2} V_2 - \frac{R_f}{R_3} V_3$$

$$\Rightarrow V_o = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3\right)$$

if

$$\begin{cases} R_f = 1 \\ R_1 = 1 \\ R_2 = 1 \\ R_3 = 1 \end{cases}$$

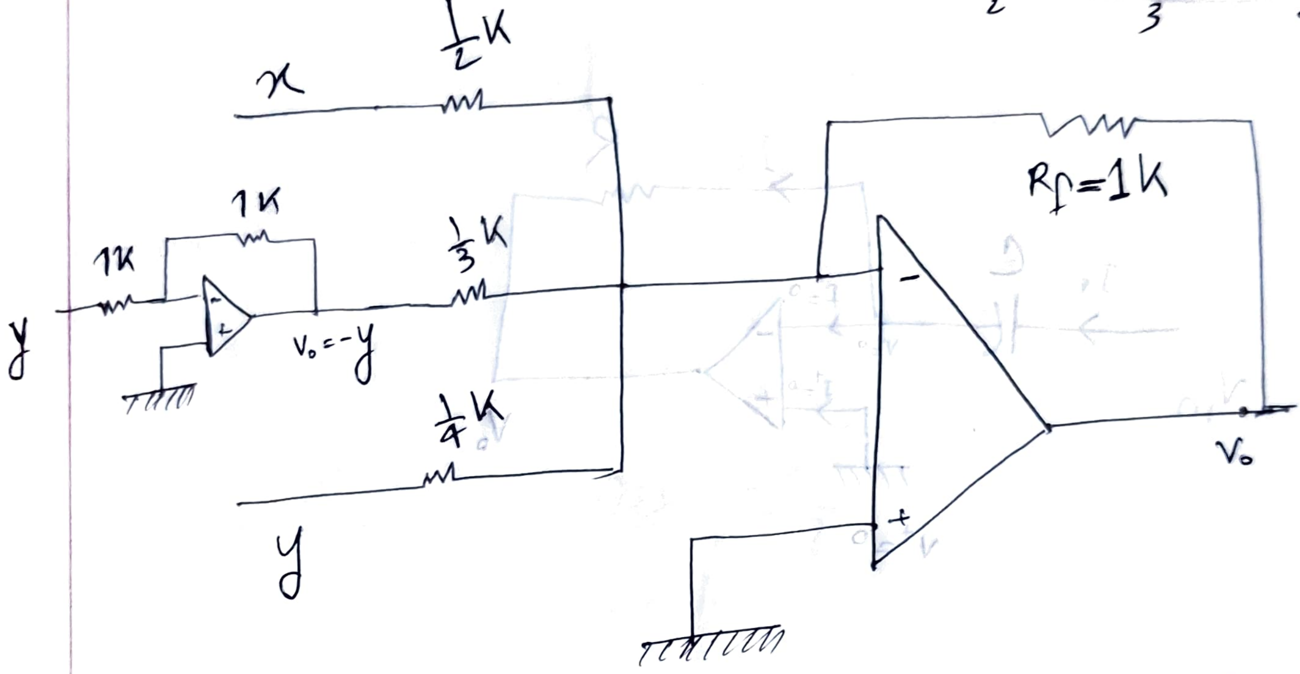
$$\Rightarrow V_o = -(V_1 + V_2 + V_3)$$

সবগুলো যোগ করে just (-) করে দিছে, তাই এটার নাম, inverting adder.

★ Draw a circuit where $f = -2x + 3y - 4z$

$$= -(2x - 3y + 4z)$$

$$= -\left(\frac{1}{\frac{1}{2}}x - \frac{y}{\frac{1}{3}} + \frac{z}{\frac{1}{4}}\right)$$

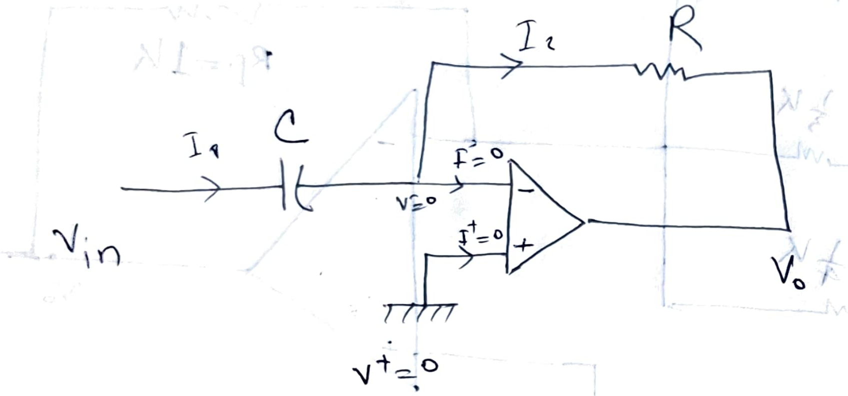


11·06·24

Math operations with OP-AMP

Differentiator :

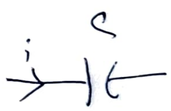
CR



(i)

$V^+ = V^- = 0$

$I^+ = I^- = 0$



$$i = C\frac{dV}{dt}$$

(ii)

$$I_1 = C\frac{dV}{dt}$$

$$= C\frac{V_{in} - 0}{dt}$$

$$= C\frac{V_{in}}{dt}$$

$I_1 = I_2$

$$\Rightarrow I_2 = \frac{0 - V_o}{R}$$

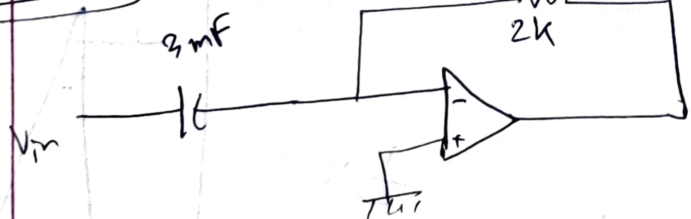
$$\Rightarrow I_2 = -\frac{V_o}{R}$$

$\therefore \; I_1 = I_2$

$$\Rightarrow C\frac{dV_{in}}{dt} = \cancel{RC} \; -\frac{V_o}{R}$$

$$\Rightarrow \boxed{V_o = -CR\,[redacted]\,\frac{dV_{in}}{dt}}$$

Problem



$V_{in} = 10 \cos 2t$

$$V_o = -\,2\times10^{3} \times 3\times10^{-3} \; -10\sin 2t \times 2$$

$$= 2\times3\times2\times10$$

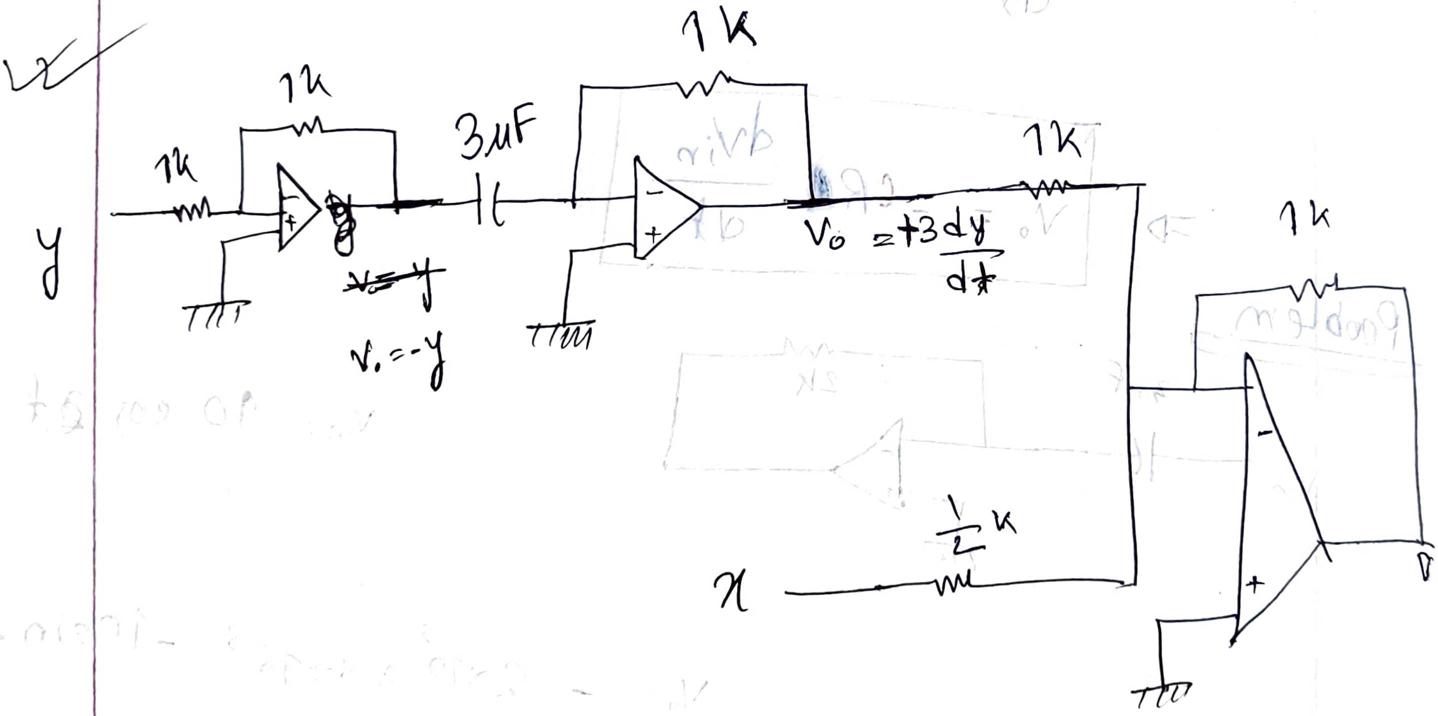
$$= 120 \sin 2t$$

Ans

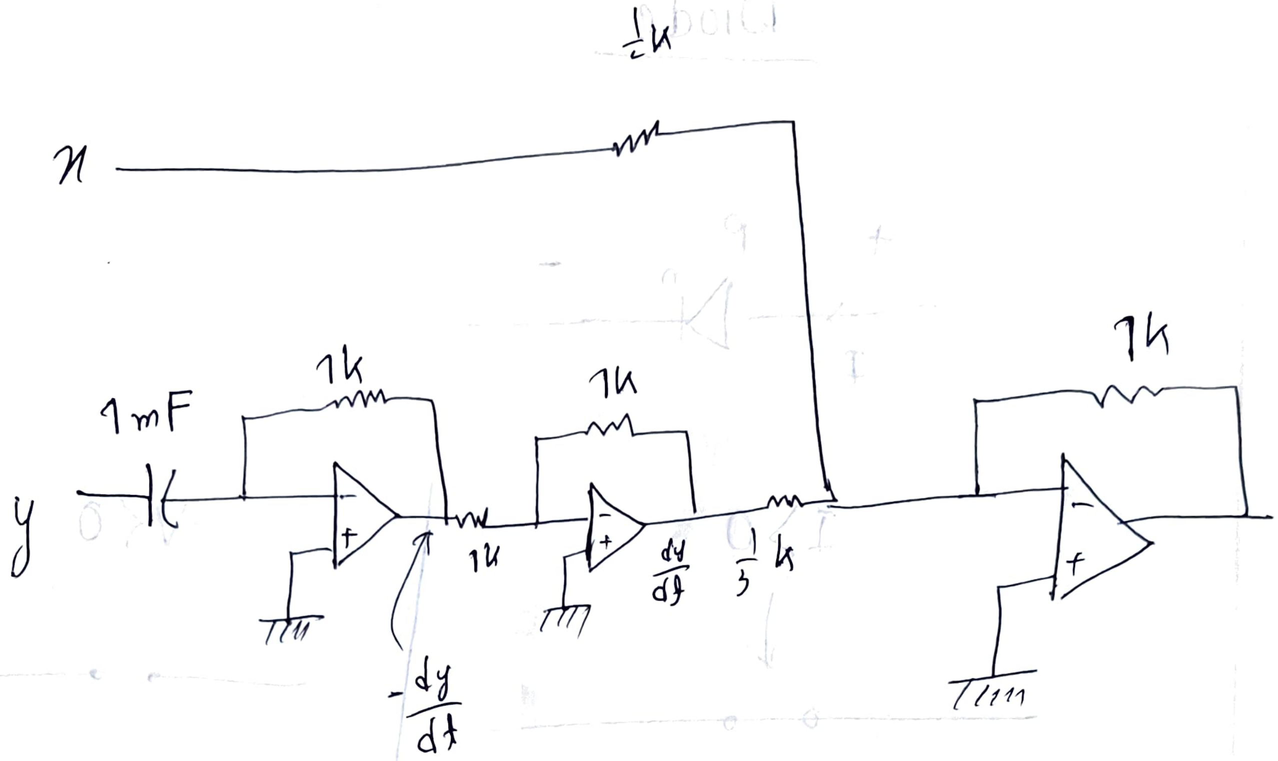
☆ Design the OP-AMP circuit :

$$f = -2x - 3\frac{dy}{dt}$$

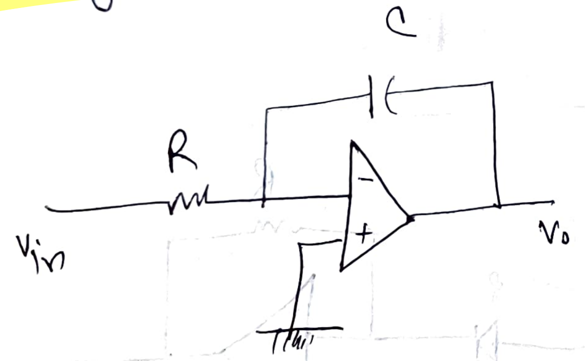
$$= -\left(2x + 3\frac{dy}{dt}\right)$$



Another



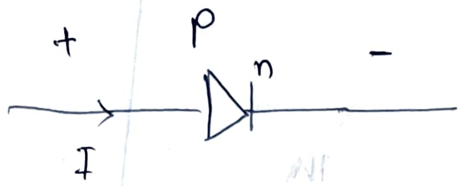
Integrator



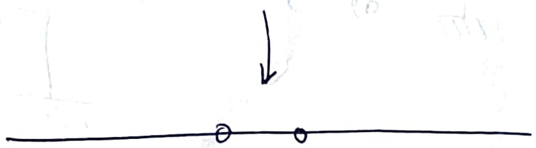
RC

$$\boxed{V_o = \frac{-1}{RC}\int V_{in}\, dt}$$

Diode



$I > 0$

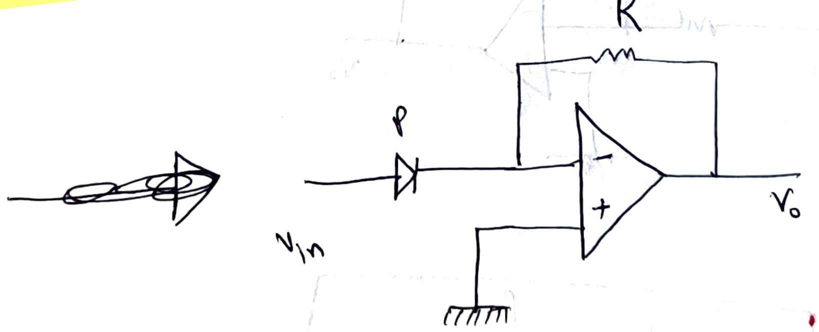


Sort circuit

$V < 0$

open circuit

Exponentiation



PR

PR $\boxed{V_o = -e^{V_{in}}}$

এমন ভাবে R বসাতে হবে যেন এই earvation মিলে।

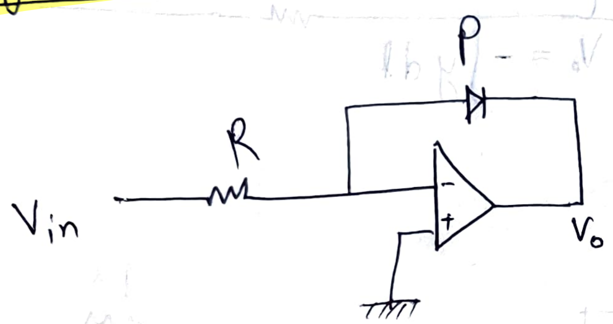
$$I_s R = 1$$

diode saturation current

$$V_T = 1$$

Diode knee voltage

Logarithm



RP

$$\boxed{V_o = -\log_e (V_{in})}$$

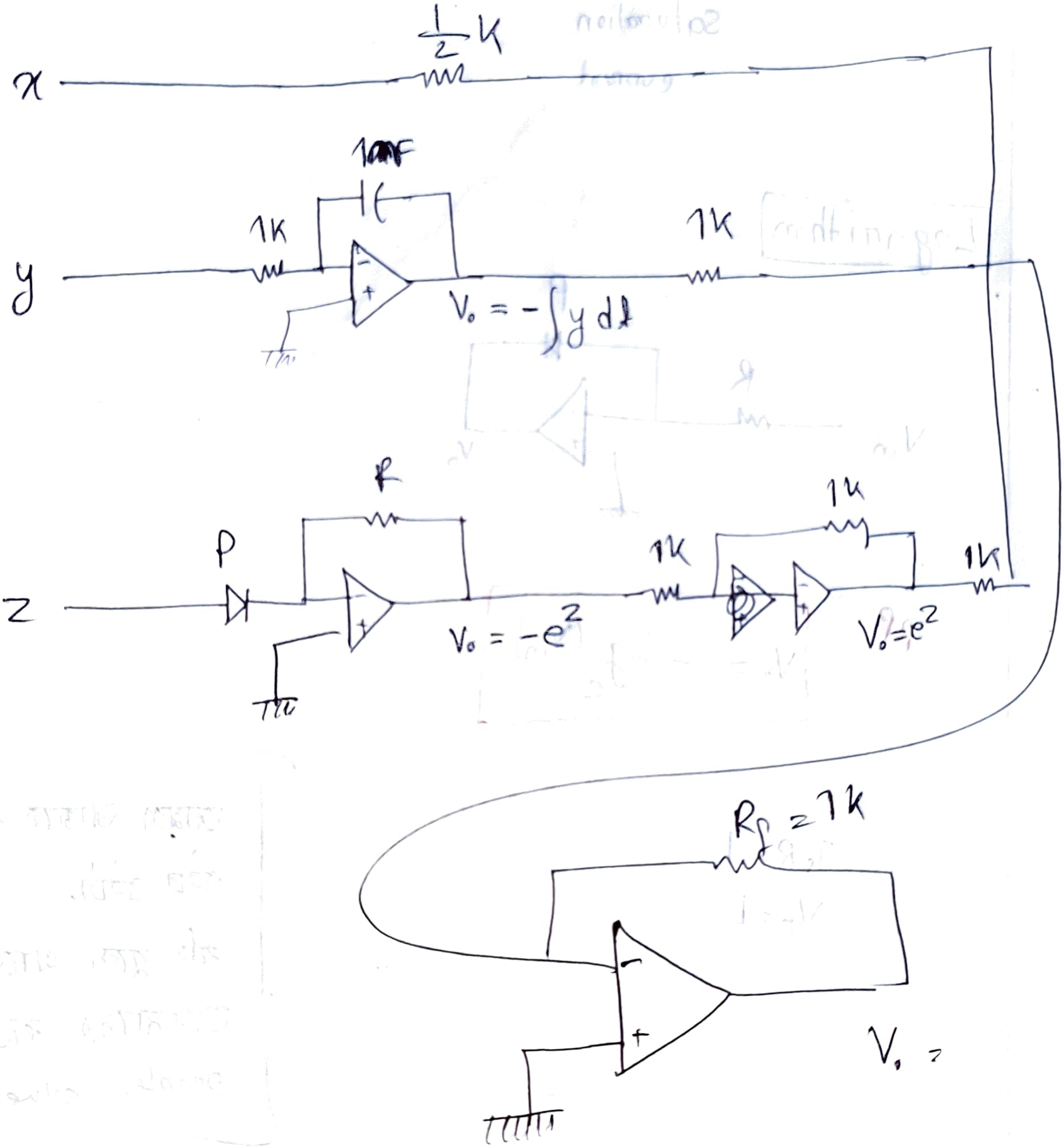
$I_s R = 1$

$V_T = 1$

আমরা আজকে পড়াইছি এইটা এইটা.
যদি বুঝে থাকেন তাহলে আপনাদের কাজ হলো problem solve করা

$$f = -2x + \int y\,dt - e^2$$

$$= -\left(2x - \int y\,dt + e^2\right)$$

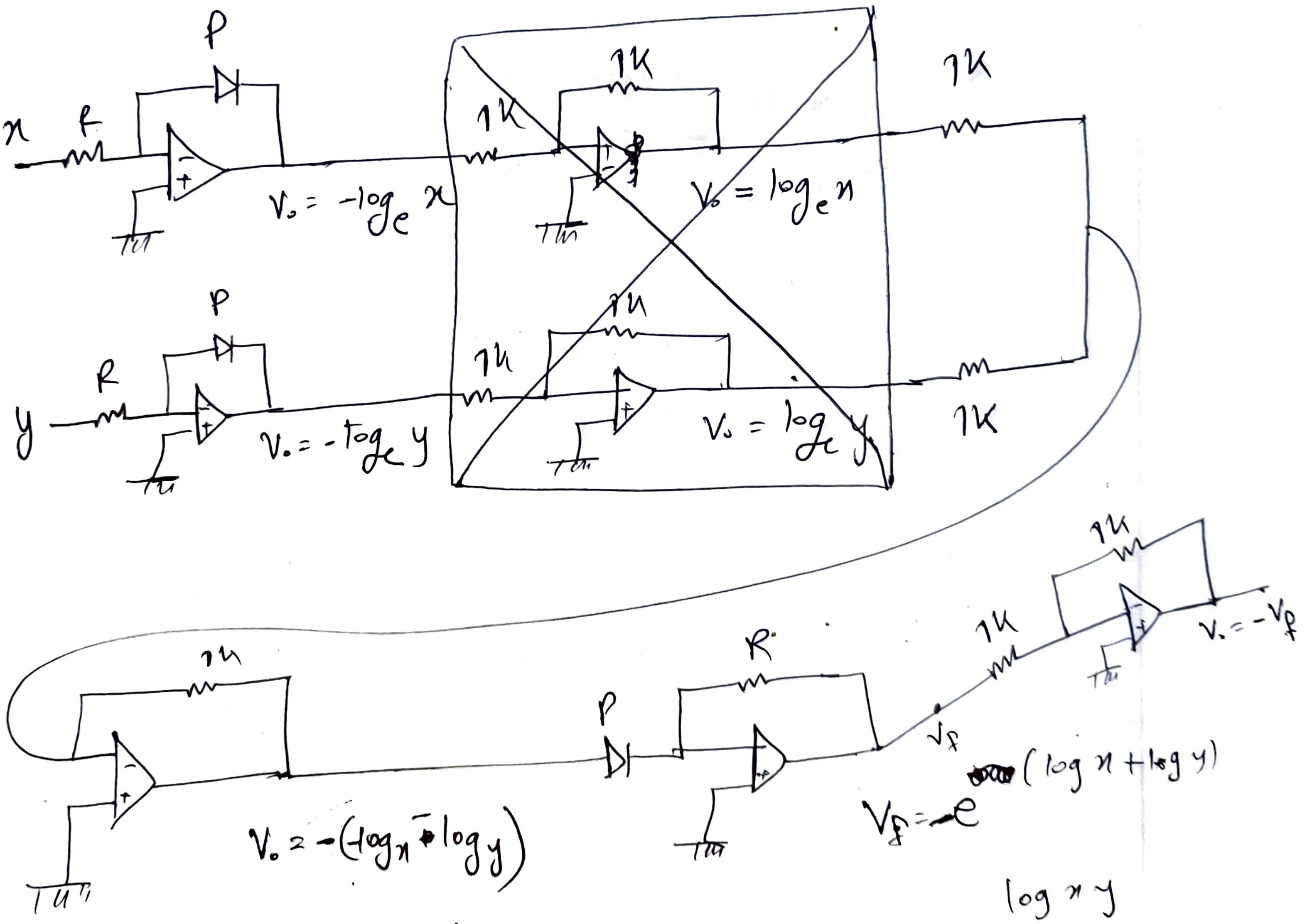


* Multiplication (xy)

* Division $\left(\frac{x}{y}\right)$

$$-\log x + \log$$
$$= -(\log x + \log y)$$

$$\therefore x \to \log x$$
$$y \to \log y$$
$$\log x + \log y$$
$$= \log(xy) \xrightarrow{\exp} xy$$



$$V_f = -e^{(\log x + \log y)}$$

$$V_o = -(\log x + \log y)$$

$$= \log x + \log y$$

$$=$$

$$V_f = -e^{\log xy}$$

$$V_f = -xy$$

$$\therefore V_o = xy$$

Quiz$_1$ ⇒ 25 June

sylabuss

↳ Alternate circuit

↳ OP-AMP

$\boxed{\text{H.W}}$

max complex

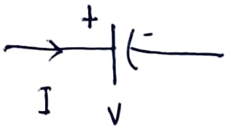
$$f = \frac{d}{dt}(x \log x)$$

23·06·24

I-V characteristics

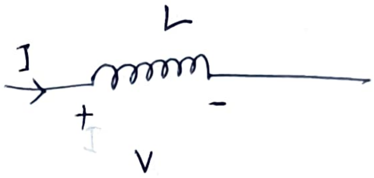
Functional form:

$I = f(V)$



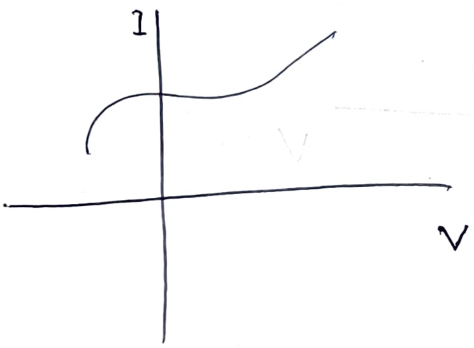
$i = C\dfrac{dv}{dt}$

$V = g(I)$

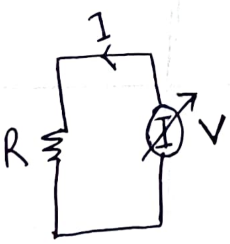


$V = L\dfrac{di}{dt}$

Graphical form:



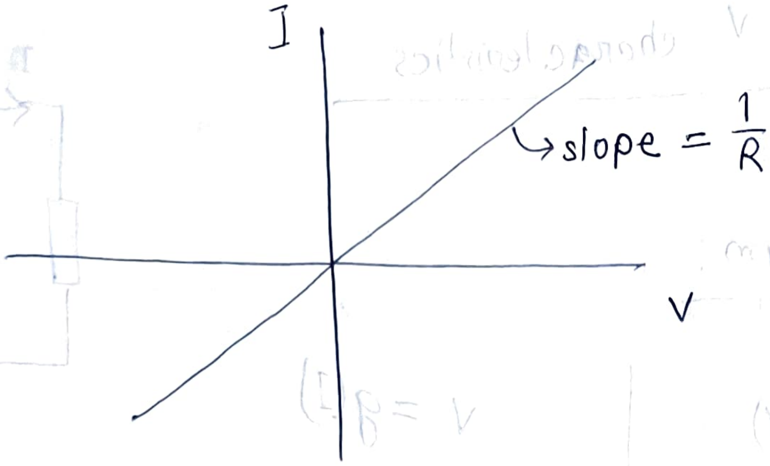
Ressistance



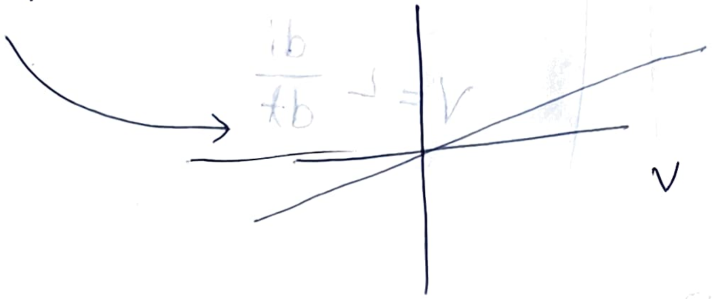
$V = IR$

$\Rightarrow I = \frac{1}{R} V$

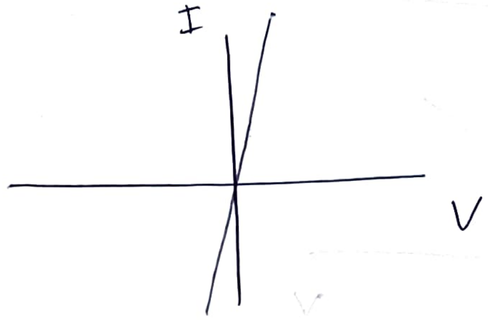
$\Rightarrow y = mx$



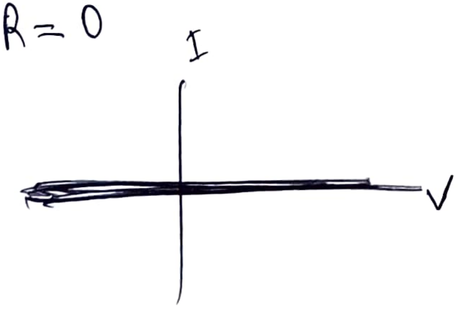
R ↑



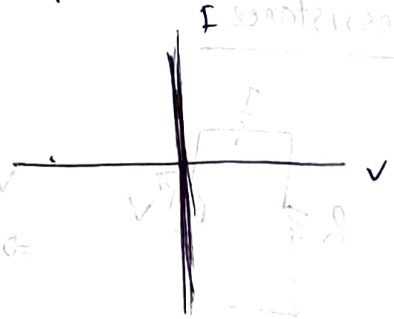
R ↓



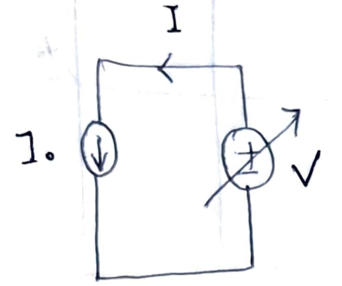
R = 0

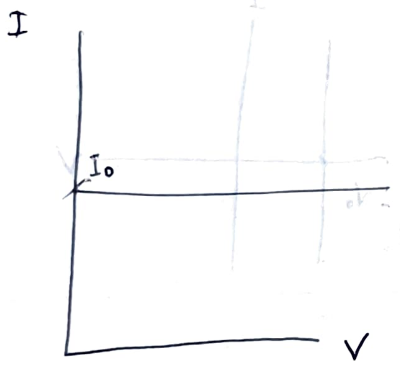


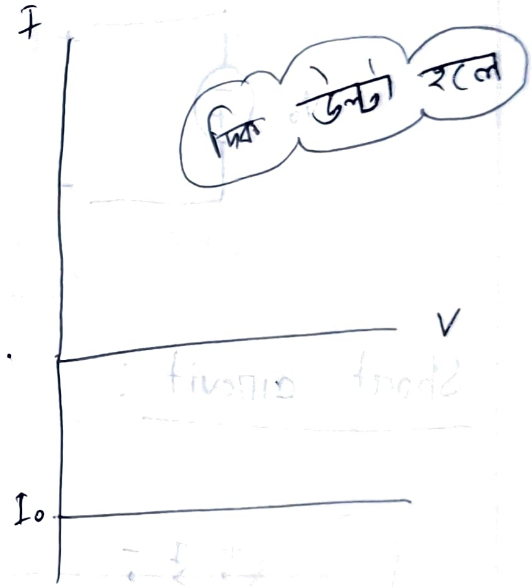
R = ∞



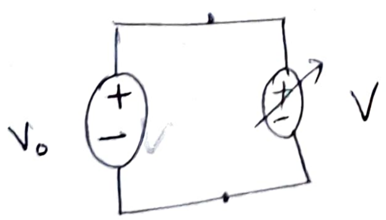
Current source IV curve







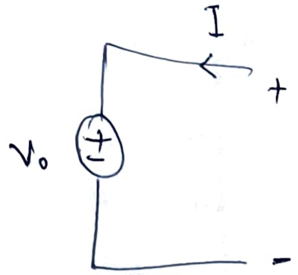
Voltage Source

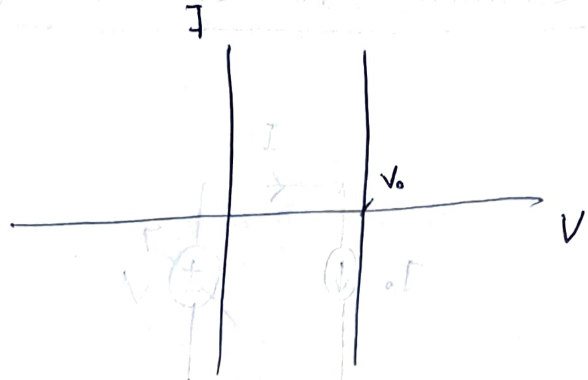


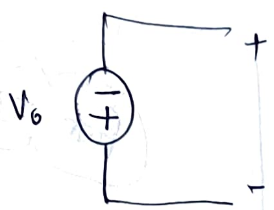
একই node এ ২ রকম ভোল্টেজ হলে।

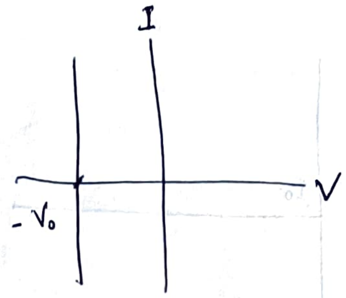
cz it violates KVL,

$-V_0+V=0$



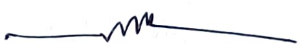


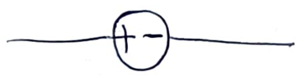




Short circuit :

$R=0$





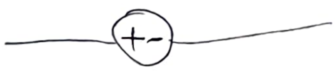
$V=0$

V

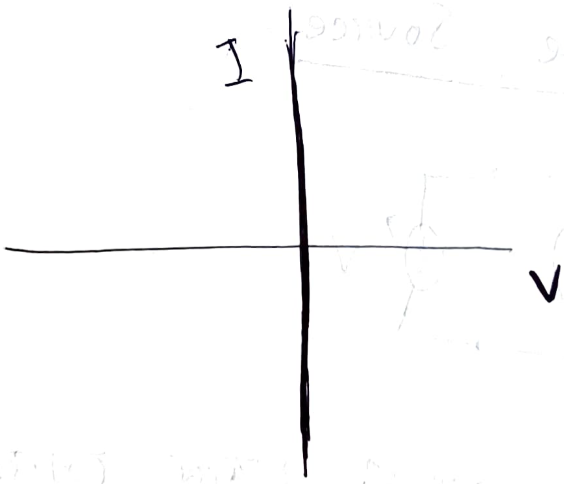
$\Delta V=0$

equivalant

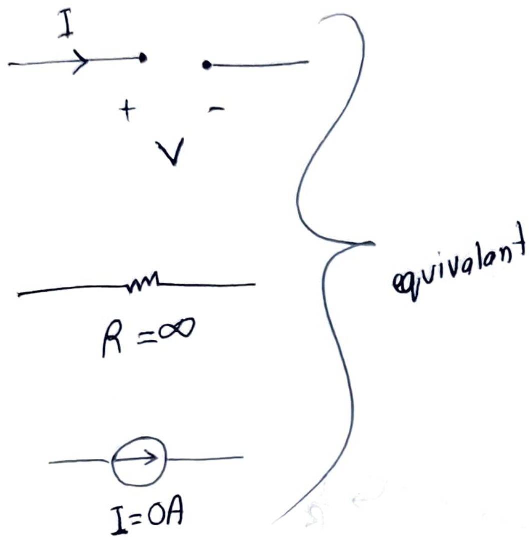
$R=0$



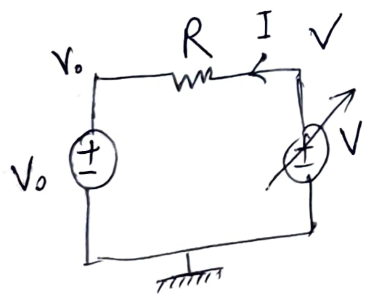
$V=0$

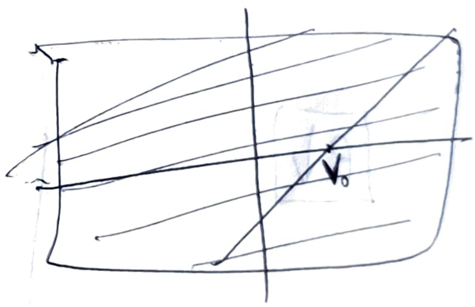


Open Circuit :



⇒ Voltage Source with series resistance :



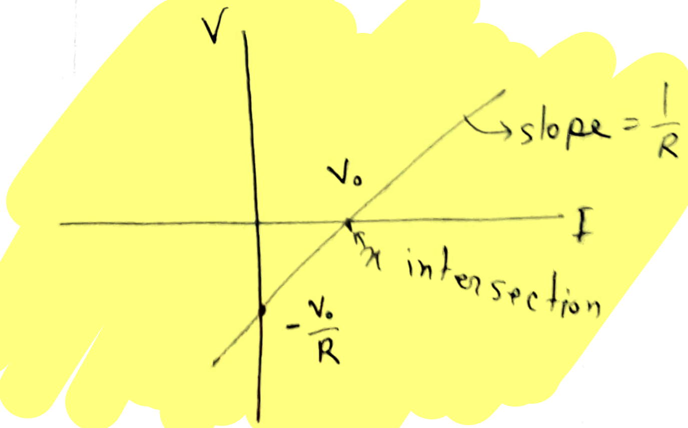


$$I = \frac{(V - V_0)}{R}$$

$$\Rightarrow I = \frac{1}{R}(V - V_0)$$

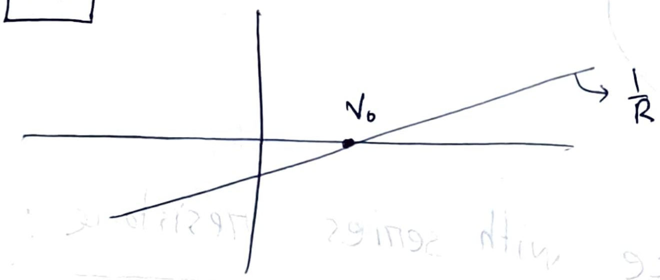
$$\Rightarrow I = \frac{1}{R}V - \frac{V_0}{R}$$

$$\Rightarrow y = mx + c$$

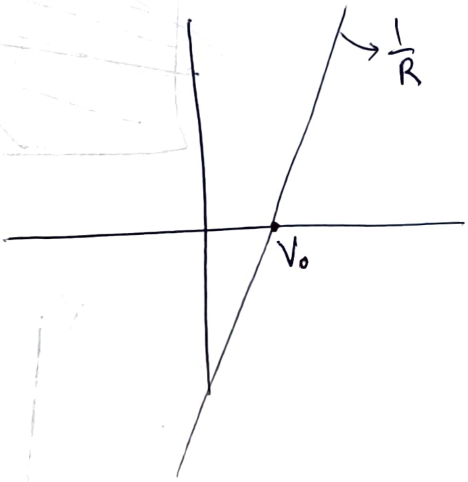


$$0 = \frac{1}{R}V - \frac{V_0}{R} \Rightarrow \boxed{V = V_0}$$

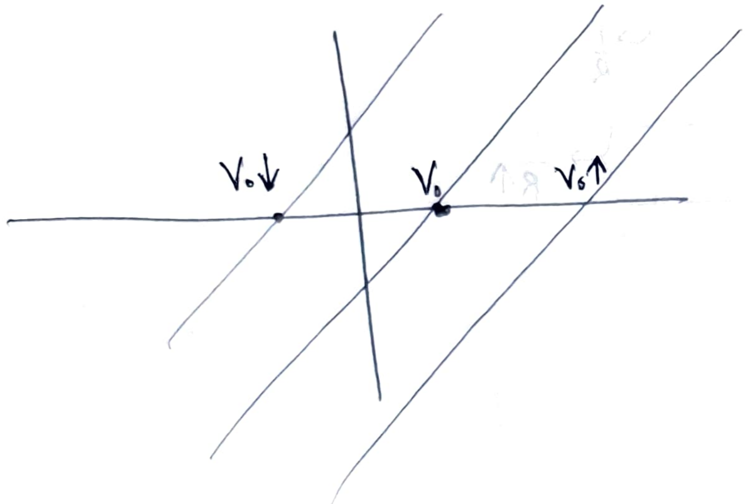
just $\boxed{R\uparrow}$ with fixed V_0



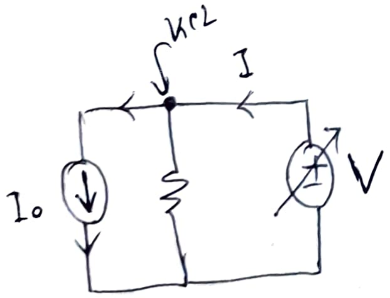
$\boxed{R\downarrow}$

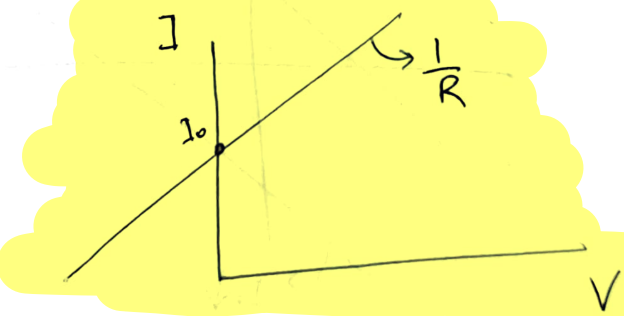


$\boxed{V_0 \uparrow \text{ with fixed } R}$



Current source with parallel Resistance :

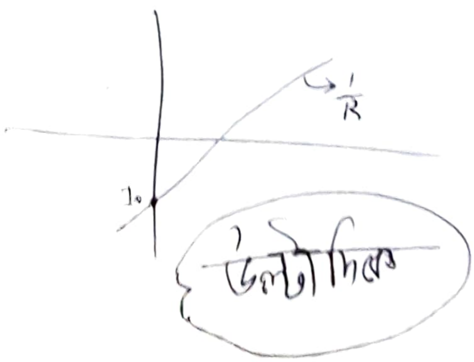




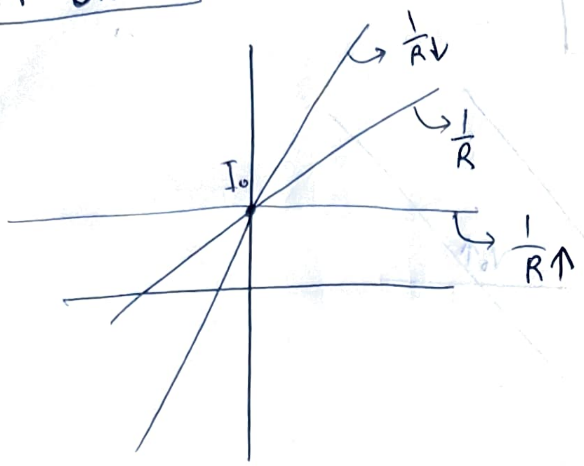
$$I = I_0 + \frac{V}{R}$$

$$\Rightarrow I = \boxed{\frac{1}{R}} V + I_0$$

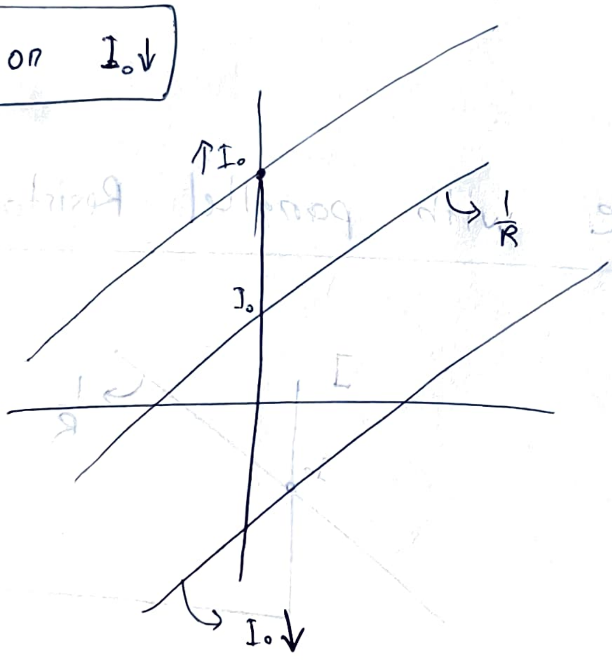
$$\Rightarrow y = mx + c$$



$\boxed{R\uparrow \text{ on } R\downarrow}$



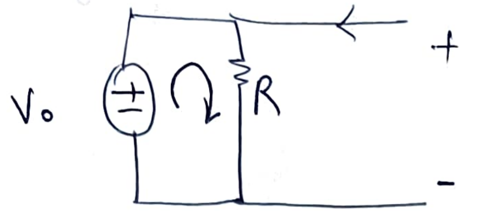
$\boxed{I_0\uparrow \text{ on } I_0\downarrow}$



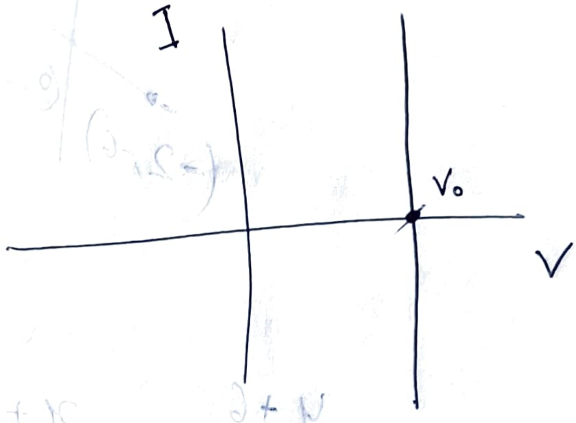
এই পর্যন্ত আপনাদের কোন প্রশ্ন আছে?
না থাকলে আমাদের কাজ হলো এখন একটা circuit design করা।

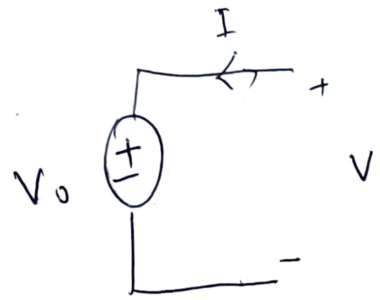
Resistance ~~se~~ parallel with ~~vol~~ VS..

No change



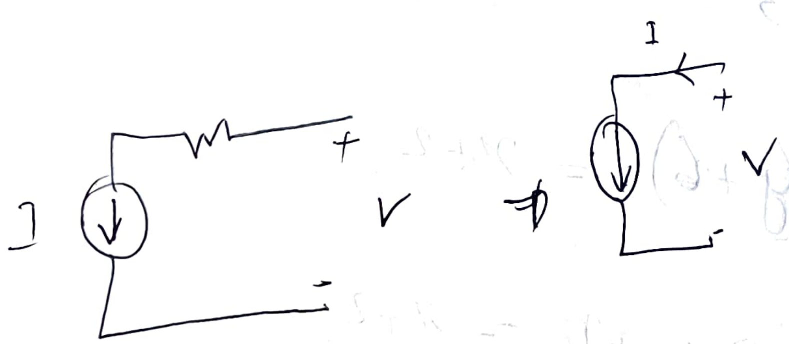
$\cancel{V_0 R - V_0 = 0}$

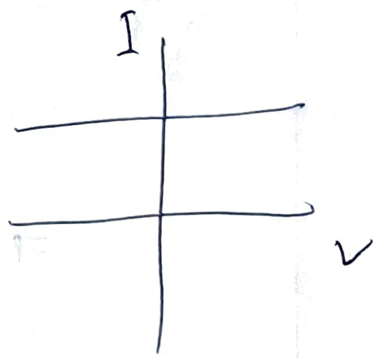




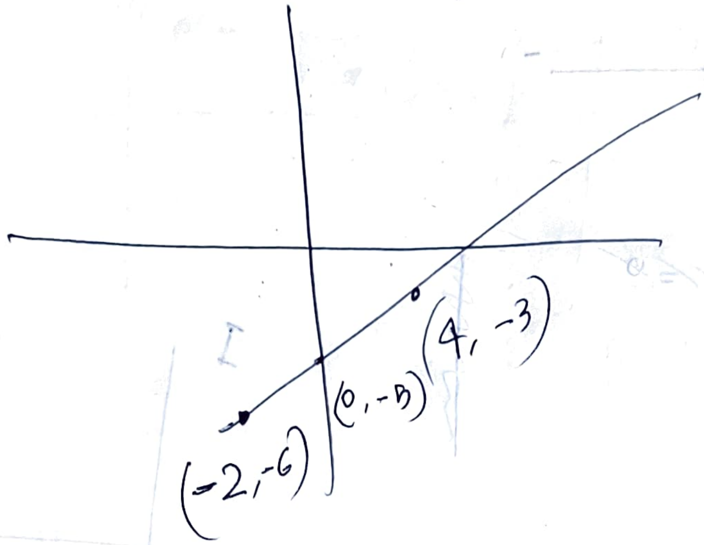
No change

Resistance series with CS :





Design the circuit from the I.V graph



$$\frac{y+6}{-6+3} = \frac{x+2}{-2-4}$$

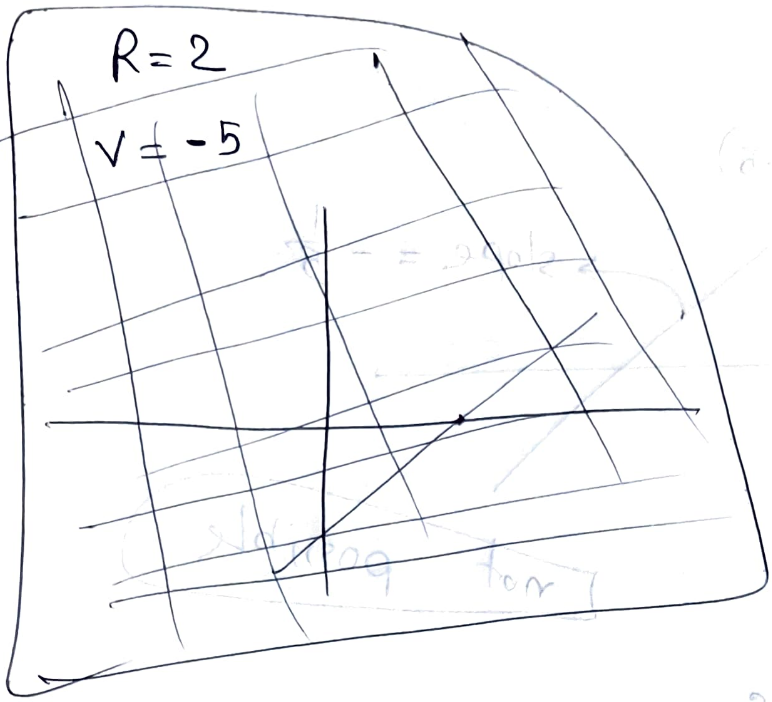
$$\Rightarrow \frac{y+6}{-3} = \frac{x+2}{-6}$$

$$\Rightarrow 2(y+6) = x+2$$

$$\Rightarrow 2y+12 = x+2$$

$$\Rightarrow y = \frac{1}{2}x - \frac{10}{2}$$

$$\therefore y = \frac{1}{2}x - 5$$



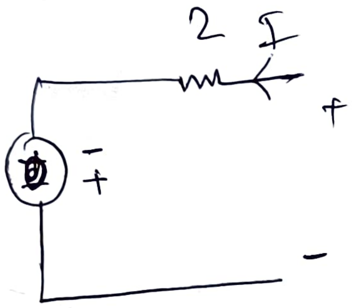
y axis

$$y = \frac{1}{2}x - 5$$

$$\Rightarrow 0 = \frac{1}{2}x - 5$$

$$\Rightarrow x = 10$$

$10 = V$

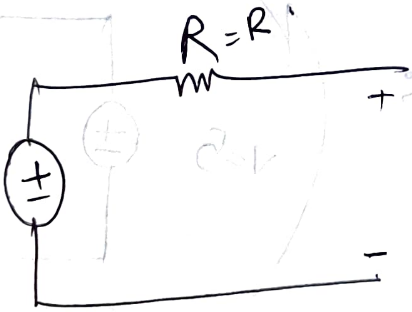


$$y = \frac{1}{2}x - 5$$

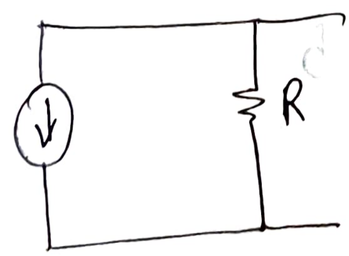
$$= 0 - 5$$

$$\Rightarrow y = -5$$

-10 V_0

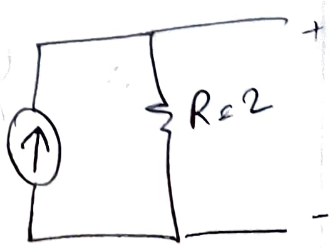


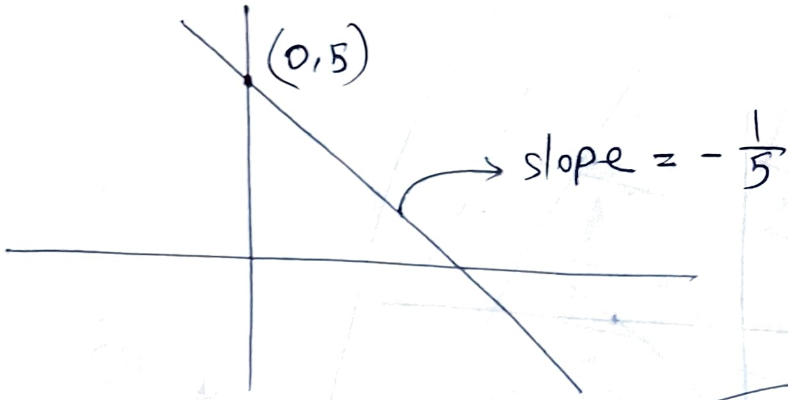
$I_0 = -5$



$\Rightarrow$

$I_0 = -5$





not possible

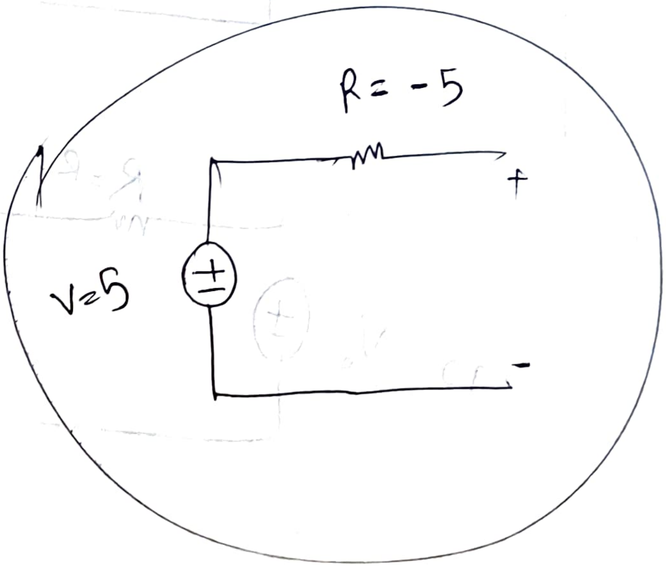
$y = mx + c$

$\Rightarrow y = \frac{-x}{5} + c$

$\therefore (0,5) \Rightarrow$

$5 = 0 + c$

$\Rightarrow c = 5$



$\therefore y = \frac{x}{-5} + 5$

25·6·24

Diode

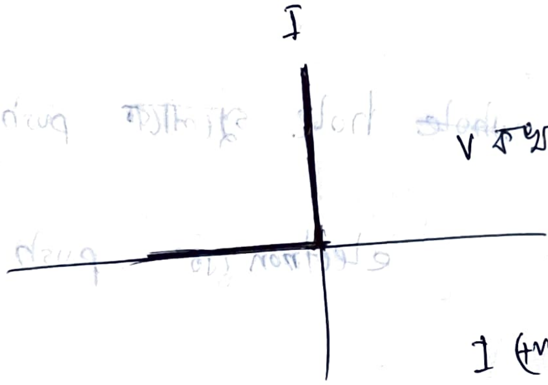
p n

V

I > 0

V < 0

I = 0



V কখনো-ই +ve হবে না।

I (+ve) হলে current flow হবে

Semiconductor (Si, Ge)

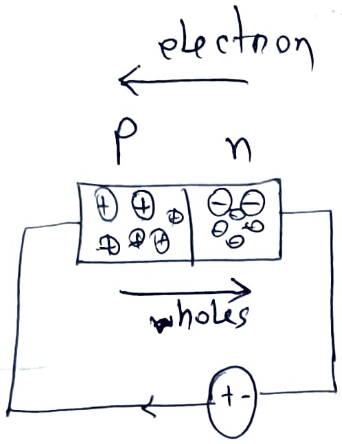
doping

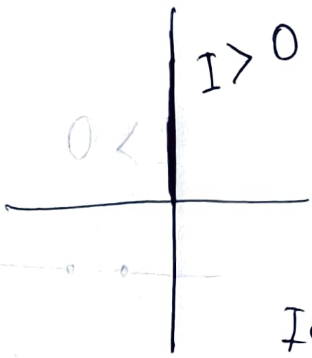
(Al) III — p-type

V (P) — n type.

Ideal Diode

p type → majority carrier holes (+ve)

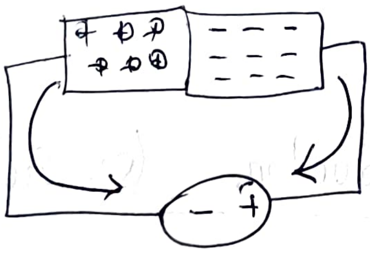


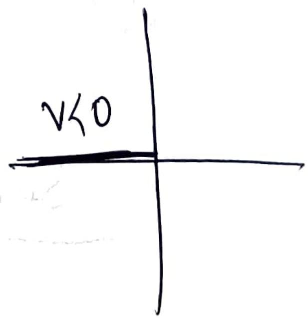


Ideal diode

(+)যেয় ~~whole~~ hole গুলোকে push করবে।

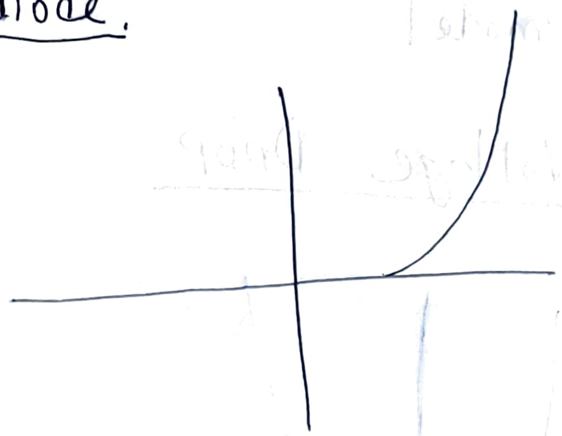
– 〃 electron কে push করবে।





Ideal diode

Real diode:



$$I = \left[I_s \left(\exp\left(\frac{V}{nV_T}\right) - 1 \right] \right.$$

I_s = reverse saturation current ($10^{-9} A$)

n = ideality factor (1,2)

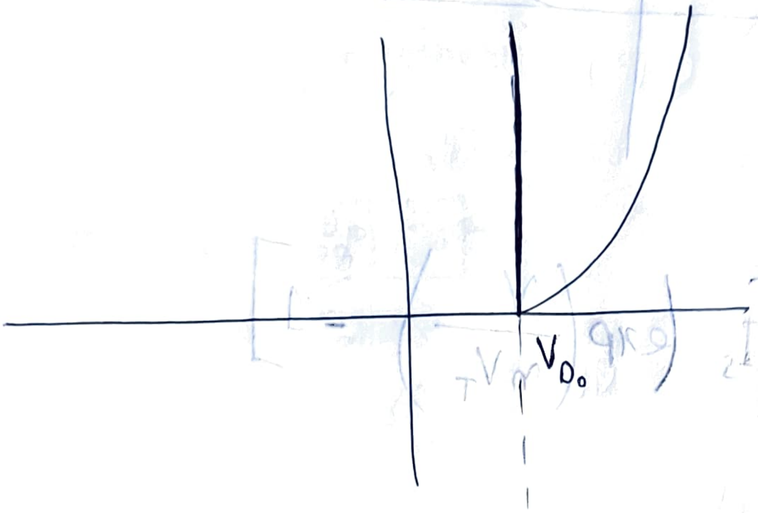
V_T = thermal voltage ($\frac{kT}{q}$, 26 mV for room temp)

diode বানানোর সময় এই গুলো fix করে দেওয়া হয়।

গ্রাফ পরে আর change করা যায় না।

CVD model

Constant Voltage Drop



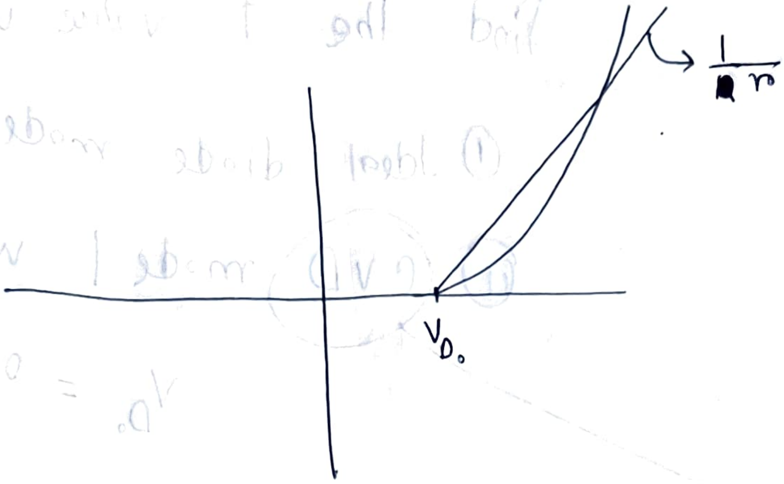
for → Si → $V_{D_0} = 0.7\,V$

for → Ge → $V_{D_0} = 0.2\,V$

- when $I > 0$,

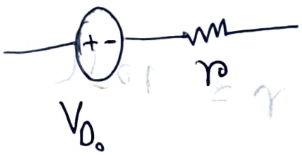
when $V < V_{D_0}$

~~CVD+r~~ $\boxed{\text{CVD} + r \text{ model}}$



when,

$I > 0,$



when,

$V < V_{D_0}$

$I = 0$

find the I value using

(i) Ideal diode model

(ii) CVD model with

$V_{D_0} = 0.7V$

কিছু বলে নাই
যে ওরা থাকবে
CVD

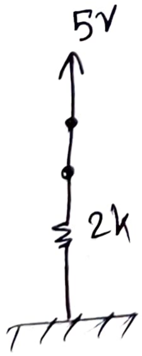
(iii) CVD+r model with

$V_{D_0} = 0.7V$

$r = 10\Omega$

(i) Diode linear component নাই, linear component এ convert করে নিতে হবে।

(i)



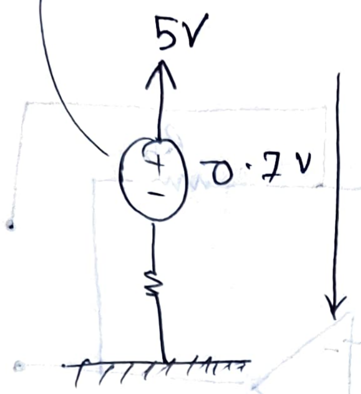
$$I = \frac{5-0}{2} = 2.5$$

behaves like a voltage source
but not exactly voltage source.

passive

(ii)

CVD



KVL

শুরু - শেষ = প্রতি stepএ voltage drop

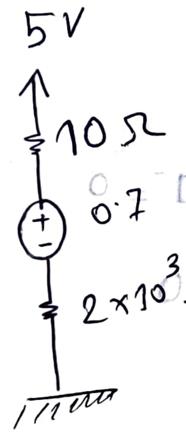
$5 - 0 = 0.7 + I \times 2$

$\Rightarrow I = 2.15\ mA$

(Ans)

(iii)

CVD+r



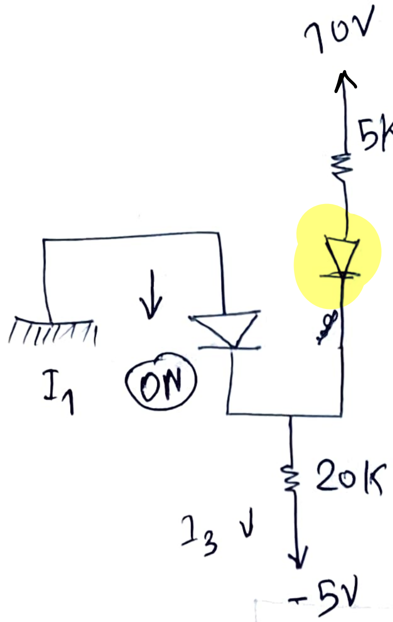
$5 - 0 = 10I + 0.7 + \cancel{I \times 2 \times 10^3}\ 2I$

$5 = 0.01I + 0.7 + 2I$

$I = 2.139$

$I \approx 2.14$

30/06/24



ON কারণ মনে হচ্ছে, current +ve আসছে।

current high → low Voltage এ যায়।

Find I_1, I_2, I_3 ।

Assume CVD diode model, with $V_{D_0} = 1\,V$

To know I_D, we need to know diode ON/off

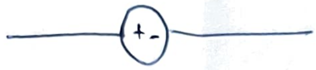
To know ON/OFF, we need to know I_0

Method of Assumed State

Step 1:

Assume
- ON
- OFF

Step 2:

ON 

OFF 

Solve the circuit, Find I_D, V_D for All diode

Step 3:

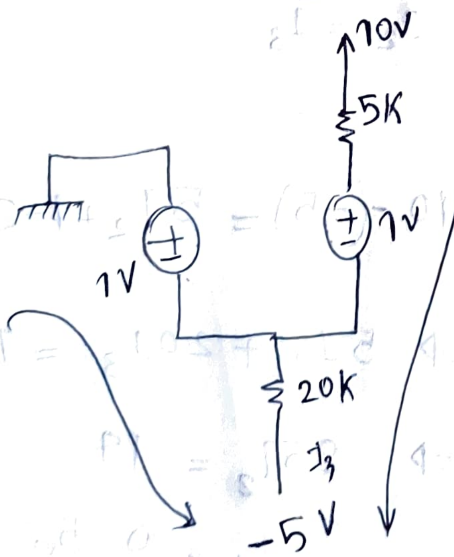
ON, $I > 0$

OFF $V < 0$

Assume that,

$D_1 \rightarrow$ ON

$D_2 \rightarrow$ ON



$$10 - -5 = 5I_2 + 1 + 20I_3$$

$$\Rightarrow 15 = 5I_2 + 20I_3 + 1$$

$$0 - (-5) = 1 + 20I_3$$

$$\Rightarrow 20I_3 = 4$$

$$\Rightarrow I_3 = \frac{4}{20} = \frac{1}{5} \quad \Rightarrow I_3 = 0.2$$

$$I_1 + I_2 = I_3$$

$$\Rightarrow I_1 + I_2 - I_3 = 0$$

$I_1 = -\frac{9}{5} = -1.8\ mA \not> 0.$

এইটা OFF করতে হবে But মিলবে-ই তা বলা যাবে না।

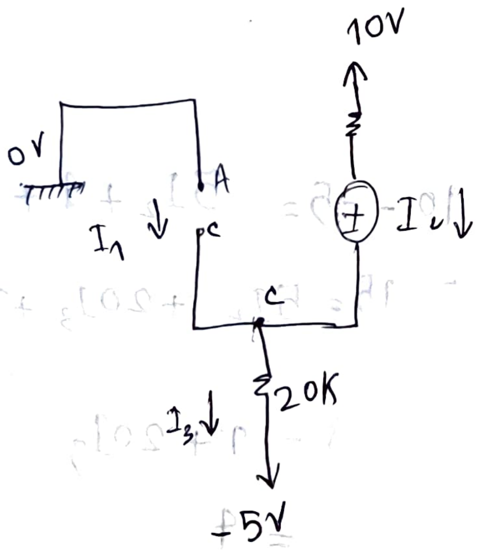
$I_2 = 2\ mA > 0$

$I = 0.2\ mA$

Assume

D_1 OFF

D_2 ON



$I_1 = 0$

$I_2 = I_3$

$$10 - (-5) = 5I_2 + 1 + 20I_3$$

$$\Rightarrow 5I_2 + 20I_3 = 14$$

$$\Rightarrow 25I_2 = 14$$

$$\therefore I_2 = 0.56$$

$I_1 = 0$

$I_2 = 0.56 \text{ mA} > 0$

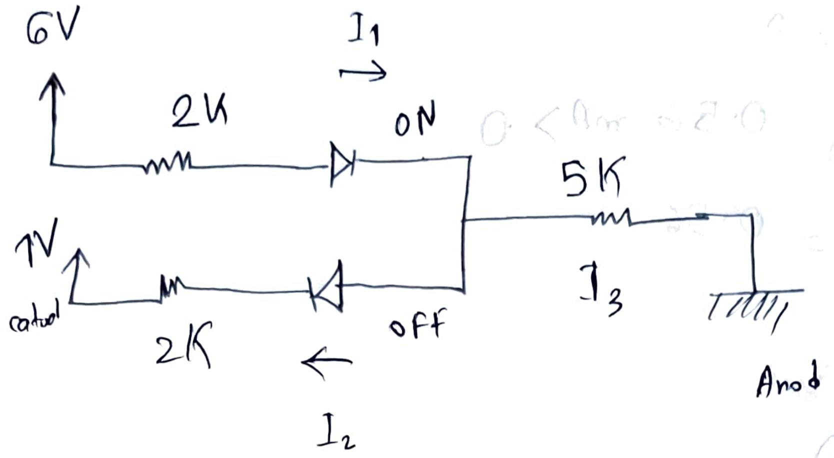
$I_3 = 0.56$

$$\frac{V_c - (-5)}{20} = 0.56$$

$\Rightarrow V_c = -6.2 < 0$

$\therefore$ Assumption verified.

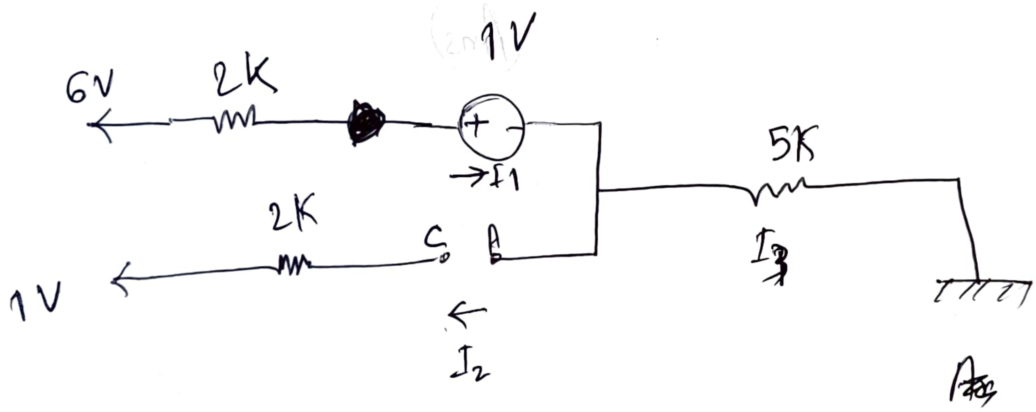
(Ans)



6 আর 0 থেকে মনে হচ্ছে I_1 +ve হতে পারে।

D_1 = ON

D_2 = OFF



$I_2 = 0$

$I_3 = I_1$

$6 - 0 = 2I_1 + 7 + 5I_3$

$\Rightarrow 7I_1 = 5 \Rightarrow I_1 = 0.71$

$I_1 = 0.71 > 0$

$I_2 = 0$

$I_3 = 0.71$

~~$V = V_A - V_C$~~

$= \dfrac{V_A - 0}{5} = 0.71$

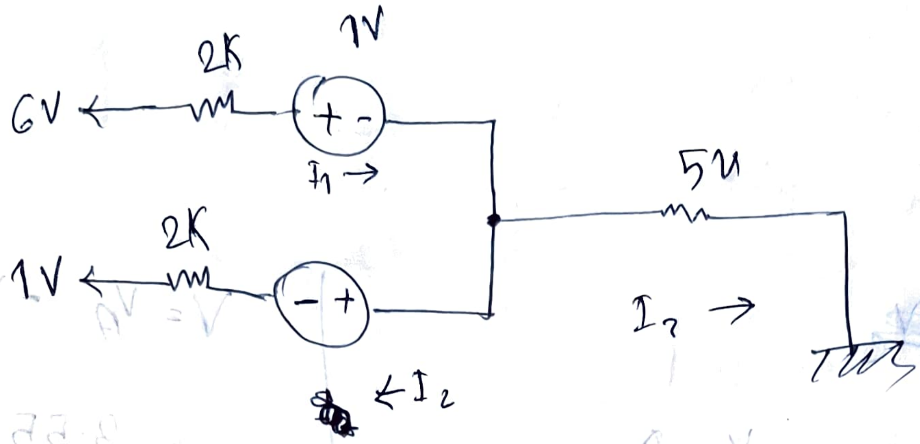
$= 3.55$

$V = V_A - V_c$

$= 3.55 - 1$

$= 2.55 < 0$

$\therefore$ Assumption wrong.



$$6-0 = 2I_1 + 1 + 5I_3$$

$$\Rightarrow \boxed{2I_1 + 5I_3 = 5}$$

$$1-0 = -2I_2 + 5I_3 - 1$$

$$\Rightarrow \boxed{-2I_2 + 5I_3 = 1}$$

$$I_1 = I_2 + I_3$$

$$\Rightarrow \boxed{I_1 - I_2 - I_3 = 0}$$

$I_1 = \frac{5}{4} = 1.25$

$I_2 = \frac{3}{4} = 0.75$

$I_3 = \frac{1}{2} = 0.5$

Anode cathode

$I_1 = 1.04$ mA > 0

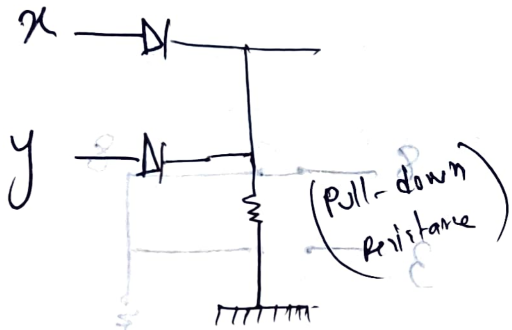
$I_2 = 0.95$ mA > 0

$I_3 = 0.58$ mA

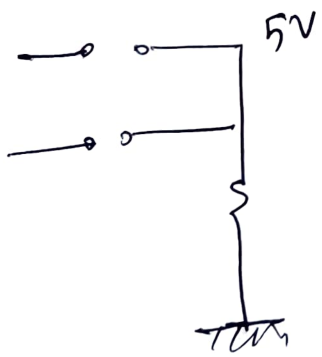
Connect!

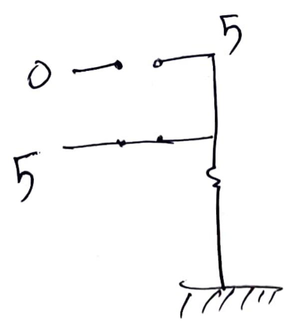
Logic gate with Diodes (Ideal diode)

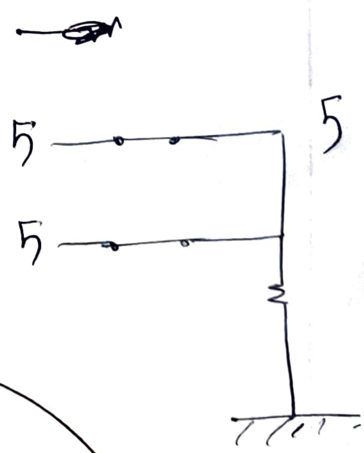
OR gate এর circuit

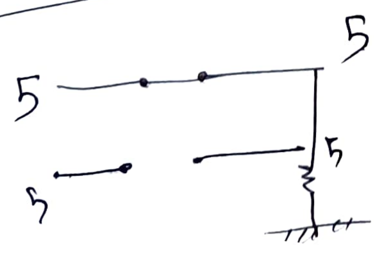


x	y	V_{out}
0	0	0
0	5	5
5	0	5
5	5	5

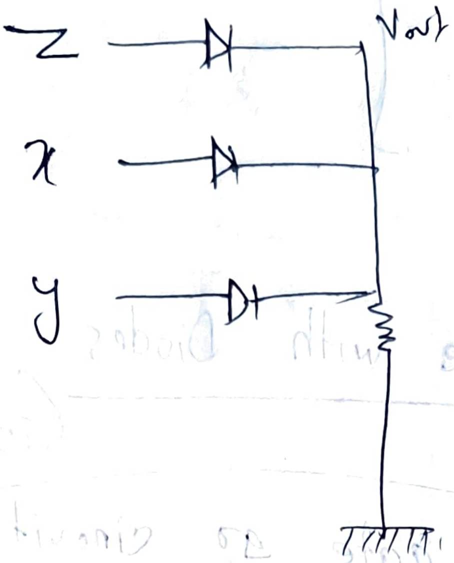








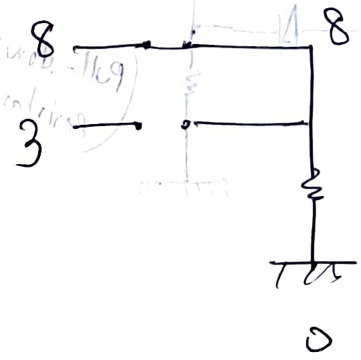
⇒ -ve হবে না



$V_{out} = x+y$ on

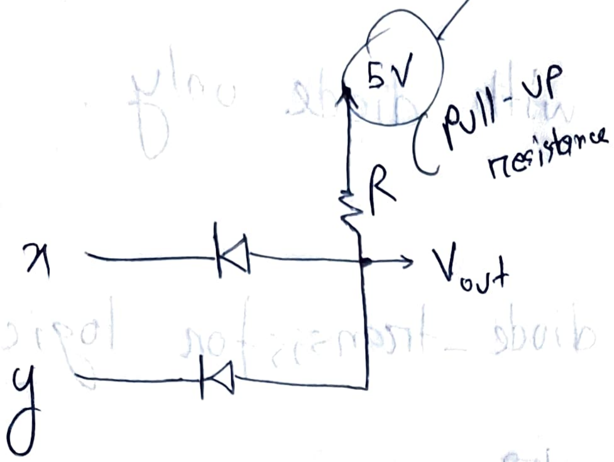
$= x+y+z$ on

$\therefore V_{out} = max(x, y)$

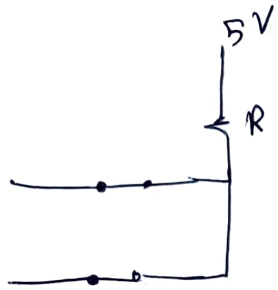


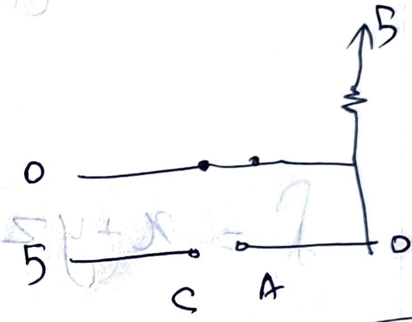
x, y, z গুলো থেকে কম হতে হবে।

And gate circuit



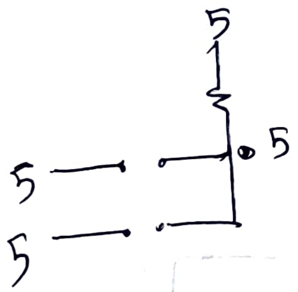
x	y	V_{out}	
0	0	0	0
0	5	0	0
5	0	0	0
5	5	5	1





ON হলে +ve current flow দেখাতে হবে।

$V_A - V_C = -5$



$V = xy$

$V_{out} = xyz$

$x = 3\ v$
$y = 2\ v$

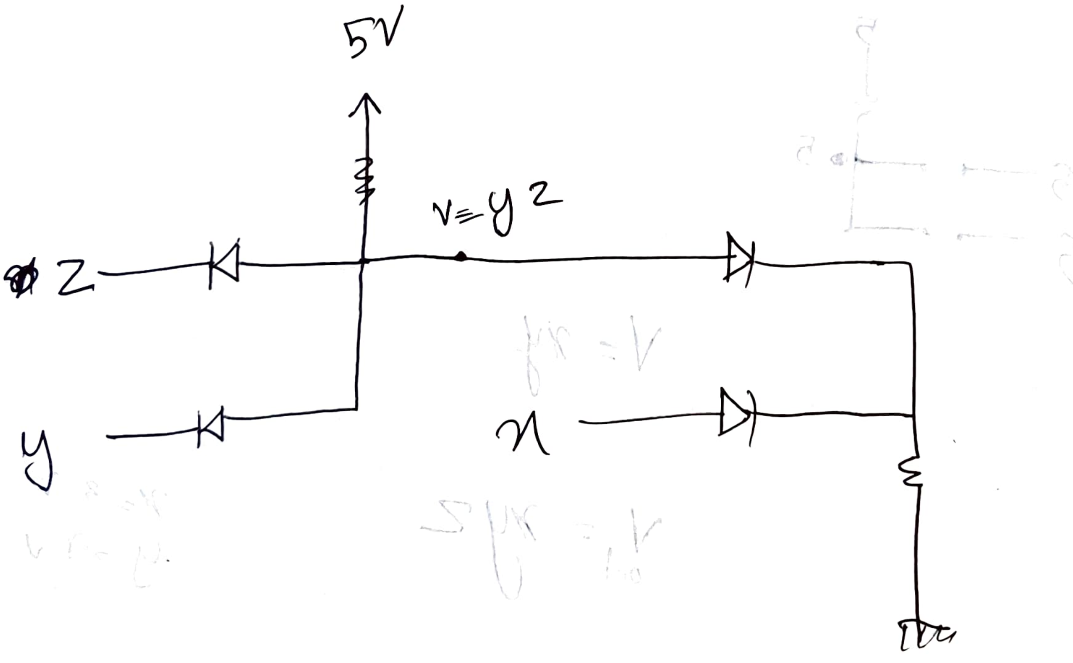
$V_{out} = \min(x, y, z)$

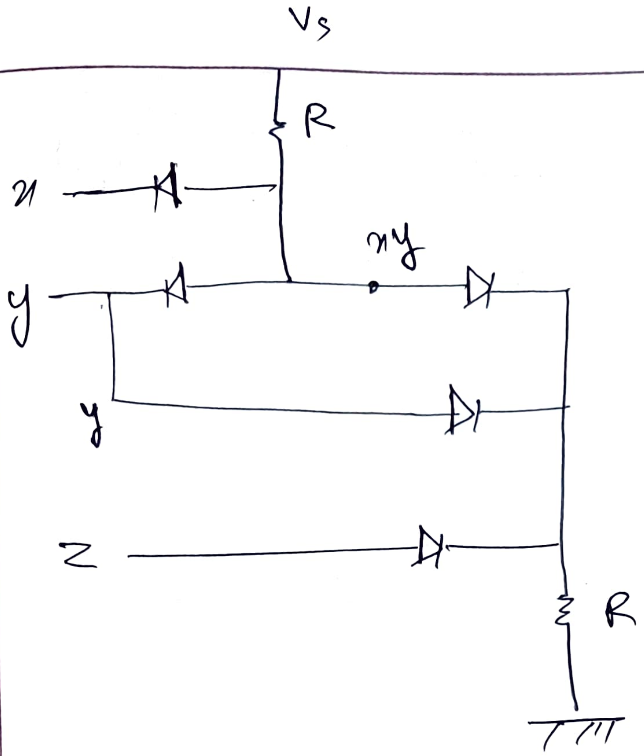
Not Gate

Not possible with diode only.

DTL (diode - transistor logic
এই কোর্সে নাই)

$f = x + yz$





$$f = xy + y + z$$
$$= y(x+1) + z$$
$$= y + z$$

Quiz 2

আজকে পর্যন্ত ~~য~~ সব → ~~diode~~

(i) IV characteristic

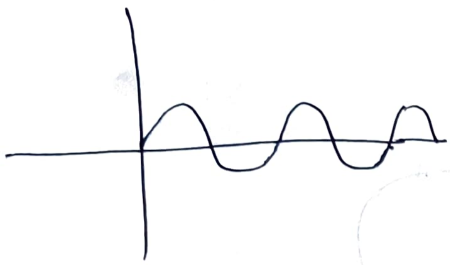
(ii) Diode

07 July

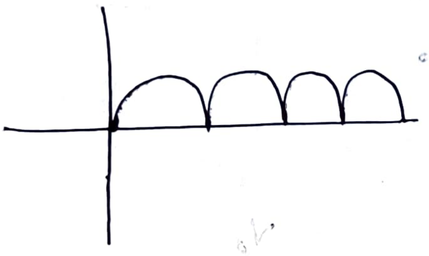
02.07.24

Half Rectifier

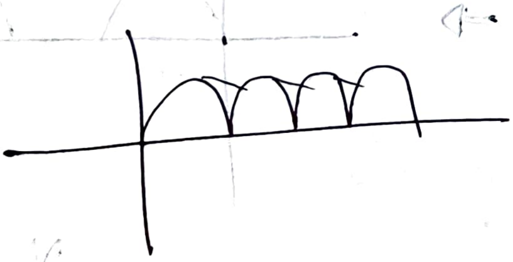
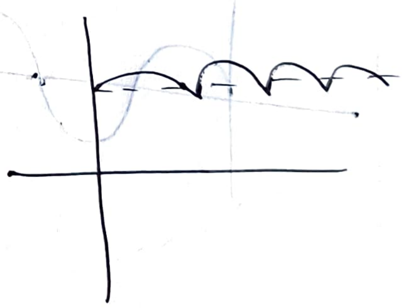
AC to Dc conversion



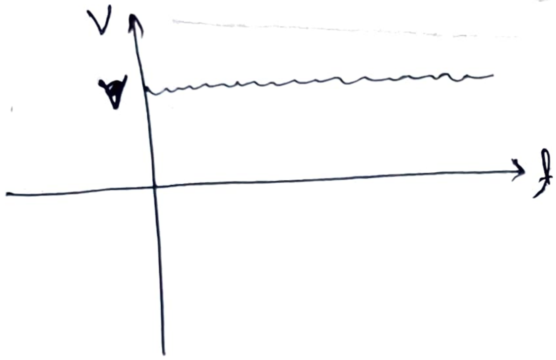
Rectification



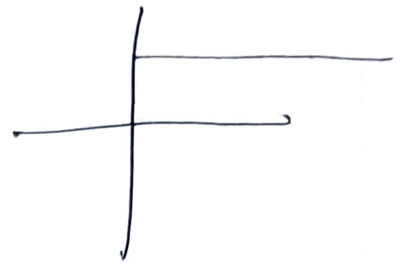
Filtering

 ⇒ 

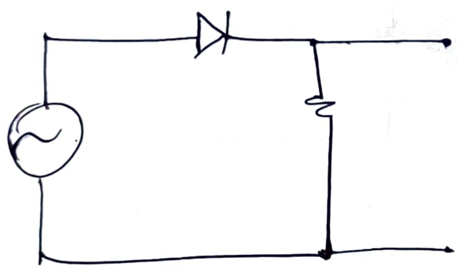
regulation ⇒ zener diode

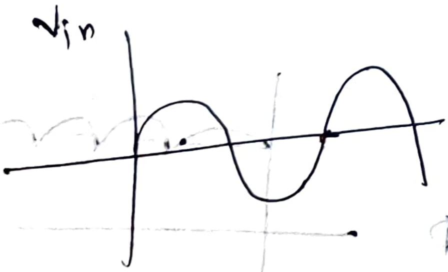


⇒

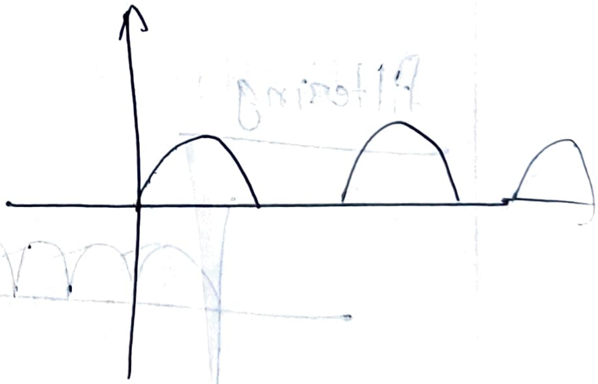


Ideal diode





⇒

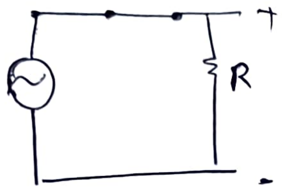


Vin $\qquad\qquad$ V_{out}

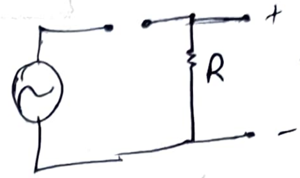
$V_{in} > 0$ হলে $V_{in} = V_{out}$

$V_{in} < 0$ " $V_{out} = 0$

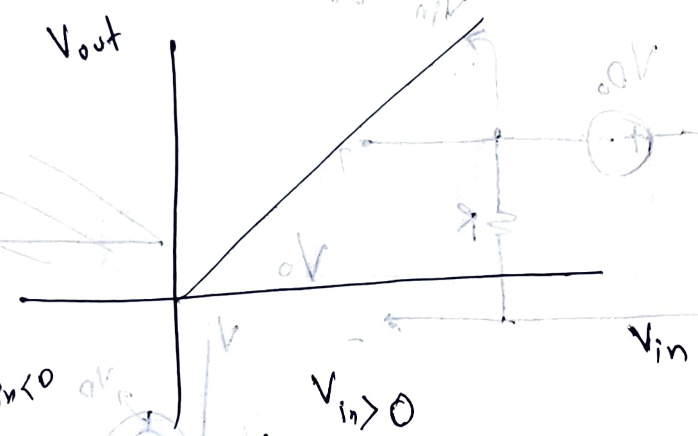
ON



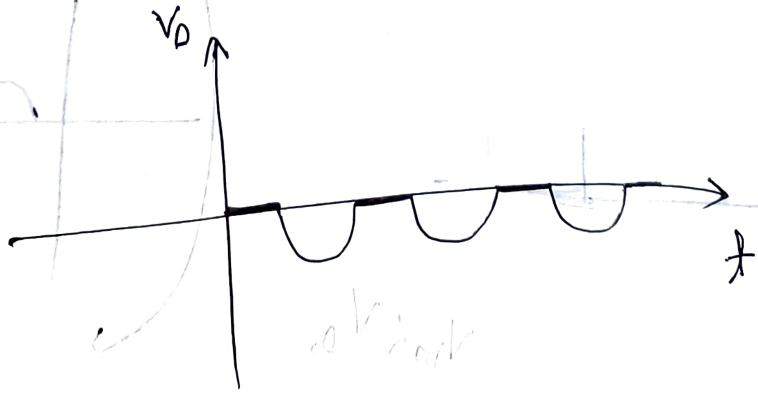
OFF



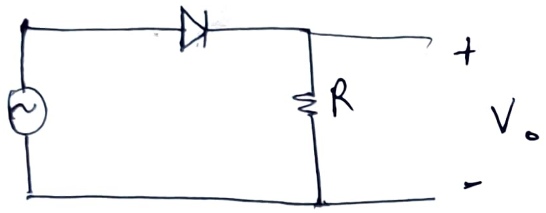
Transfor characteristics



Voltage of Diode

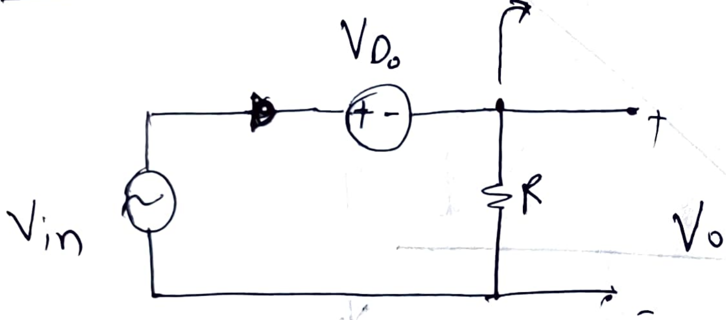


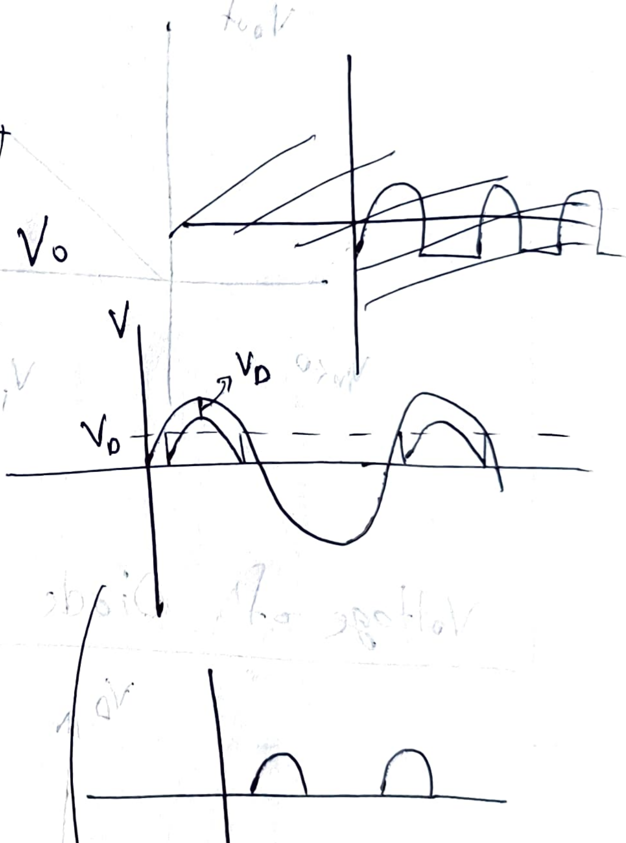
CVD diode



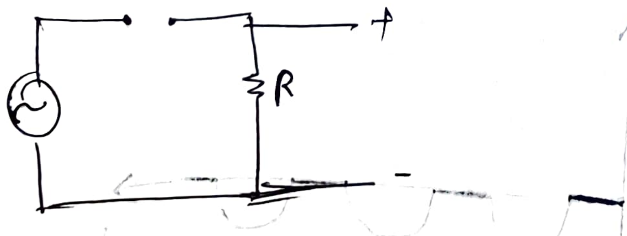
Diode ON

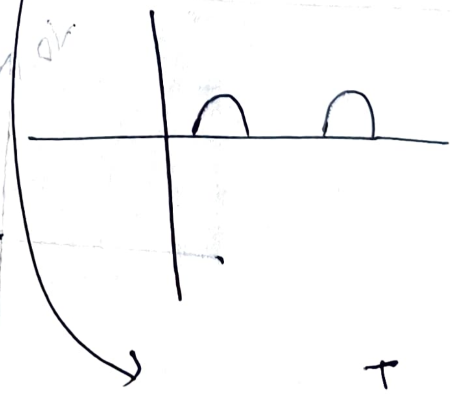
$V_{in} - V_{D_0} \Rightarrow V_{in} > V_{D_0}$





Diode OFF



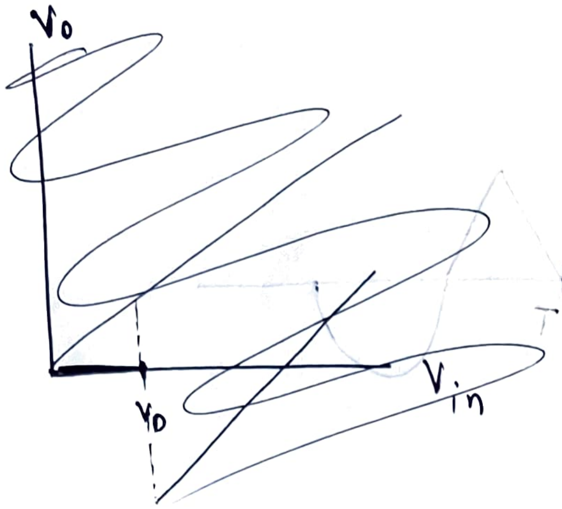


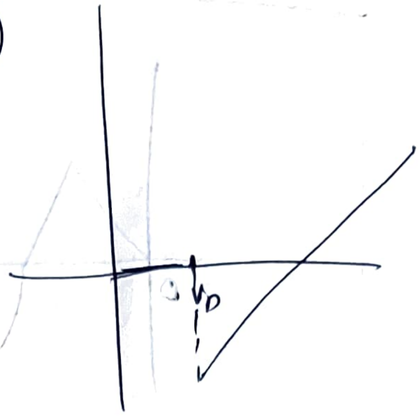
$V_{in} < V_{D_0}$

$$\therefore V_{avg} = \frac{1}{T}\int_0^T v_o\, dt$$

(Vm = peak of vin) $= \frac{V_m}{\pi} - \frac{V_{D_0}}{2}$

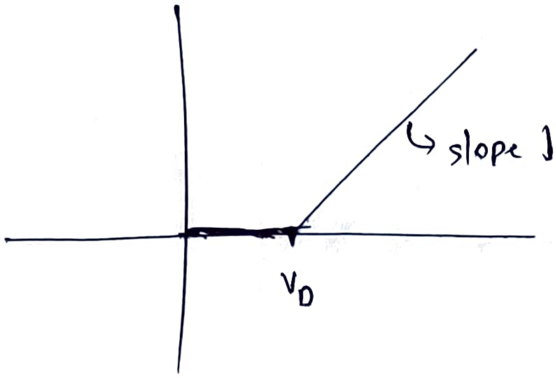
Transfer characteristics



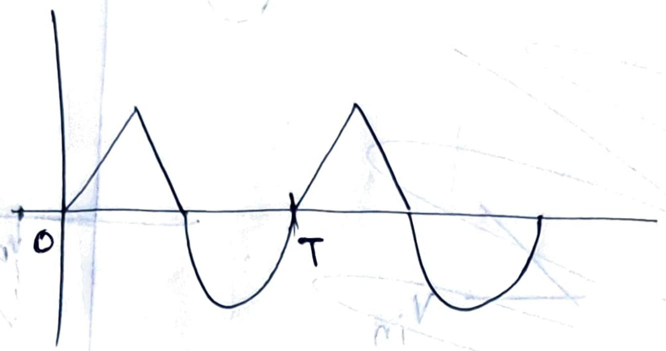


$$V_{out} = V_{in} - V_D$$

$$\Rightarrow y = x - c$$



Example

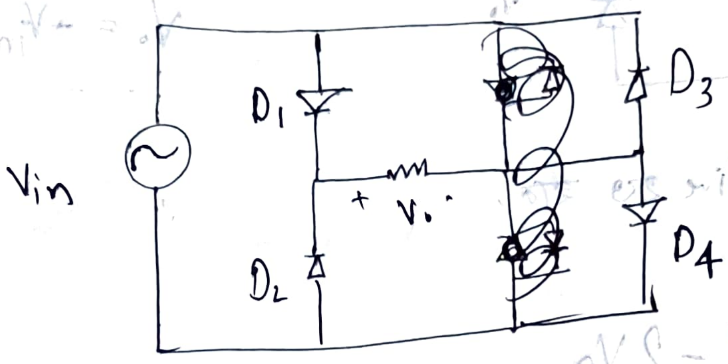


average value of $y = ?$

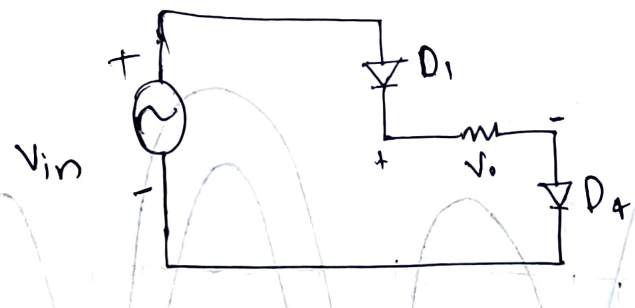
$$y = \frac{1}{T}\int_0^T y\,dt$$

$\therefore$

Full-wave rectifier (CVD model)



Positive Half cycle

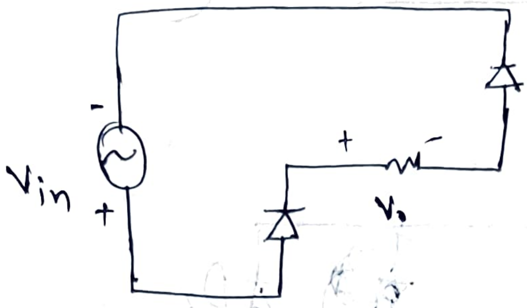


$\therefore V_0 = V_{in} - V_{D_1} - V_{D_4}$

$\Rightarrow V_0 = V_{in} - 2V_{D_0}$

~~Even~~, Positive V_0 ~~হবে~~,

$V_{in} > 2V_{D_0}$

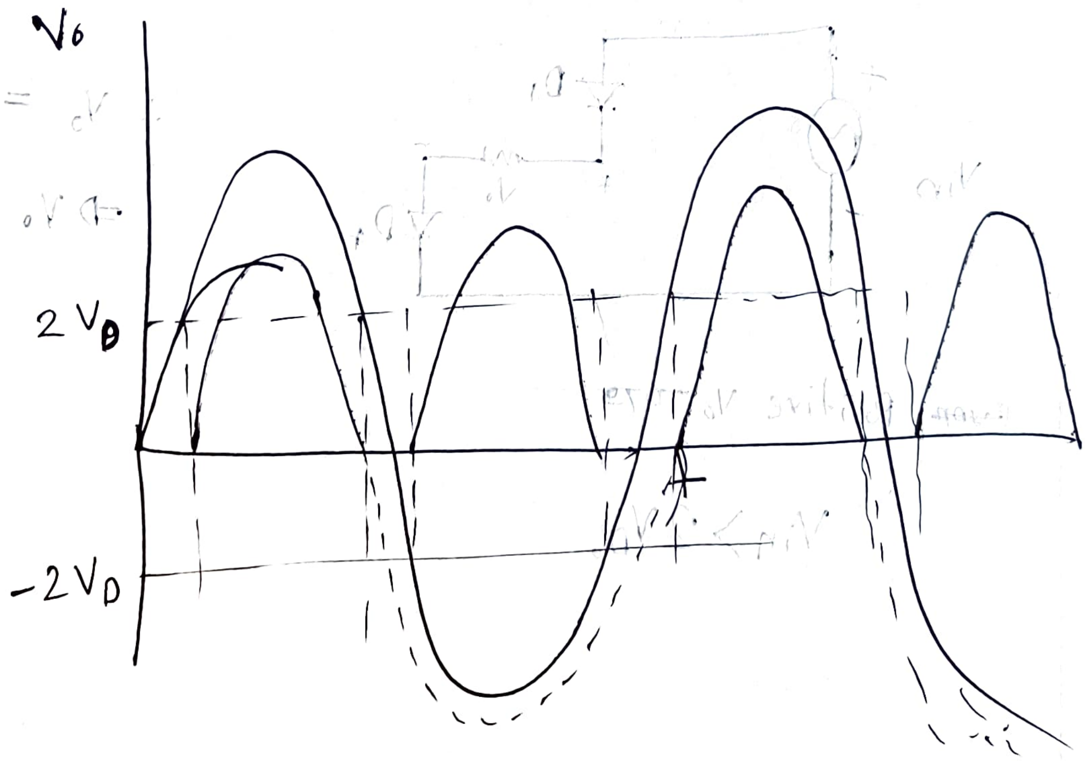


$V_o = -V_{in} - 2V_D$

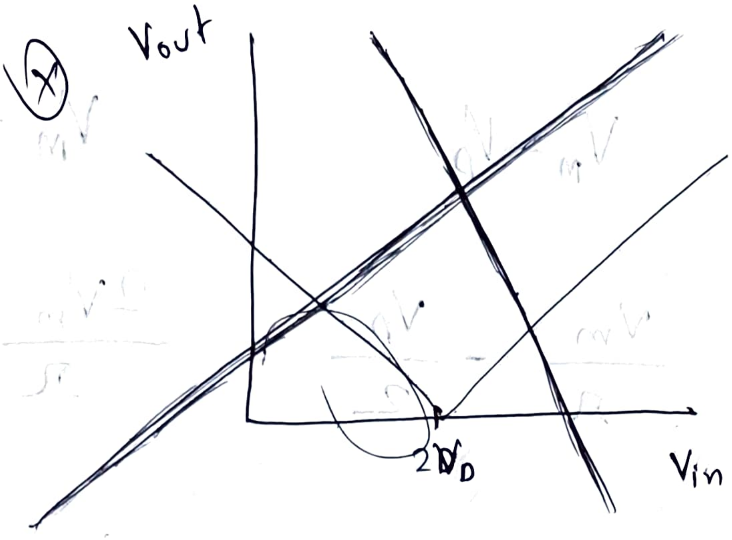
V_o positive হতে হলে,

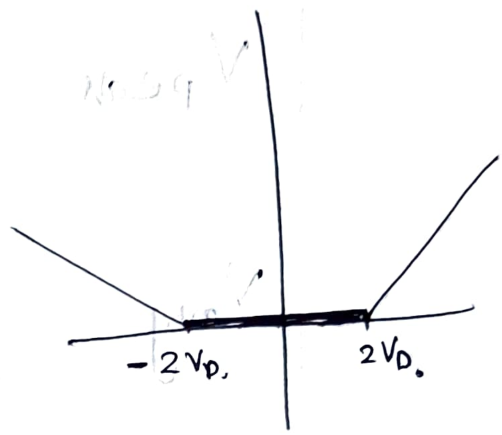
$V_o < -2V_D.$

$\therefore \quad -2V_D < V_{in} < 2V_D \Rightarrow V_O = 0$



Transference characteristic graph





$V_{out} = V_{in} - 2V_D.$

$\Rightarrow y = x - c$

$V_{out} = -V_{in} - 2V_D.$

$\Rightarrow y = -mx - c$

average value

$$V_{avg} = \frac{1}{T}\int_0^T V_o\,dt = \frac{2V_m}{\pi} - 2V_D.$$

	Half-wave	Full-wave
V_{peak}	$V_M - V_D$	$V_M - 2V_D$
V_{avg}	$\frac{V_m}{\pi} - \frac{V_D}{2}$	$\frac{2V_m}{\pi} - 2V_D$

~~Date~~ 02.07.24

Practice for Quiz 2

17

(i) Ideal

(ii) CVD ⇒ $0.7 = V_D$

(iii) CVD + r_D:

$V_D = 0.7$

$r = 10\Omega$

(i)

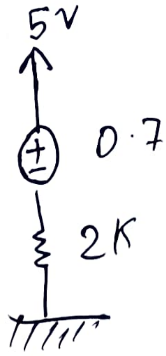
⇒ Ideal

∴ $5 - 0 = 2I$

⇒ $I = 2.5$ mA.

(ii)

⇒



⇒ $5 - 0 = 0.7 + 2I$

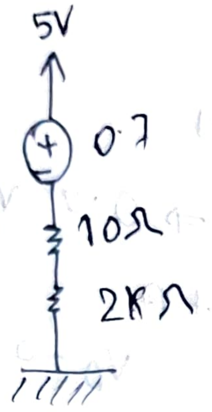
⇒ $4.3 = 2I$

⇒ $I = 2.15$ mA

$\frac{1\cancel{0}}{100\cancel{0}}$

0.01

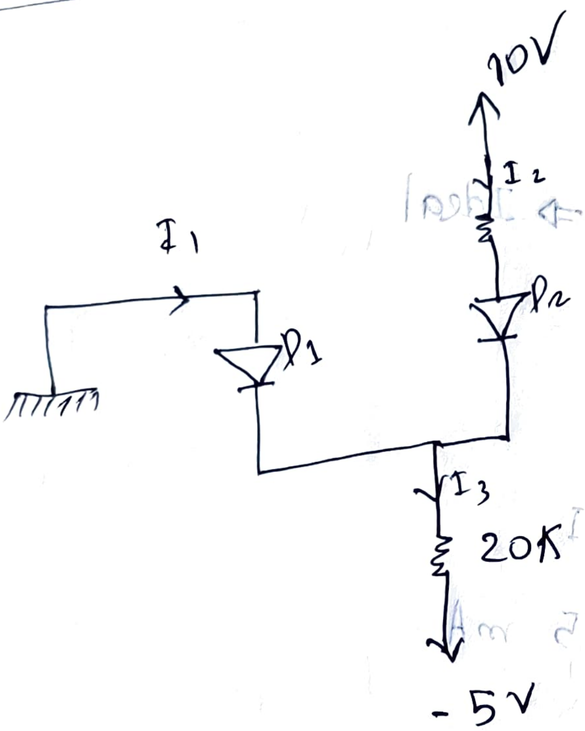
(iii)



$\Rightarrow 5 - 0 = 0.7 + 2.01 K\Omega I$

$\Rightarrow 4.3 = \cancel{20}\ 2.01 \Omega I$

$\therefore I = 2.139 \approx 2.14$



$V_D = 1$

$I_1 = ?$

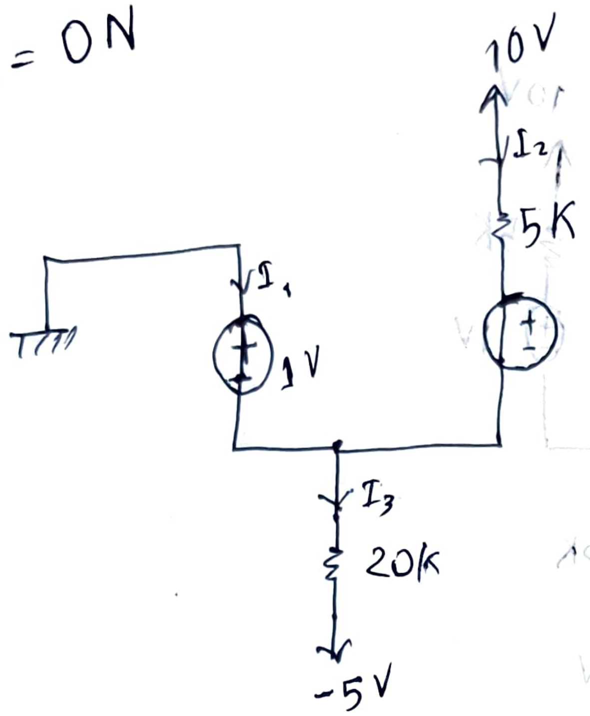
$I_2 = ?$

$I_3 = ?$

Let's assume that

$D_1 = ON$

$D_2 = ON$



$10 - (-5) = 5I_2 + 1 + 20I_3$

$\Rightarrow \quad 5I_2 + 20I_3 = 14$ —①

$0 - (-5) = 1 + 20I_3$

$\Rightarrow \quad I_3 = 0.2 \text{ mA}$

$I_2 = 2 \text{ mA}$

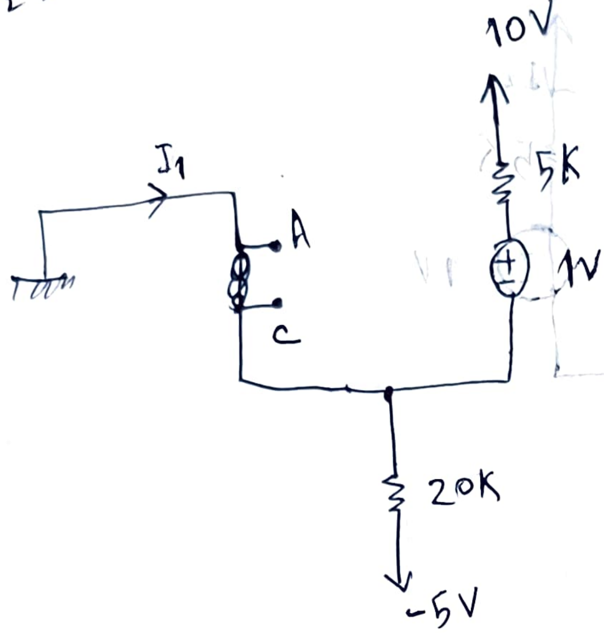
$I_1 + I_2 - I_3 = 0$

$\Rightarrow \quad I_1 = I_3 - I_2$

$I_1 = 0.2 - 2 = -1.8 \text{ mA}$

$D_1 = OFF$

$D_2 = ON$



$$\frac{V_c - -5}{20} = 0.56$$

$\Rightarrow$

$I_1 = 0$

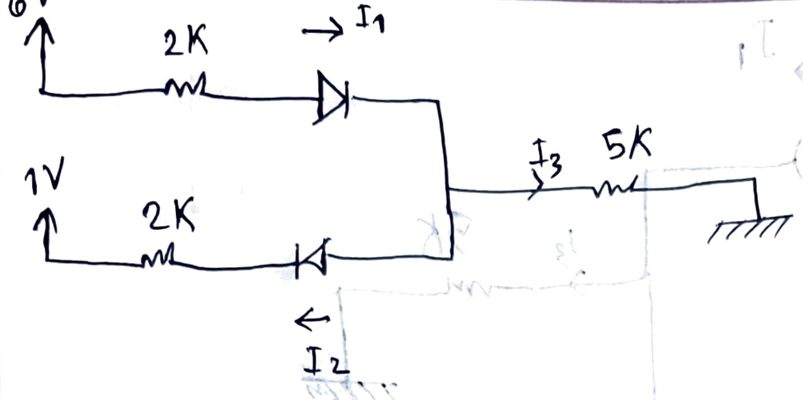
~~10 - 0~~

$10 + 5 = 5I_2 + 1 + 20I_3$

$\Rightarrow \quad 5I_2 + 20I_3 = 14$

$\Rightarrow \quad 25 I_2 = 14$

$\Rightarrow \quad I_2 = 0.56 > 0$



$D_1 = ON$

$D_2 = OFF$

$6 - 0 = 2I_1 + 1 + 5I_3$

$\Rightarrow 2I_1 + 5I_3 = 5$

$\Rightarrow I_1 = 0.71 > 0$ ON

$\cancel{1 - 0 = -2I_2 - 1 + 5I_3}$

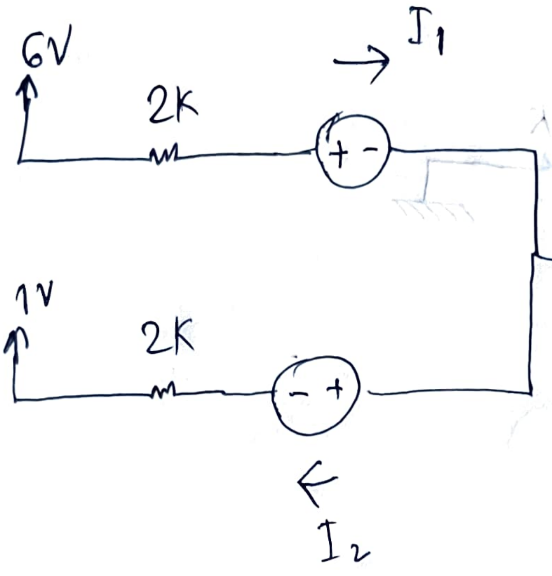
$\Rightarrow \cancel{-2I_2 + 5I_3 = 2}$

$I_2 = 0$

$\frac{V_A - 0}{5} = 0.71$

$I_1 = I_2 + I_3$

$I_1 = I_3$



$6 - 0 = 2I_1 + 1 + 5I_3$

$\Rightarrow 2I_1 + 5I_3 = 5$

$1 - 0 = -2I_2 - 1 + 5I_3$

$\Rightarrow -2I_2 + 5I_3 = 2$

$I_1 - I_2 - I_3 = 0$

$I_1 = 1.04 > 0$

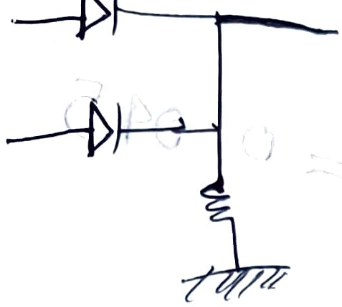
$I_2 = 0.45 > 0$

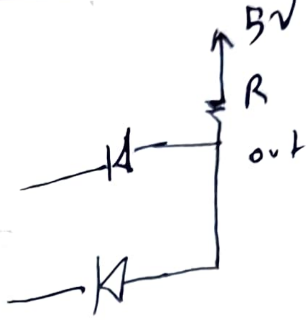
$I_3 = 0.58$

assumption verified.

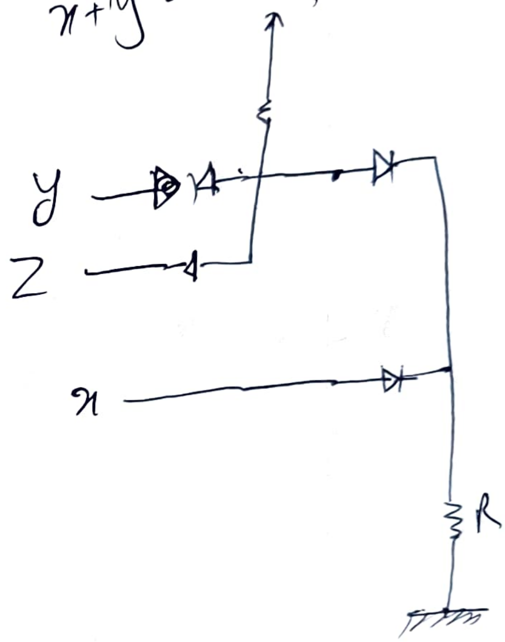
OR

AN





x+yz



$f = xy + y + z$