CSE251

Assignment-01

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Section: 03

1. Given,

$V^+ = 10\mu V \quad A = 2105$

$V^- = 5\mu V$

$V_o = ?$

$\therefore V_o = AV_d$

$= A(V^+ - V^-)$

$= 2105(10-5)\mu V$

$= 10525\mu V$

$= 10.525\ mV$

$= 0.010525\ V$

Given, $V^+ = 1\ mV$

$V^- = 0.2\ mV$

$A = 2105$

$V_o = AV_d$

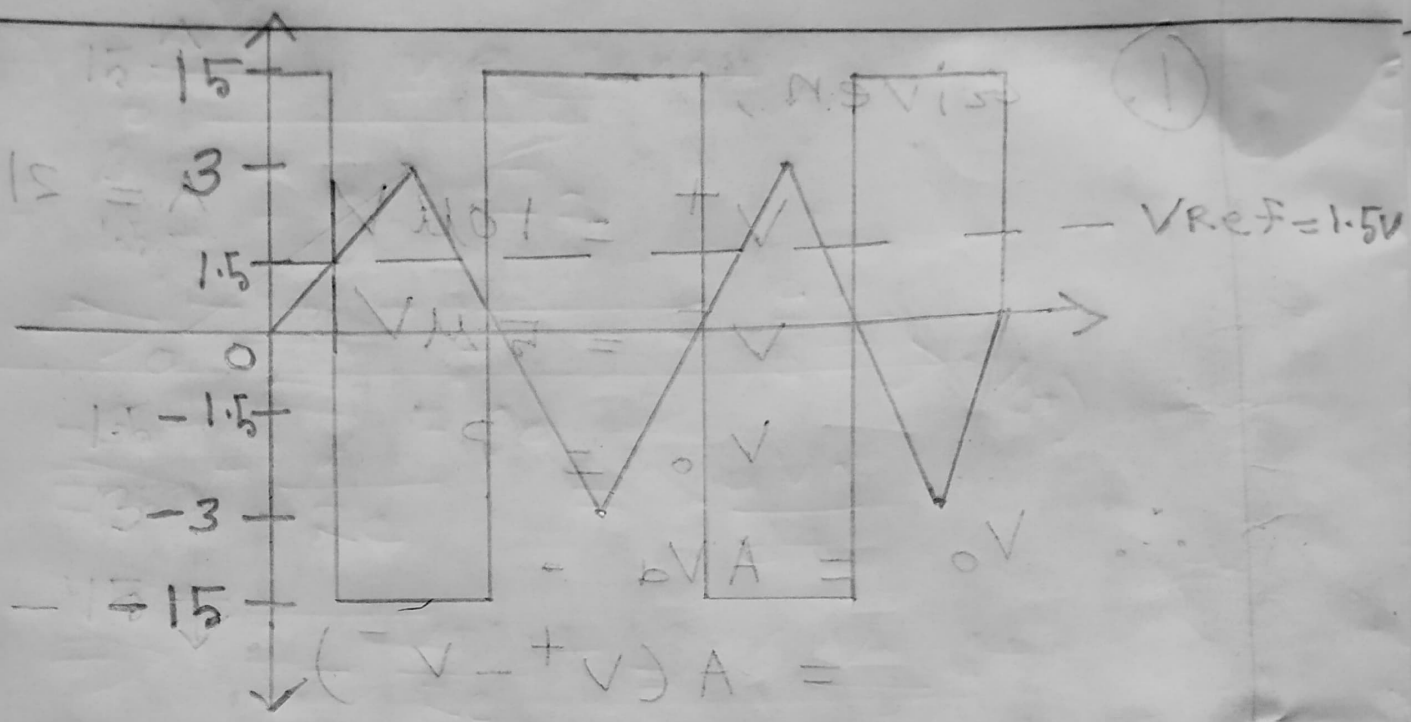
$= A(V^+ - V^-)$

$= 2105 \times (1 - 0.2)$

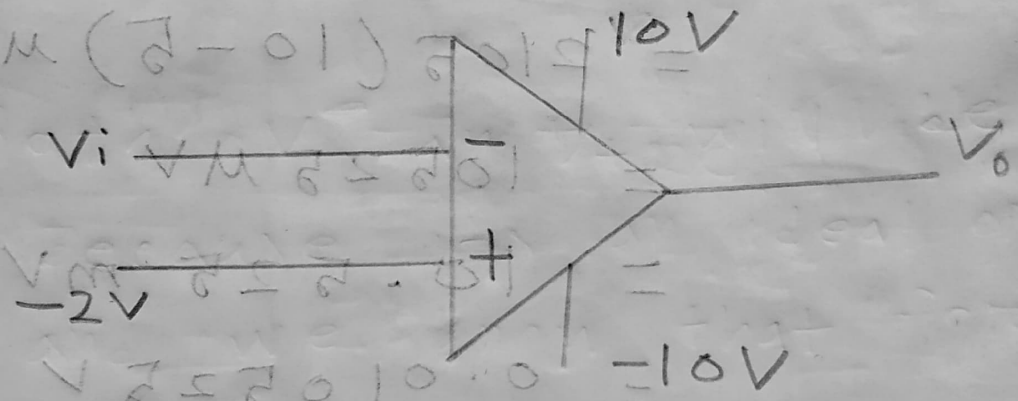
$= 1684\ mV$

$= 1.684\ V$

(2)



(3) (1)



(5) $P = h\rho g$

$= 10 \times 1000 \times 9.8$

$= 98000\ Pa$

Given,

$h = 10m$

$\rho = 1000\ kgm^{-3}$

$g = 9.8ms^{-2}$

$101325\ Pa = 1\ atm$

$\therefore 1\ Pa = \frac{1}{101325}\ atm$

$\therefore 98000\ Pa = \frac{98000}{101325}\ atm$

$= 0.967 \text{ atm}$

Again,

$1 \text{ atm} = 3V$

$\Rightarrow 0.967 \text{ atm} = (0.967 \times 3)V$

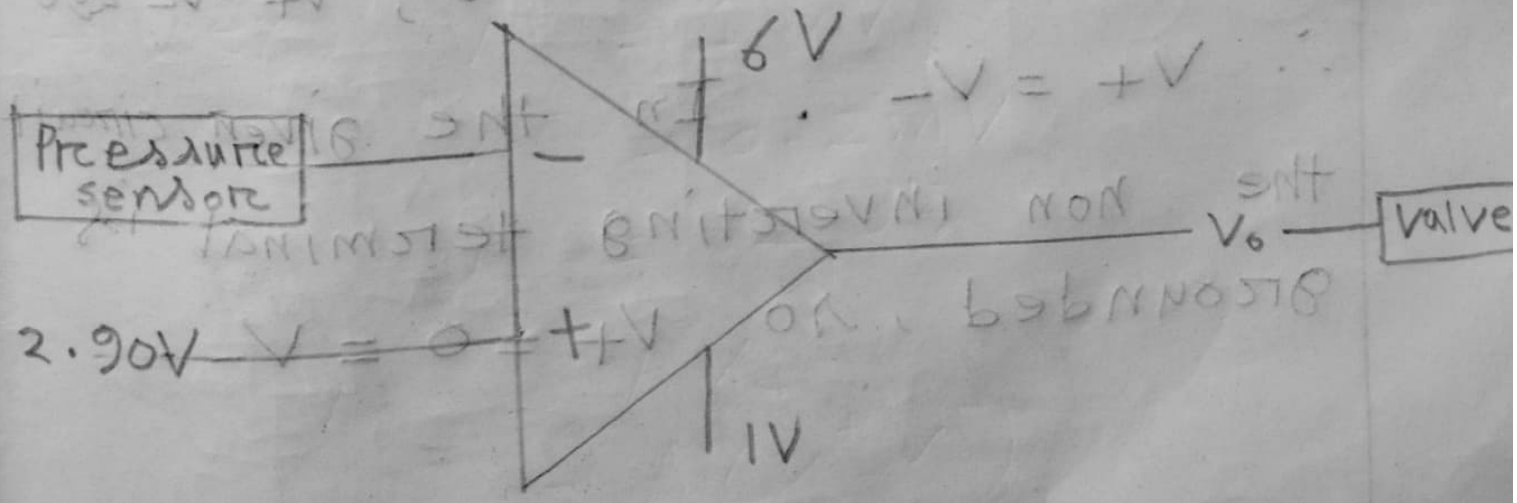
$= 2.90V$

Active Low Logics,

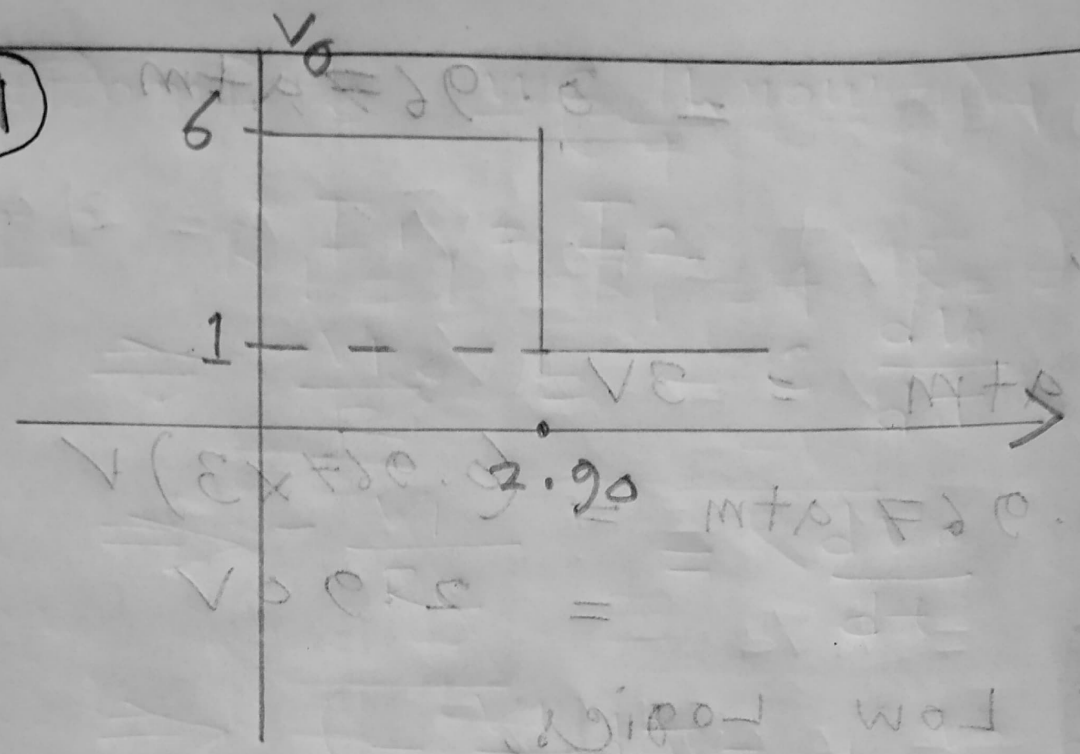
High Pressure $\rightarrow$ OPEN $\rightarrow$ 1V

Low " $\rightarrow$ CLOSED $\rightarrow$ 6V

So, it will be inverting OP-AMP comparator.



(11)



(6) (a) Both V_- an V_+ will be 0. Because its an ideal op-amp and we know that for ideal op-amp $V_d \approx 0$; $V_+ - V_- \approx 0$

$\therefore V_+ = V_-$. In the given circuit the non inverting terminal is grounded, so $V_+ = 0 = V_-$.

(b) $I_1 = I_2$, Directly proportional

In an ideal op-amp, no current flows into the input terminals because of the input resistance of an ideal op amp is infinite. On the other hand both the input voltages are same, thats why no current flow.

$$I_1 = I_- + I_2$$

$$\Rightarrow I_1 = 0 - I_2$$

$$\Rightarrow I_1 = I_2$$

(c)

$$I_1 = \frac{V_1 - 0}{R}$$

$$= \frac{V_1}{R}$$

$$I_2 = C \frac{dV_e}{dt}$$

$$= C \frac{d(0 - V_o)}{dt}$$

$$= -C \frac{dV_o}{dt}$$

From b we know,

$$I_1 = I_2$$

$$\Rightarrow \frac{V_1}{R} = -C\frac{dV_o}{dt}$$

$$\Rightarrow -\frac{V_1}{RC} = \frac{dV_o}{dt}$$

$$\Rightarrow \int -\frac{V_1}{RC}dt = \int \frac{V_o}{dt}dt$$

$$\Rightarrow V_o = -\frac{1}{RC}\int V_1 dt$$

(d) The diagram in the next page represents a generalized square wave where amplitude is V_m and time period is T. In this question it is given that, $V_m = 1V$ and $T = 2ms$. So the area under the square into pulse until time t is $\int_0^t V_1 dt = V_m - t$. For the entire half time period this area becomes $V_m . T/2$. Also the input

output relation of an inverting integrator is :

$$V_o = -\frac{1}{RC}\int_0^t V_1 dt = -\frac{V_m t}{RC}$$

So the waveform of the output voltage V_o is shown here,

$$\frac{V_m T}{2RC} = \frac{1 \times 2}{2 \times 10k \times 0.1\mu} = 1V$$

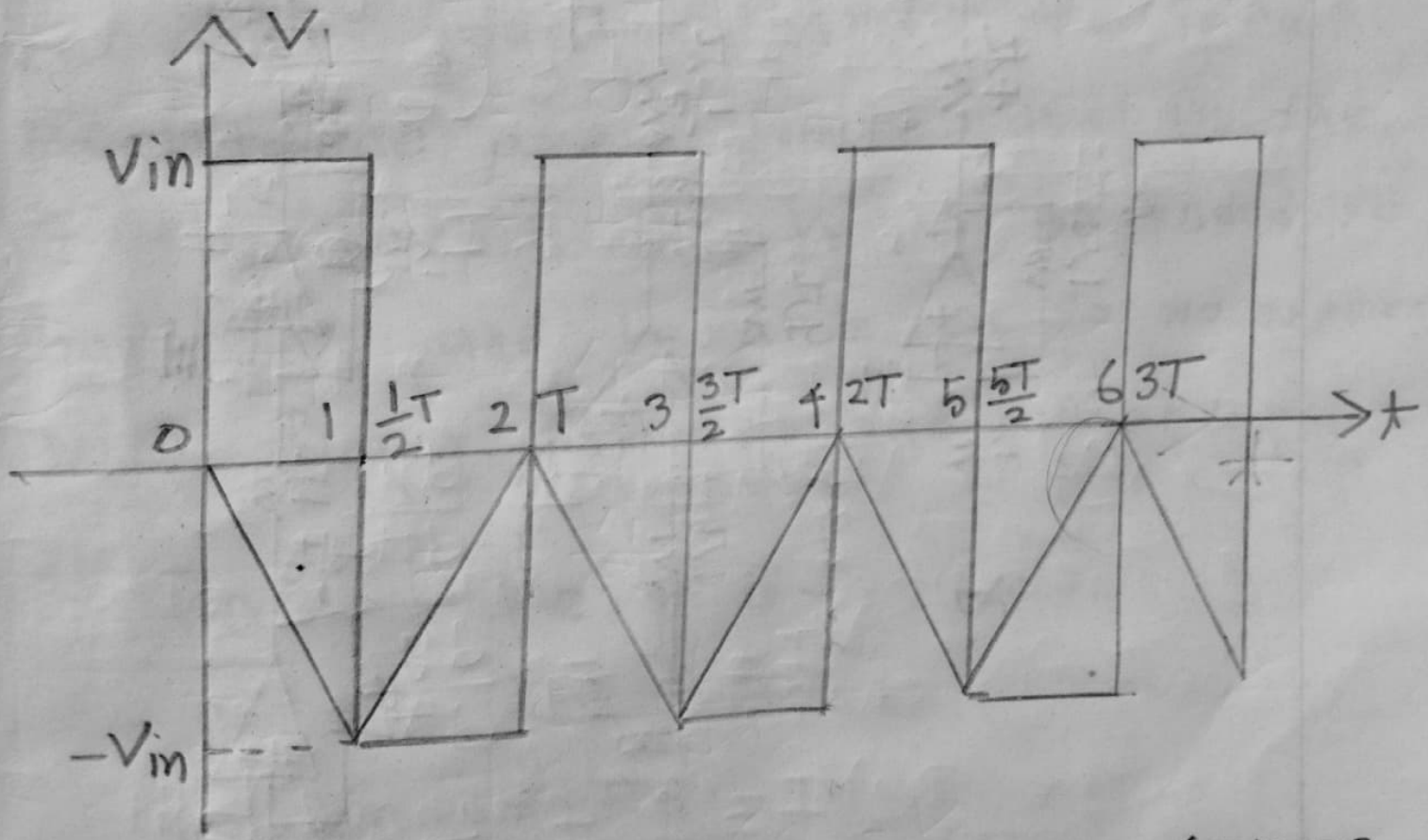
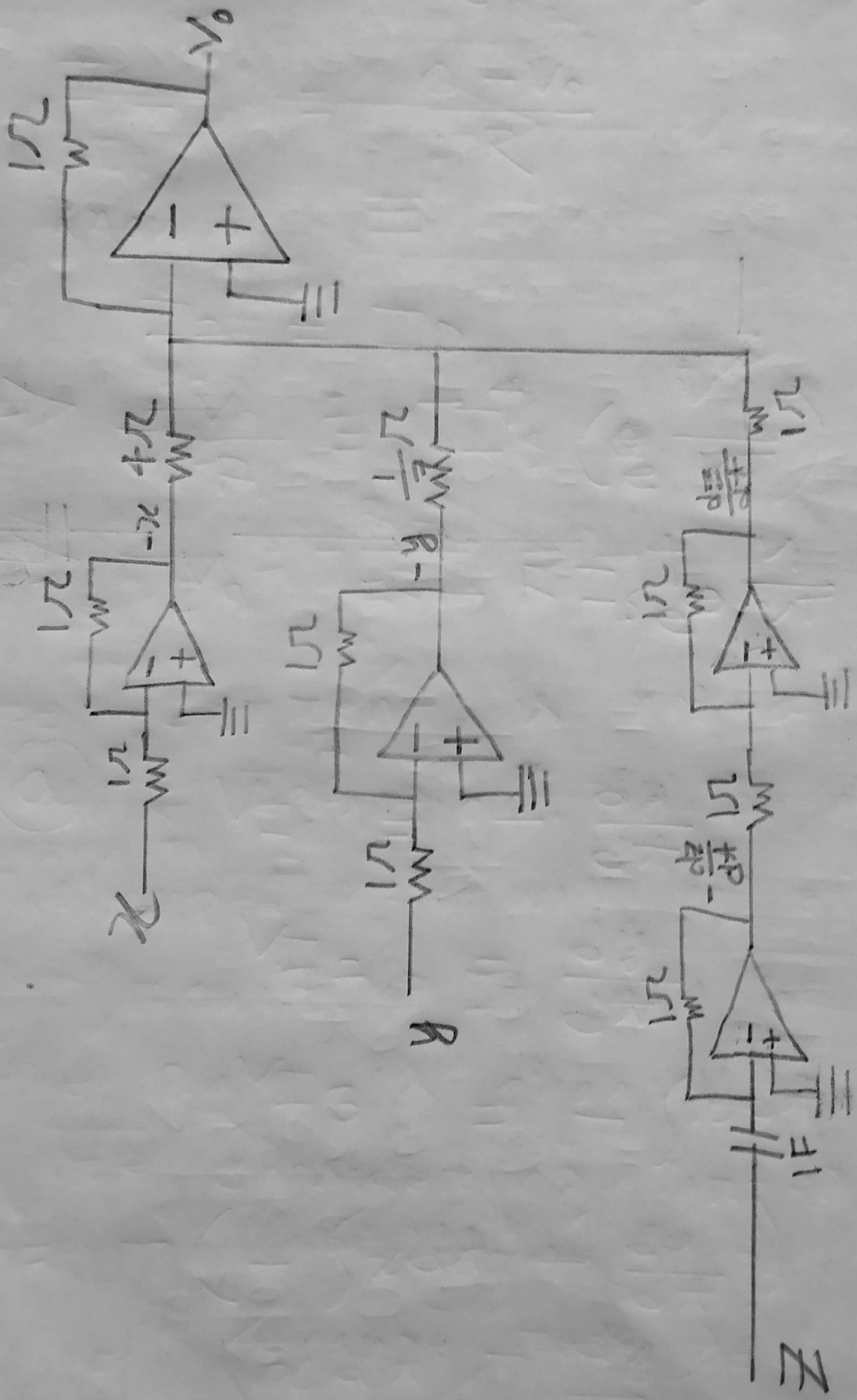


Fig : V_1 : input voltage (square wave)

V_o : output voltage (Triangle wave)

(e) $f = -\left(-\frac{1}{4}x - 7y + \frac{d}{dt}z\right)$

If $R_f = 1$, $R_1 = 4$, $R_2 = \frac{1}{7}$, $R_3 = 1$



7 a In ideal op-amp,

$$V_d \approx 0$$

$$\Rightarrow V_+ - V_- \approx 0$$

$$\Rightarrow V_+ = V_-$$

Here $V_+ = 0$, thats why V_- will be 0 also.

b In ideal op-amp, the input resistance are infinite, and in the given circuit the V_+ is grounded. so both V_+ and V_- are 0. So no current will flow through the opamp's terminal

$$I_D = I_2 + I_-$$

$$= I_2 + 0$$

$$\therefore I_D = I_2$$

(c) $I_D = I_S\left(e^{\frac{V_D}{V_T}}\right)$

$$= I_S\left(e^{\frac{V_1 - 0}{V_T}}\right)$$

$$I_2 = \frac{0 - V_0}{R}$$

We know,

$$I_2 = I_D$$

$$\Rightarrow -\frac{V_0}{R} = I_S\left(e^{\frac{V_1}{V_T}}\right)$$

$$\Rightarrow V_0 = -R I_S e^{\frac{V_1}{V_T}}$$

(8) (a) $V_{I_1} = -\frac{dy}{dt}$

$$V_{I_2} = \frac{dy}{dt}$$

$$V_{I_3} = -\int x\,dt$$

$$f = -\left(-\int x\,dt + \frac{dy}{dt}\right)$$

$$= \int x\,dt - \frac{dy}{dt}$$

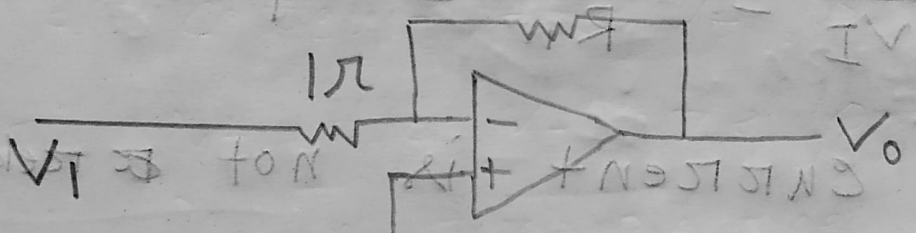
(b) $V_o = -\frac{R_2}{R_1} V_1$ we know

$\Rightarrow \frac{V_o}{V_1} = -\frac{R_2}{R_1}$ $\qquad \frac{V_o}{V_1} = \text{Gain} = -4$

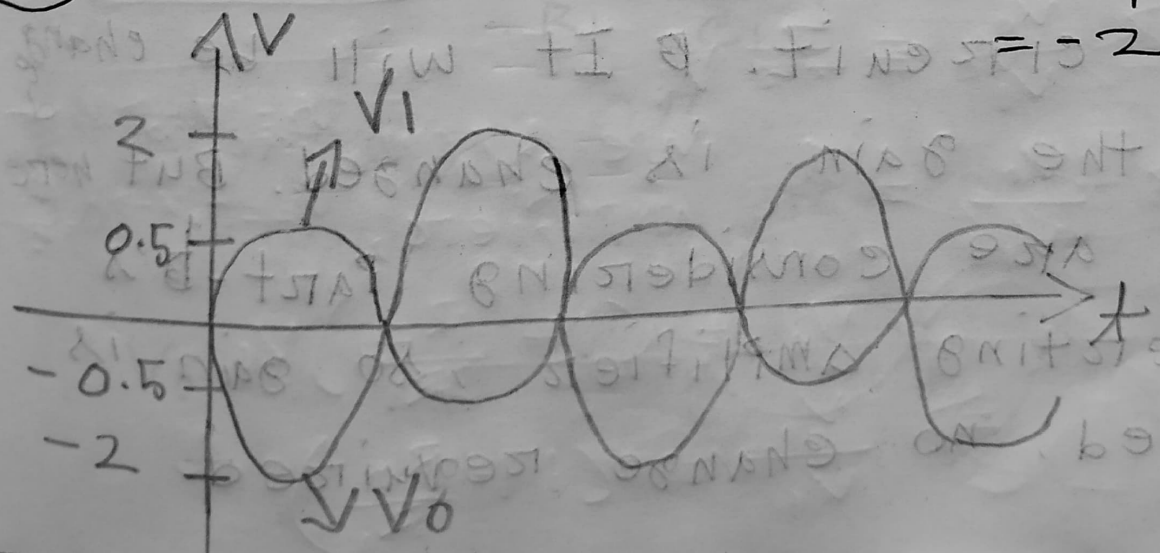
$\therefore -\frac{R_2}{R_1} = -4 \Rightarrow \frac{R_2}{R_1} = 4$

$\therefore$ Let, $R_1 = 1\Omega$, $R_2 = 4\Omega$

~~Let, $R_2 = 80\Omega$, $R_1 = 20\Omega$~~

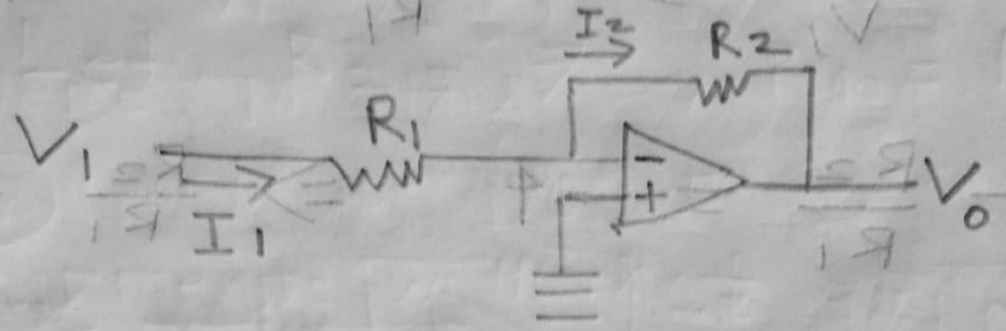


(c) $V_1 = 0.5V$, $V_o = -\frac{4}{1} \times 0.5V$
$= -2V$



(d) Given,

$$I_1 = I_2 = 0.5$$



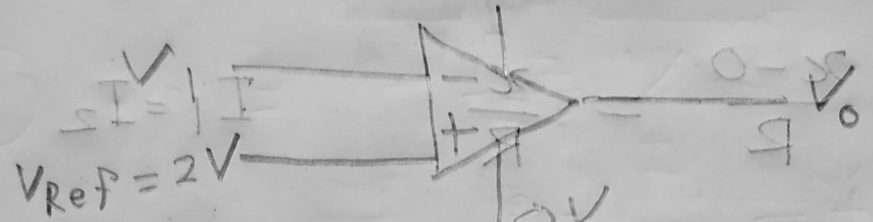
We know,

$$\frac{V_o}{V_I} = -4$$

$$\Rightarrow \frac{V_o}{V_I} = -\frac{R_2}{R_1} = -4$$

Here current is not related to this equation, so whenever the current is changed, it will not effect the circuit. It will be changed if the gain is changed. But here we are considering Part-B's inverting amplifier, so gain is fixed, no change required.

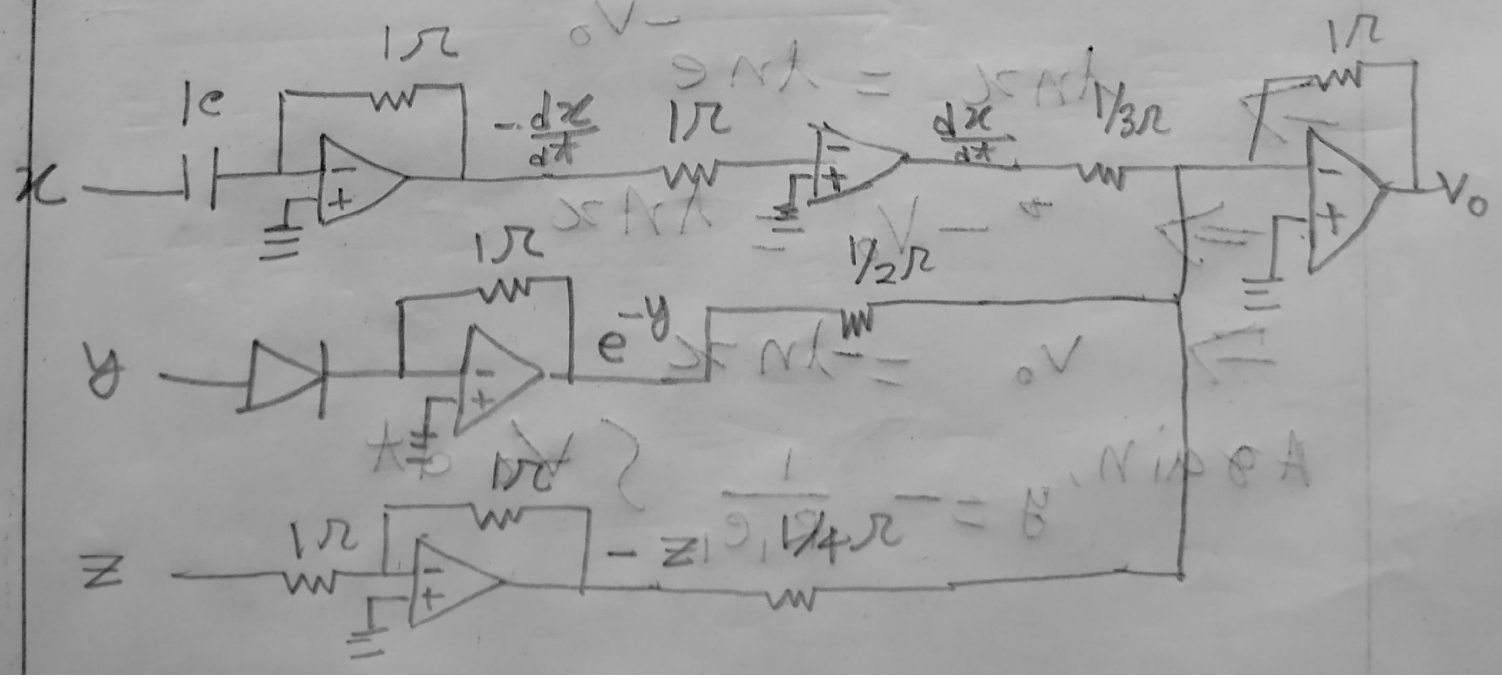
(9) (a) It will be a inverting amplifier.



(b) $f = -3\frac{dx}{dt} + 2e^{y} + 4z$

$= -\left(3\frac{dx}{dt} - 2e^{y} - 4z\right)$

If $R_f = 1\Omega$, $R_1 = \frac{1}{3}\Omega$, $R_2 = \frac{1}{2}\Omega$, $R_3 = \frac{1}{4}\Omega$



(c) Given, $I_S R = 1$

$V_T = 1$

$$I_1 = \frac{x-0}{R} = \frac{x}{R} \qquad I_1 = I_2$$

$$I_2 = \left(I_S e^{V_D/V_T} - 1\right)$$

$$\Rightarrow \frac{x}{R} = I_S e^{V_D/V_T}$$

$$\Rightarrow x = e^{V_D} \quad [I_S R = 1]$$

$$\Rightarrow x = e^{0-V_o}$$

$$\Rightarrow x = e^{-V_o}$$

$$\Rightarrow \ln x = \ln e^{-V_o}$$

$$\Rightarrow -V_o = \ln x$$

$$\Rightarrow V_o = -\ln x$$

Again, $y = -\frac{1}{R_1 C_1} \int V_o \, dt$

$$y = -\frac{1}{R_1 C_1}\int -\ln x \, dt$$

$$y = \frac{\ln x}{R_1 C_1}\int dt$$

(10) From the 1st inverting amplifier we get,

$$-\frac{1}{RC_0}\int V_1 dt$$

$$\Rightarrow -\frac{1}{R_1C_1}\int \sin x\, dt$$

$$\Rightarrow -\frac{\sin x}{R_1C_1}\int dt$$

From the 2nd inverting amplifier,

$$-R_2C_2\frac{d}{dt}\left(-\frac{\sin x}{R_1C_1}\int dt\right)$$

$$\Rightarrow -R_2C_2 \cdot -\frac{\sin x}{R_1C_1}\frac{d}{dt}\int dt$$

$$\Rightarrow -\frac{R_2}{R_1}\frac{C_2}{C_1}(-\sin x)$$

$$\Rightarrow \frac{R_2}{R_1}\frac{C_2}{C_1}\sin x$$

Let $R_5 = 0\Omega$.

So From the 3rd inverting amplifier

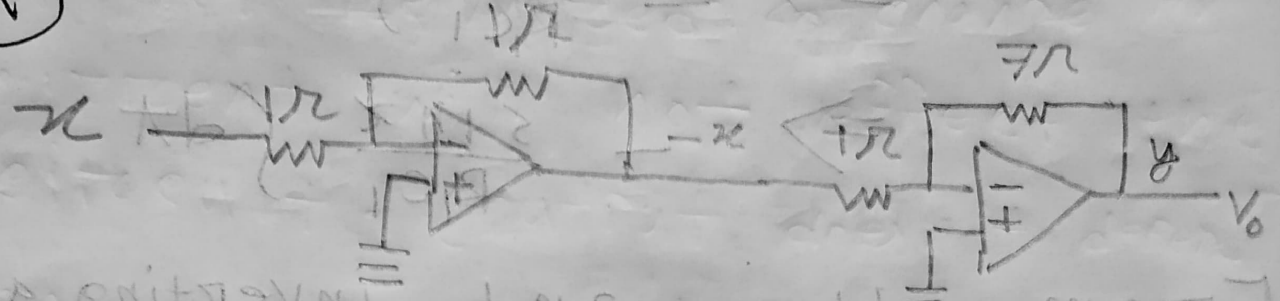
$$V_0 = -\frac{R_4}{R_3} \times \frac{R_2}{R_1} \times \frac{C_2}{C_1}\sin x$$

(11) $y = 7x$

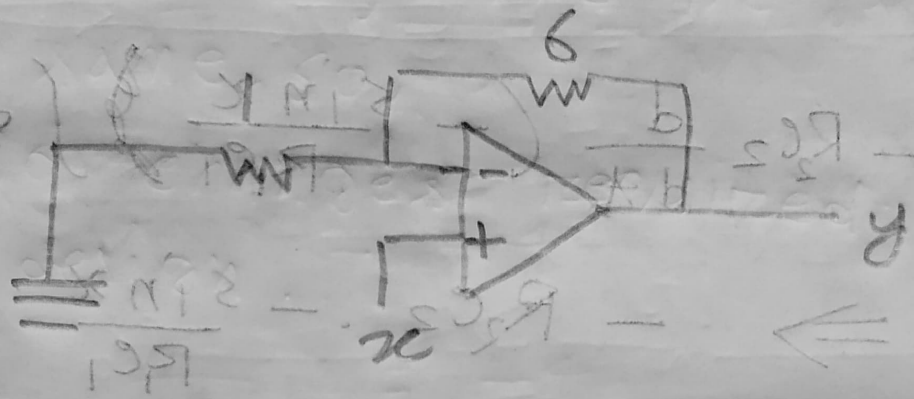
$\Rightarrow y = -7(-x)$

Let, $R_2 = 7$, $R_1 = 1$

(a)



(b)



$y = 7x \longrightarrow \boxed{\begin{array}{l} V_o = y \\ V_1 = x \end{array}}$

$\Rightarrow V_o = 7V_1$

$\Rightarrow \dfrac{V_o}{V_1} = 7$

~~$\Rightarrow \dfrac{V_o}{V_1} = 1$~~ We know, for non inverting amplifier,

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

$$\Rightarrow \frac{V_o}{V_1} = \left(1 + \frac{R_2}{R_1}\right)$$

$$\Rightarrow 1 + \frac{R_2}{R_1} = 7$$

$$\Rightarrow \frac{R_2}{R_1} = 7 - 1 = 6$$

$\therefore$ we Let $R_2 = 6\Omega$ and $R_1 = 1\Omega$

(12) Given, Gain $= -5 = \frac{V_o}{V_1}$

we know, For inverting amplifier

$$V_o = -\frac{R_2}{R_1} V_1$$

$$\Rightarrow \frac{V_o}{V_1} = -\frac{R_2}{R_1}$$

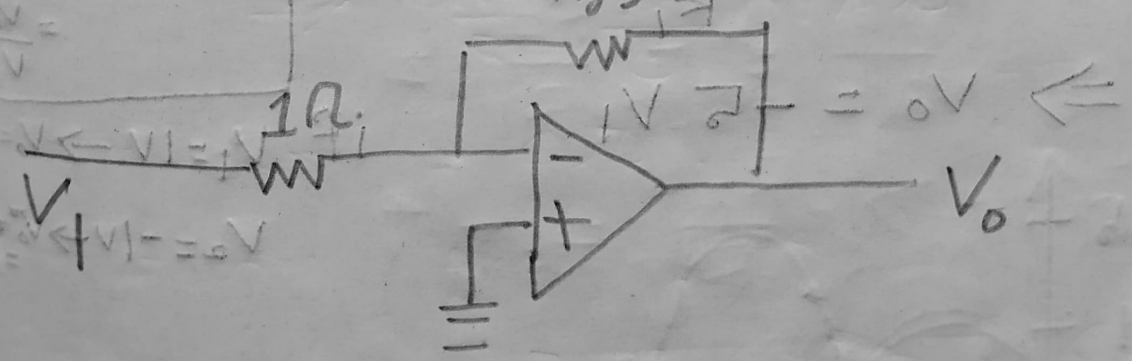
$$\Rightarrow -\frac{R_2}{R_1} = -5$$

$$\Rightarrow \frac{R_2}{R_1} = 5$$

$\therefore$ Let,

$R_2 = 5\Omega$

$R_1 = 1\Omega$



(b) From a we know that,

$$\frac{V_o}{V_1} = -\frac{R_2}{R_1} = -5 \; , \; I_1 = I_2 = 5MA$$

Here, in this equation current is not required. so change in current will not effect the circuit. (output doesn't depend on current). And the gain is also same, so,

No changes required in the design.

(c) We know,

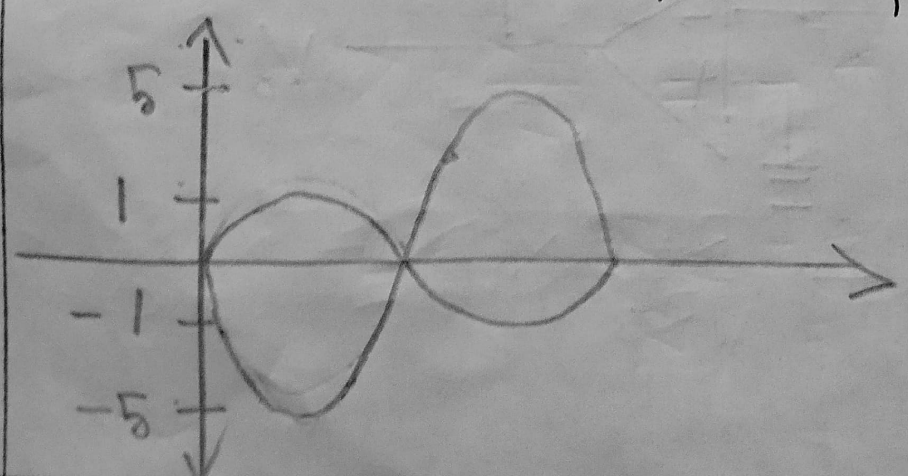
$$V_o = -\frac{R_2}{R_1} V_1$$

$$\Rightarrow V_o = -5 V_1$$

$$\boxed{\text{Gain} = -5 = -\frac{R_2}{R_1} = \frac{V_o}{V_1}}$$

if $V_1 = 1V \rightarrow V_o = -5V$

$V_2 = -1V \rightarrow V_o = 5V$



Given, $V_1 = 1V$, $V_2 = 2V$, $V_3 = 1.5V$

As all the resistors are same,

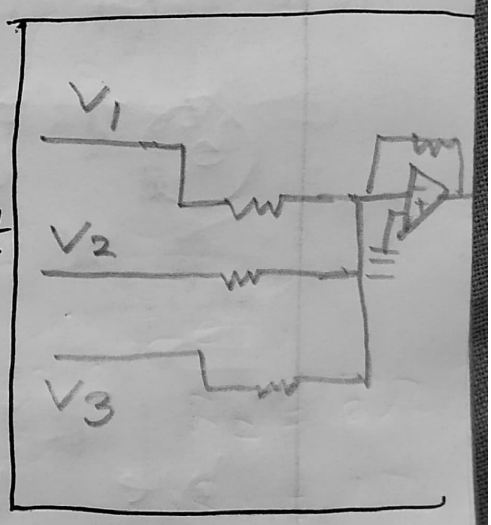
$$R_{in} = R_F = 1\,\Omega$$

$$V_o = -(V_1 + V_2 + V_3) \cdot \left[\frac{R_f}{R_{in}} = \frac{1}{1} = 1\right]$$

$$= -(1 + 2 + 1.5)$$

$$= -4.5\,V$$

(13) $\cancel{V_1 = -\frac{1}{0.5}\int y\,dt}$



$$V_1 = -\frac{1}{0.5 \times 10^6 \times 1 \times 10^{-6}} \int y\,dt$$

$$= -2\int y\,dt$$

$$V_2 = -1 \times 10^{-6} \times 10^6 \frac{dz}{dt}$$

$$= -\frac{dz}{dt}$$

Again inverting V_2

$$-\frac{5}{5} V_2$$

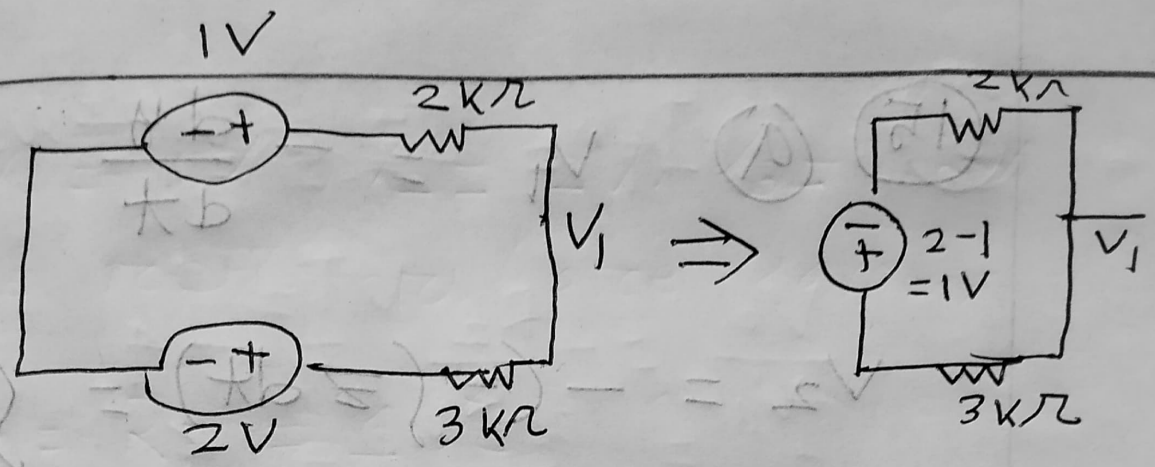
$$= -1\left(-\frac{dz}{dt}\right) = \frac{dz}{dt}$$

$$V_3 = -\frac{1}{4}x$$

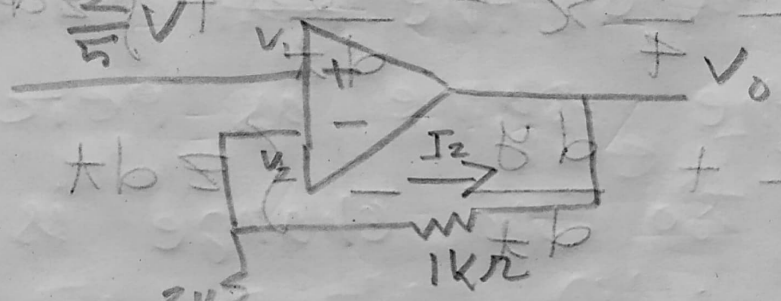
$$f = -\left(-2\int y\,dx + \frac{dz}{dx} - \frac{1}{4}x\right)$$

$$= 2\int y\,dx - \frac{dz}{dx} + \frac{1}{4}x$$

(14)



$$\therefore V_1 = \frac{2}{3+2} \times 1 = \frac{2}{5} V$$



$$V_1 = V_2 = \frac{2}{5} V$$

$$\therefore I_1 = I_2$$

$$I_1 = \frac{0 - V_2}{3}$$

$$= \frac{-\frac{2}{5}}{3}$$

$$= 0.133 \text{ A}$$

$$I_2 = \frac{\frac{2}{5} - V_o}{1}$$

$$\therefore \frac{2}{5} - V_o = 0.133$$

$$\Rightarrow V_o = 0.533 V$$

(15) (a) $V_1 = -\frac{dy}{dt}$

$V_2 = -\left(-\int z\,dt\right) = \int z\,dt$

$V_3 = -\frac{1}{4}x$

$f = -\left(-\frac{1}{4}x - \frac{dy}{dt} + \int z\,dt\right)$

$= \frac{x}{4} + \frac{dy}{dt} - \int z\,dt$

(b) Gain $= -4$

$\frac{V_o}{V_1} = -4$

We know for inverting

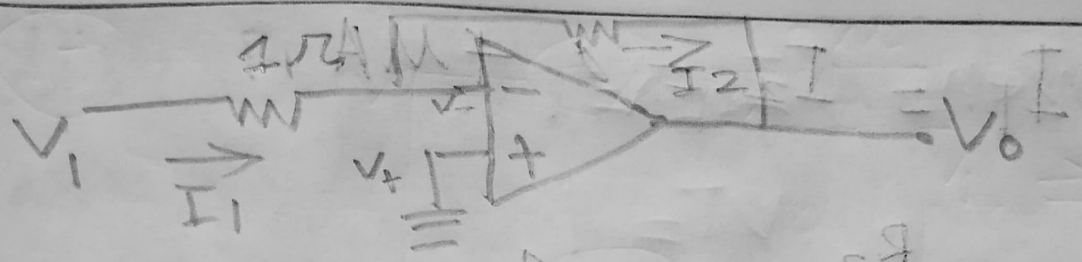
$\frac{V_o}{V_1} = -\frac{R_2}{R_1}$

$\Rightarrow -\frac{R_2}{R_1} = -4$

$\therefore$ Let $R_2 = 4\,\Omega$

$R_1 = 1\,\Omega$

4Ω

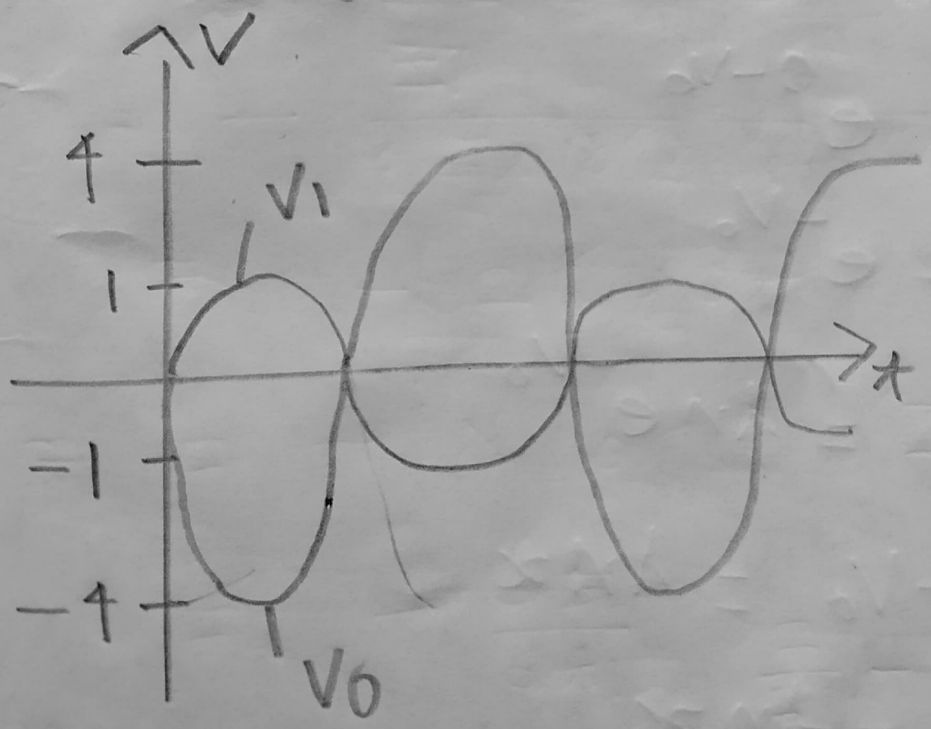


(c) $V_o = -\frac{R_2}{R_1} V_1$

$\Rightarrow \frac{V_o}{V_1} = -\frac{R_2}{R_1} = -4$

if $V_1 = 1V$ $V_o = -4V$

$V_1 = -1V$ $V_o = 4V$



(d) $I_1 = I_2 = 4\mu A$

$$\frac{V_o}{V_1} = -\frac{R_2}{R_1} = -4$$

Output is not dependend on current and the ~~desi~~ gain remains the same as per question so no change is required in the design.