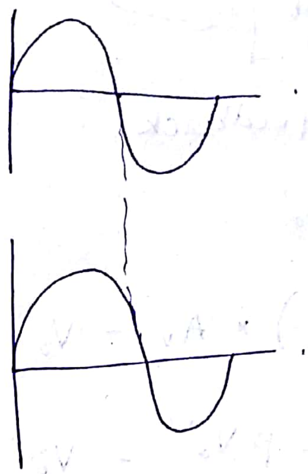
★ CONCEPT OF FEEDBACK :-

Feedback is the process of taking some fraction from the output & fed back that portion to the input. This process is called feedback.

Types → (i) Positive feedback.

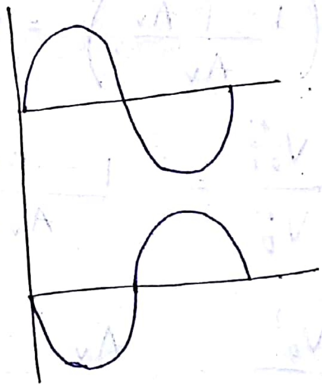
(ii) Negative feedback.

Positive Feedback.



same phase.

Negative Feedback.

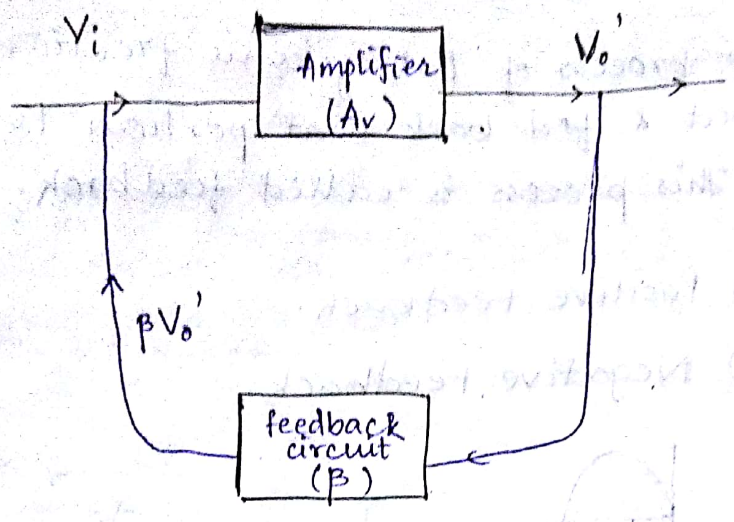


opp. phase

★ PRINCIPLE OF FEEDBACK :-

A_v → gain of amplifier without feedback.

β → feedback ~~factor~~ ratio.



Assuming the +ve feedback,

$$\Rightarrow V_i + \beta V_o'$$

so, $$(V_i + \beta V_o') \times A_v = V_o'$$

$$\Rightarrow \frac{V_o'}{A_v} - \beta V_o' = V_i$$

$$\Rightarrow V_o' \left(\frac{1 - \beta A_v}{A_v} \right) = V_i$$

$$\Rightarrow \frac{V_i}{V_o'} = \frac{1 - \beta A_v}{A_v}$$

$$\Rightarrow \boxed{\frac{V_o'}{V_i} = \frac{A_v}{1 - \beta A_v}} = A_{vf}$$

$$\boxed{A_{vf} > A_v}$$

used in oscillators where gain is ∞.

Similarly if feedback is -ve.

$$A_{vf} = \frac{A_v}{1 + \beta A_v}.$$

Numericals
V.K Mehta

$$\boxed{A_{vf} < A_v}$$

output < input.

* gain is reduced, As well as NOISE & UNWANTED signal will also reduce.

Advantages of Negative Feedback :-

(i) used in operational amplifiers

(ii) noise & distortion is reduced.

(iii) performance of device is enhanced.

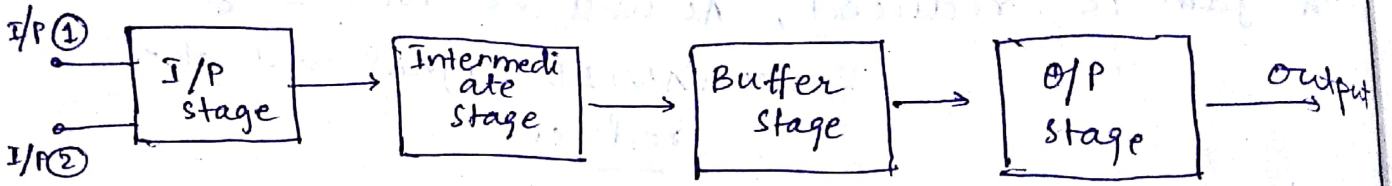
(iv) bandwidth of amplifier will also increase.

★ Operational Amplifier. (Op-Amp).

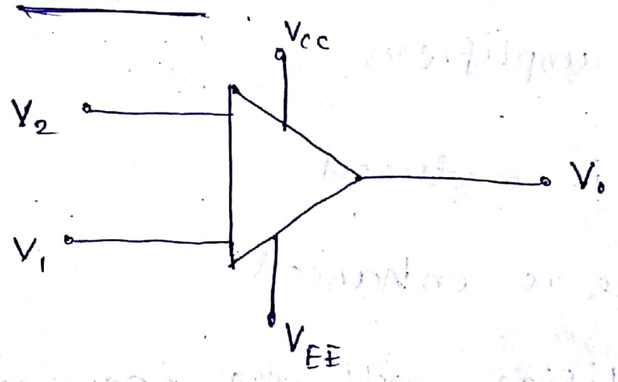
Op-Amp is a directly coupled multistage voltage amplifier with very high

Op-amps are used to perform various mathematical operat^ns like add^n, sub, div, multiplicat^n etc.

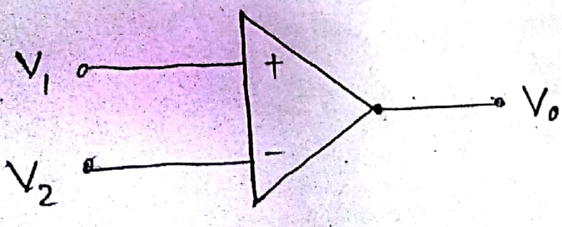
Block Diagram



Symbols.



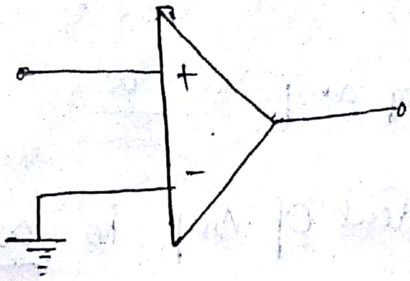
★ Open-Loop Differential Gain. Op-Amp.



$$\text{Gain}(A) = \frac{\text{Out}}{\text{In}} = \frac{V_o}{(V_1 \sim V_2)}$$

★ Study Closed-Loop Diff. Gain op-amp.

★ Non-Inverting Mode Op-Amp :-

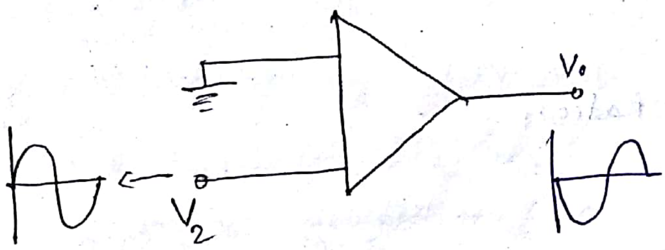


$$A = \frac{V_o}{V_i}$$

$$\boxed{V_o = A V_i}$$

Phase diff. betn O/P & I/P is ZERO.

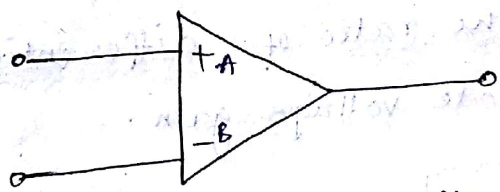
★ Inverting Mode op-Amp :-



$V_o = -A V_2$

'−' denotes out of phase by 180°.

Imp ★ VIRTUAL GROUND CONCEPT :-



There will be no current flow betn inv. & non-inv. terminals inside the op-amp because of very high INPUT IMPEDANCE.

★ The input Impedance of an op-amp is very high (why?) which suggests that there is no current flow between inverting & non-inverting terminals inside the op-amp.

This is possible only when we consider both of pt A & B are at same potential or grounded virtually.

This is called virtual Ground Concept.

★ Open Parameteres / Characteristics.

(i) Infinite Voltage Gain.

gain of ideal op-amp is ∞. $A \Rightarrow \infty$

(ii) Input Impedance for Ideal Op-Amp is ∞ $(R \rightarrow \infty)$

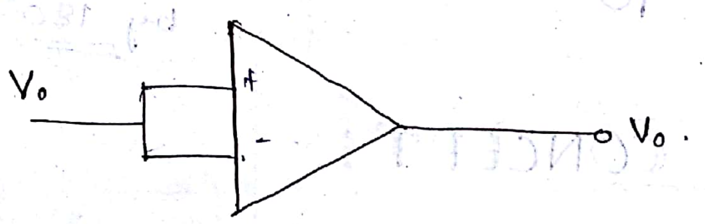
(iii) Output " " " " " 0 $(R \rightarrow 0)$

(iv) for Ideal Op-Amp,

Band width = ∞.

(v) CMRR (ρ)

Common Mode Reject^n Ratio.



CMRR is defined as the ratio of differential Gain & common mode voltage gain.

$$\boxed{\rho = \frac{A_{diff}}{A_{comm.}}}$$

decibel $\rightarrow$ unit.

$$(CMRR)_{AB} = \boxed{20 \cdot \log_{10}\left(\frac{A_d}{A_c}\right)}$$

for ideal op-amp $\rightarrow$ CMRR $\rightarrow \infty$

(vi) SLEW RATE :-

It is defined as the max^m rate of change of output voltage w.r.t time.

(Here the time is measured in $\mu sec.$) micro. sec.

$$\boxed{SR = \left(\frac{dV_o}{dt}\right)_{max}}$$

unit → Volt/sec.

(vii) P.S.R.R :-

Power Supply Reject^n Ratio.

PSRR is defined as the change in input-$\boxed{\text{offset}}$ voltage due to change in the supply voltage producing it keeping other power supply voltage constant.

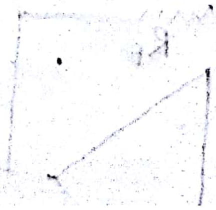
if V_{EE} → const., then

$$PSRR = \left(\frac{\Delta V_{in \cdot off}}{\Delta V_{EE}}\right)_{\Delta V_{EE}}$$

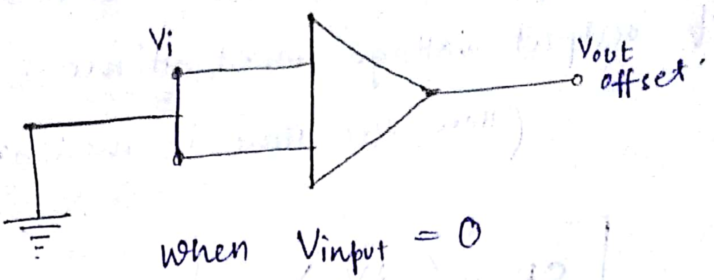
if V_{cc} → const.

$$PSRR = \left(\frac{\Delta V_{in\text{-}off}}{\Delta V_{EE}}\right)_{\Delta V_{cc}}$$

OFFSET VOLTAGES :-



* OFFSET RANGE :-



when $V_{input} = 0$

but $V_{out} \neq 0$

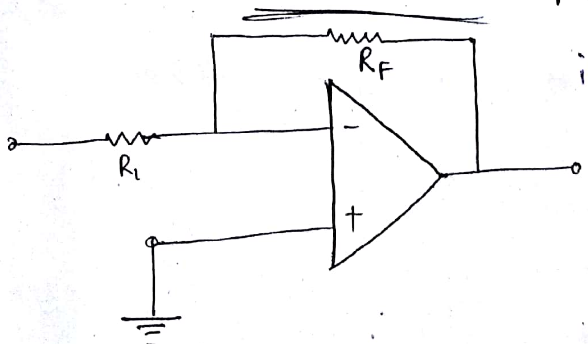
then the output voltage is called output offset.

* When both the input terminals are connected to ground Vin = 0, the output of the op-amp should be ideally 0, but practically, there exists some dc voltage at the output, even the input voltage is zero.

→ This voltage at the output is called Offset Voltage

To make the output offset voltage zero, a small voltage is to be applied at one of the input terminal.
Such a voltage in input which makes the output offset voltage zero, is called input offset voltage

* CLOSED LOOP OP-AMP GAIN :-



inverting

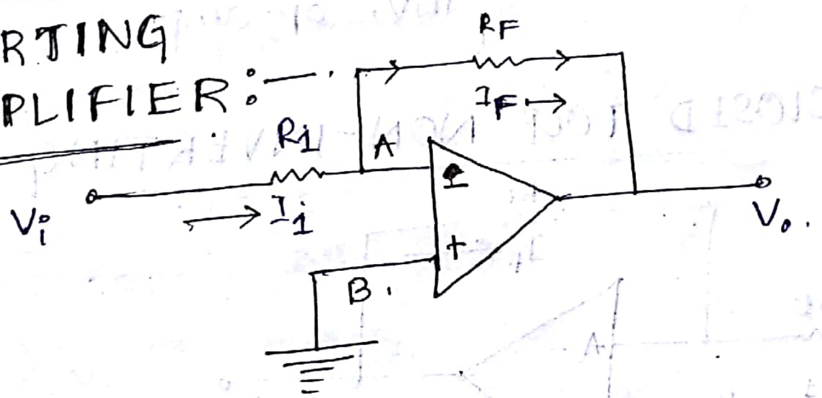
The closed loop op-amp can be designed by ~~filling~~ feeding some part of output, back to the input using resistance.

* The feedback used in op-amp is always negative.
* The gain resulting with feedback is called closed loop op-amp gain.

★ Advantages of Negative Feedback :-

(i) It reduces the gain makes it controllable
(ii) Negative feedback reduces the distortion.
(iii) increases the bandwidth.
(iv) input resistance of op-amp is increased also.
output " " " is decreased.

★ INVERTING AMPLIFIER :-



- In inverting Amplifier, output voltage is amplified & 180° out of phase w.r.t input signal.
- Due to virtual ground concept :- $V_A = V_B = 0$.
- $\boxed{I_1 = I_F}$

From Input site,

$$I_1 = \frac{-V_A + V_i}{R_i} = \frac{+V_i}{R_i} \quad \text{——— (1)}$$

From O/P site :-

$$I_F = \frac{V_A - V_o}{R_F} = \frac{-V_o}{R_F} \quad \text{——— (2)}$$

$V_A \nearrow 0$

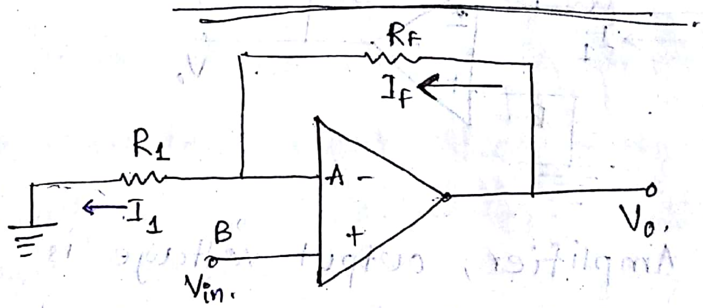
since

$$I_i = I_F$$

$$\Rightarrow \frac{V_i}{R_i} = \frac{-V_o}{R_F}$$

$$\boxed{A_V = \left(\frac{V_o}{V_i}\right) = \frac{-R_F}{R_1}} \longrightarrow$$ Gain in Closed Loop inv. op-amp.

★ GAIN of CLOSED LOOP NON-INVERTING OP-AMP :-



(i) output & input in same phase.

(ii) $\boxed{V_A = V_B = V_{in}}$ ⟶ due to virtual ground concept.

At input side :-

$$I_1 = \frac{V_A - 0}{R_1} = \frac{V_i}{R_1} \quad \text{——— (1)}$$

$V_A \nearrow V_i$

From output side :-

$$I_F = \frac{V_o - V_A}{R_F} = \frac{V_o - V_i}{R_F} \quad \text{——— (2)}$$

$V_A \nearrow V_i$

Since $I_1 = I_f$.

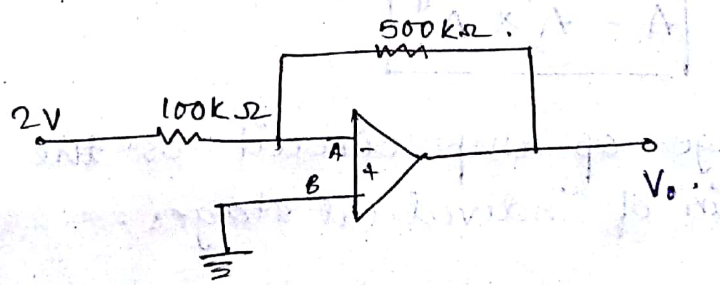
$$\Rightarrow \frac{V_i}{R_1} = \frac{V_o - V_i}{R_F}.$$

$$\Rightarrow R_F V_i = V_o R_1 - V_i R_1.$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{(R_F + R_1)}{R_1}$$

$$\Rightarrow \boxed{\frac{V_o}{V_i} = 1 + \frac{R_F}{R_i}}.$$

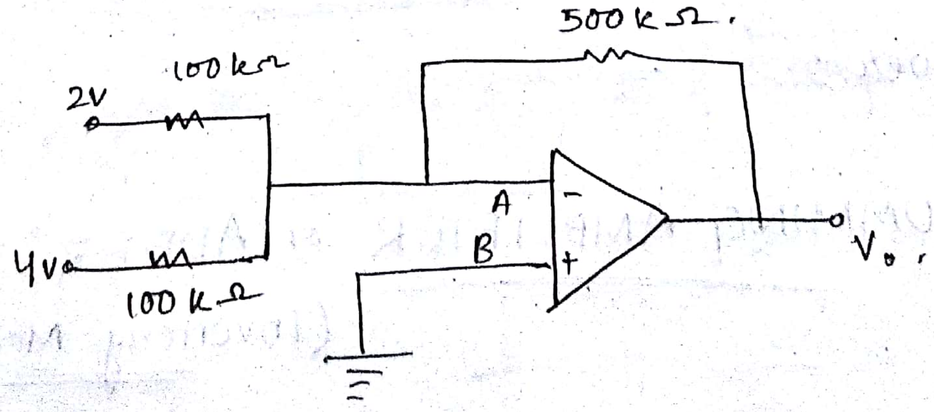
Q.



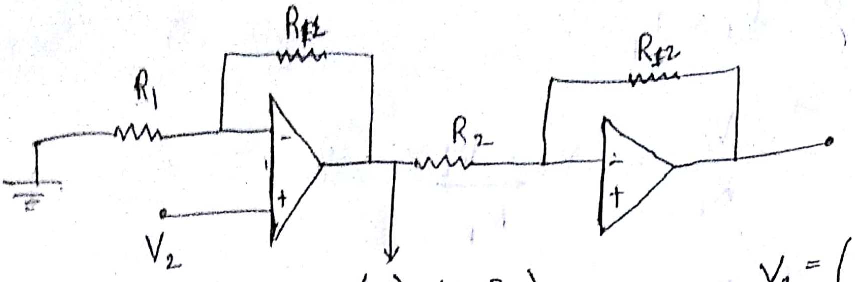
$$\frac{V_o}{2} = -\frac{500}{100}$$

$$\Rightarrow V_o = -10\,V.$$

Q.



☆



$$(V_o)_1 = \left(1 + \frac{R_{F1}}{R_1}\right) V_1$$

$$V_o = \left(-\frac{R_{F2}}{R_2}\right)(V_o)$$

$$V_o = -\left(\frac{R_{F2}}{R_2}\right)\left(1 + \frac{R_{F1}}{R_1}\right) V_1$$

$$\therefore \quad \frac{V_o}{V_1} = A = -\left(\frac{R_{F2}}{R_2}\right)\left(1 + \frac{R_{F1}}{R_1}\right)$$

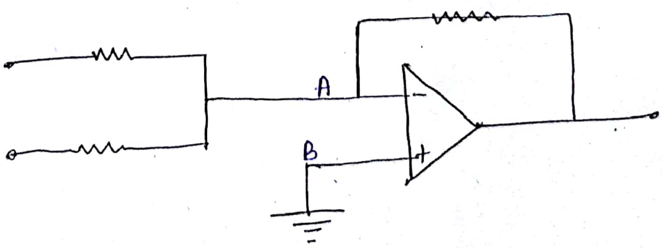
$$\boxed{A = A' \times A''}$$

Total Gain of Multistage op-amp circuit is the product of the gain of individual stages.

☆ Uses ~~of~~ Op-Amp

1. Op-Amp is used as summing Amplifier or Adder.
2. Integrator
3. Differentiator.
4. Voltage follower.

→ Op-Amp as SUMMING AMPLIFIER or ADDER :- (Inverting Mode).



★ In summing Amplifier, o/p voltage is the additn of Input Voltages.

★ From virtual ground concept :-

$$V_B = V_A = 0.$$

Scanned by CamScanner

I/P side $\rightarrow$

$$I_1 = \frac{V_1 - 0}{R_1} = \frac{V_1}{R_1} \quad \text{——— (1)}$$

$$I_2 = \frac{V_2}{R_2} \quad \text{——— (2)}$$

$$I_f = \frac{0 - V_o}{R_F} = \frac{-V_o}{R_F} \quad \text{——— (3)}$$

$$\therefore I_F = I_1 + I_2$$

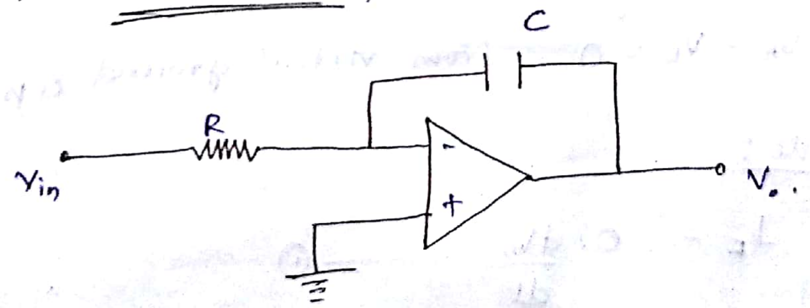
$$\frac{-V_o}{R_F} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$$

$$V_o = -\left(\frac{V_1}{\cancel{R_1}} + \frac{V_2}{\cancel{R_2}}\right)\cancel{R_F}.$$

if $R_1 = R_2 = R_f$.

$$\Rightarrow \boxed{V_o = -(V_1 + V_2)}$$

★ OP-AMP as INTEGRATOR :—



In integrator circuit, o/p is the integratⁿ of I/P voltage.

From virtual ground concept,

$$V_B = V_A = 0$$

I/P

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

o/p side

$$I_1 = (-C_f) \cdot \frac{dV_o}{dt}$$

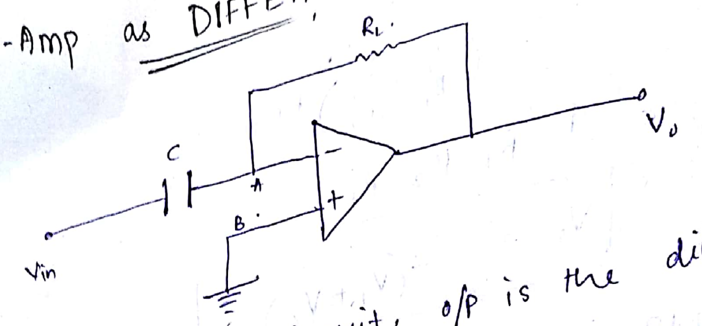
$$I_F = I_1$$

$$\frac{dV_0}{dt} = \frac{V_{in}}{R_1}$$

$$dV_0 = \frac{-1}{R_1 C_F}\left(V_{in} \cdot dt\right)$$

$$\Rightarrow \boxed{V_0 = \frac{-1}{R_1 C_F} \int_0^d V_{in} \cdot dt}$$

★ OP-Amp as DIFFERENTIATOR :-



In differentiating circuit, o/p is the differentiation of i/p waveform.

$V_A = V_B = 0$ from virtual ground concept.

i/p side :

$$I_F = C \cdot \frac{dV_{in}}{dt} \quad \text{—— (1)}$$

O/p side

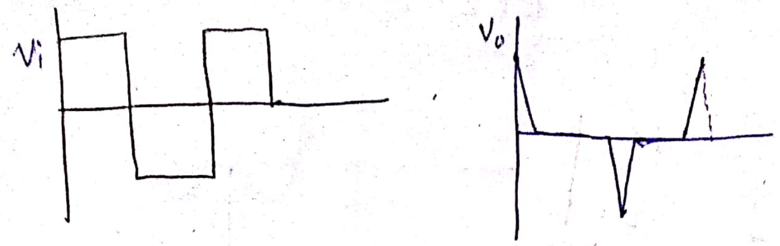
$$I_R = \frac{V_A - V_0}{R_F} = \frac{-V_0}{R_F} \quad \text{—— (2)}$$

for $I_R = I_F$.

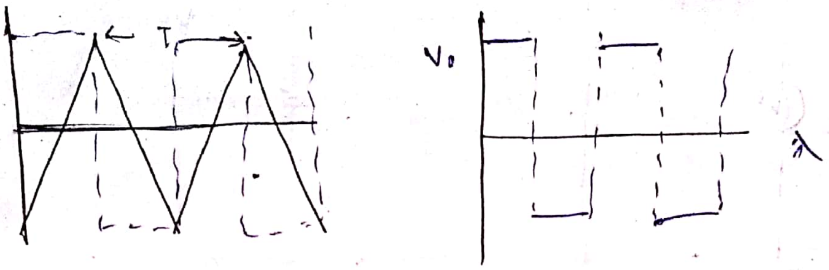
$$\frac{-V_0}{R_F} = C \cdot \frac{dV_{in}}{dt}$$

$$\Rightarrow \boxed{V_0 = -R_F C \frac{dV_{in}}{dt}}$$

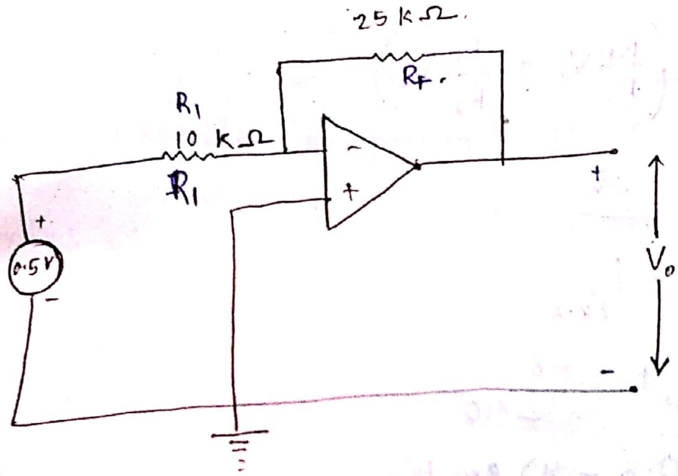
Q.



Q.



Q.



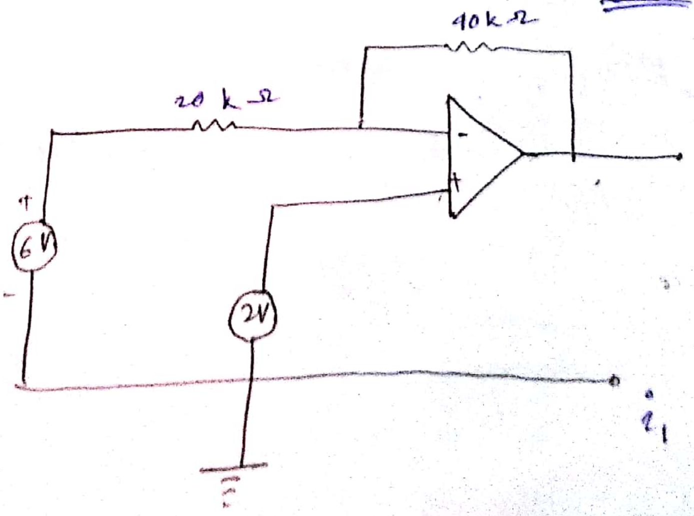
$$\frac{V_o}{V_{in}} = -\frac{R_F}{R_1} = \frac{-25}{10}$$

$$\Rightarrow V_o = -\frac{25}{10} \times 0.5 = \underline{-1.25}.$$

$$i_1 = \frac{(0.5-0)}{10\times10^3} = 0.5\times10^{-4}$$

$$= 0.\underline{05\ mA}$$

Q.



$$\cancel{\frac{V_o}{V_i} = -\frac{40}{20}}$$

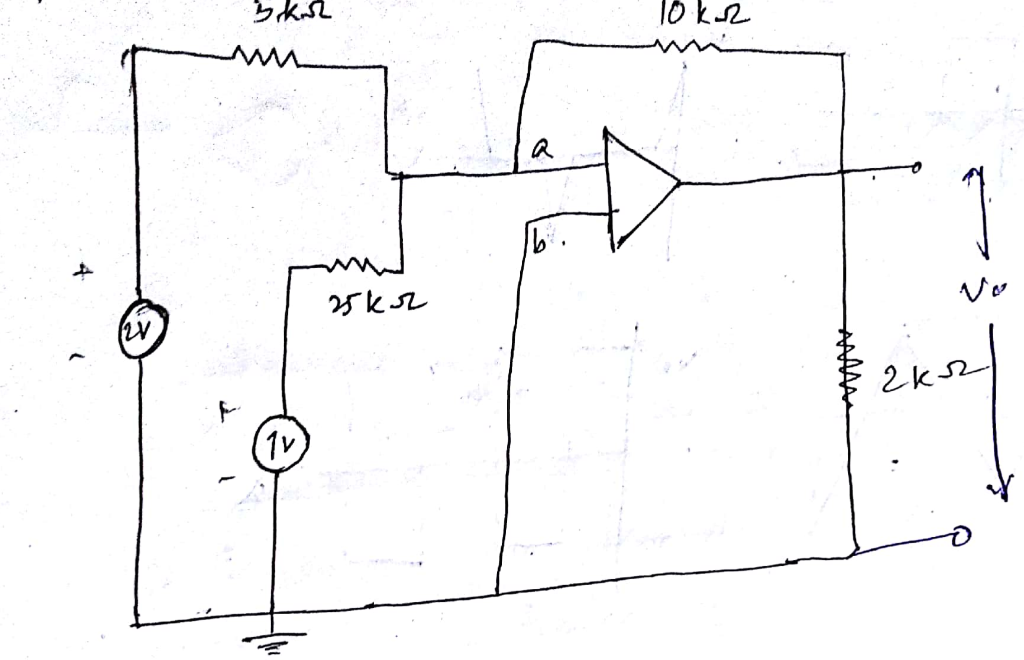
$$\cancel{\Rightarrow V_o = -2\times6 = -12}.$$

$$i_1 = \frac{6-4}{20} = \frac{1}{10} =$$

$$= 0.\underline{1\ mA}$$

Scanned by CamScanner

Q.



Summing Amplifier

$$V_o = -\left(\frac{R_F}{R_1}V_1 + \frac{R_F}{R_2}V_2\right)$$

$$= -8V$$

$$i_o = i_{in_{10k\Omega}} + i_{in_{2k\Omega}}$$

$$= \frac{-8}{10\times10^3} + \frac{-8}{2\times10^3}$$

$$= (-0.8 - 4)\ mA$$

$$= -4.8\ mA$$