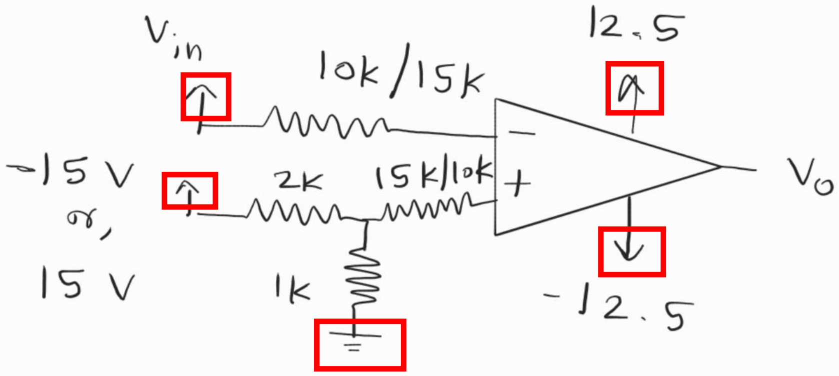
Q1

(a)



There are total 5 modifications needed (marked in the solve) to convert the loop diagram to line diagram. each contains 0.5 marks.

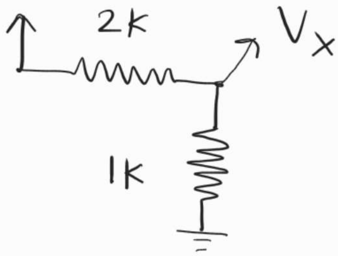
0.5*5 = 2.5 marks

(b) $i_+ = i_- = 0$

0.5 mark for each value

0.5*2 = 1 mark

(c) Op amp inputs zero current, can be treated independently:



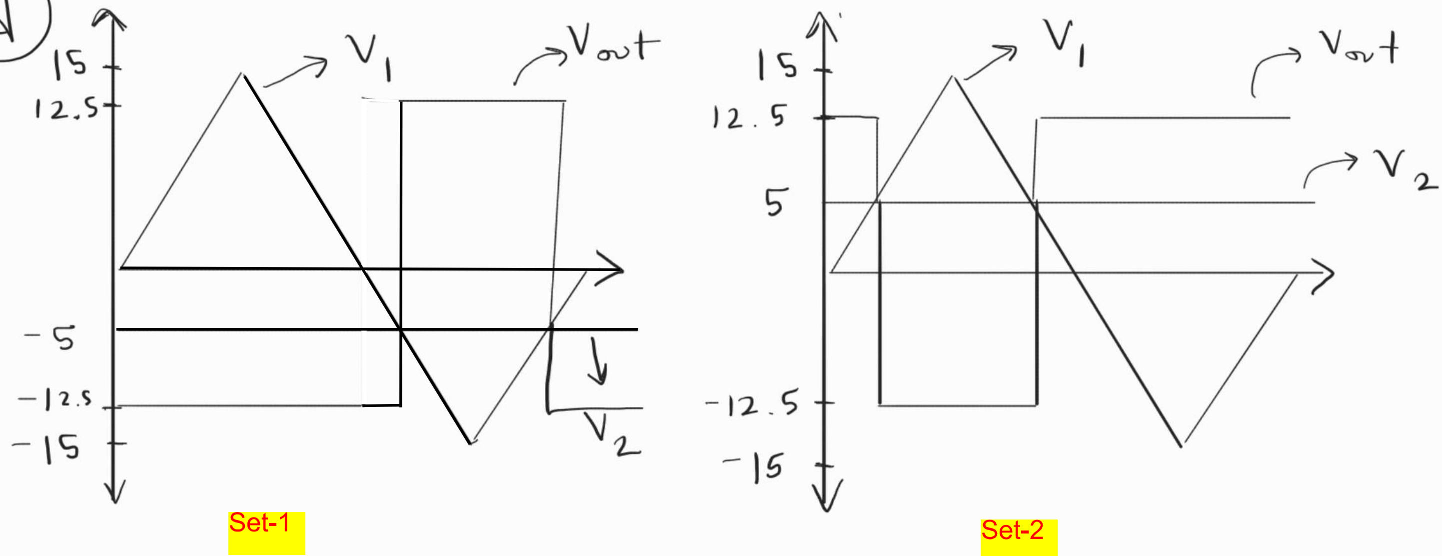
1.5 marks

$$V_x = \frac{1}{1+2} \times (15 \text{ or } -15)$$

$= -5\text{ V}$ or, 5 V

Set-1 Set-2

(d)

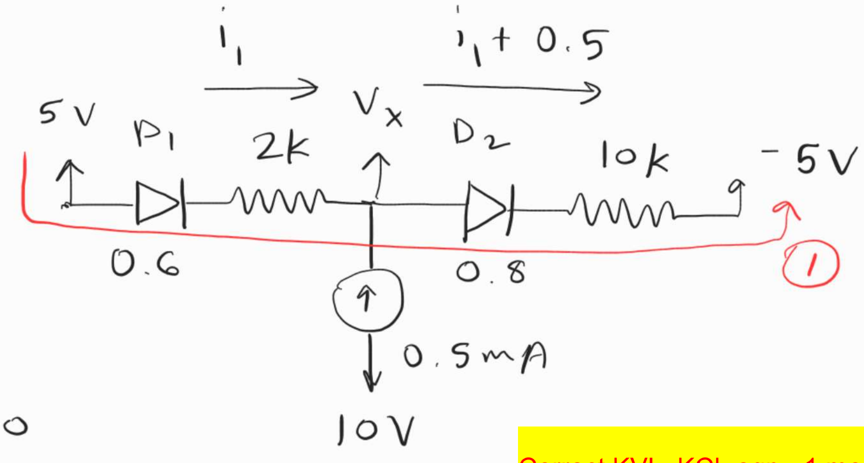


2.5 Marks

Q2

Set a:

(a)



D_1, D_2 ON:

Line 1, $12i_1 + 1.4 + 5 \times 10 = 5 + 5$

$\Rightarrow 12i_1 = \frac{3.6}{12} = 0.3\ mA$

$V_x = 5 - 0.6 - 2 \times 0.3 = 3.8\ V$

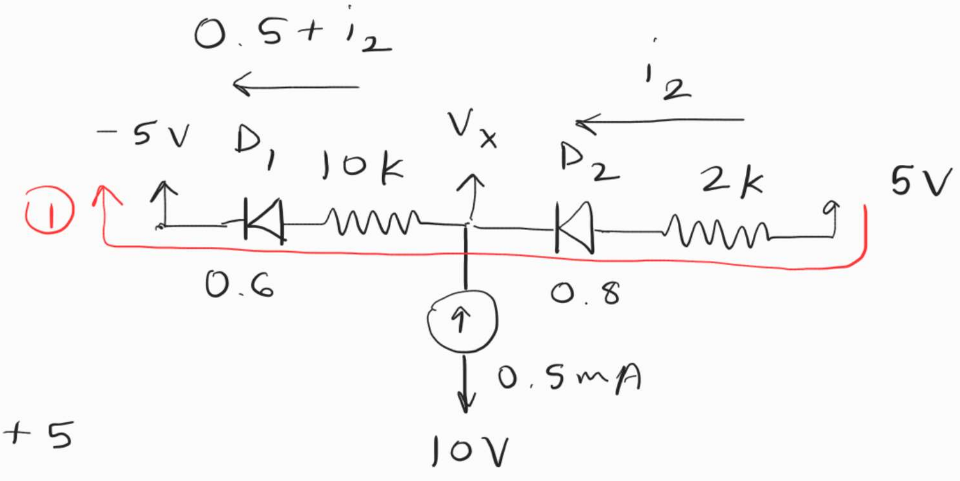
$i_{D_1} = 0.3\ mA$, $i_{D_2} = 0.8\ mA$ ✓✓

Correct KVL, KCL eqn - 1 mark
I_D1 - 1 mark
I_D2 - 1 mark
Verification - 1

total 4 marks

if the initial assumption is wrong but the procedure is ok, give 2 marks

Set b:



D_1, D_2 ON:

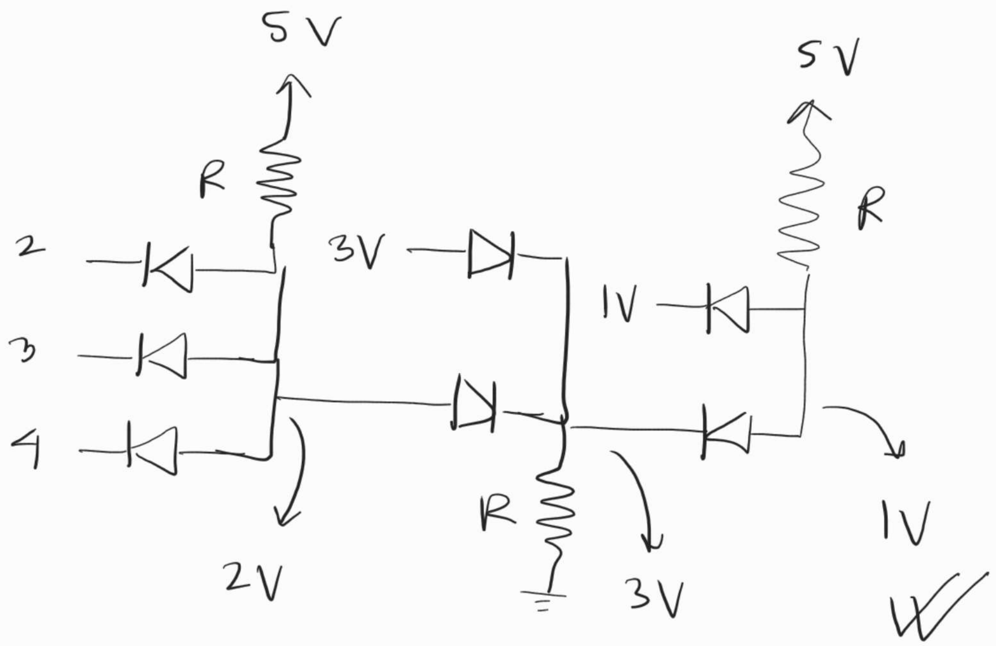
Line 1,

$12i_2 + 1.4 + 5 = 5 + 5$

$\Rightarrow i_2 = \frac{3.6}{12} = 0.3\ mA$

$i_{D_1} = 0.8\ mA$, $i_{D_2} = 0.3\ mA$ ✓✓

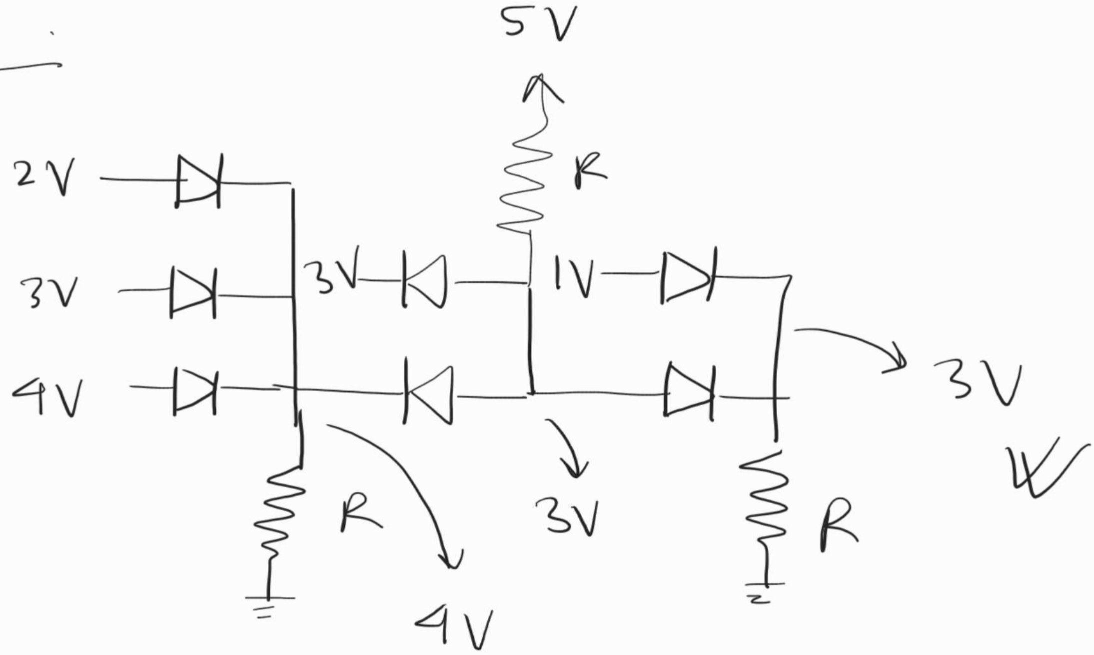
(b) Set A :



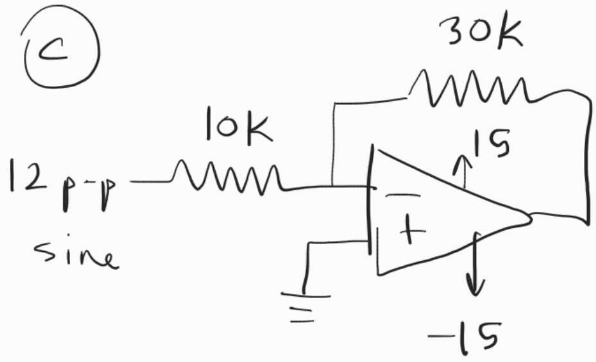
X - 0.5 mark
Y - 0.5 mark
F - 0.5 mark

total - 1.5 marks

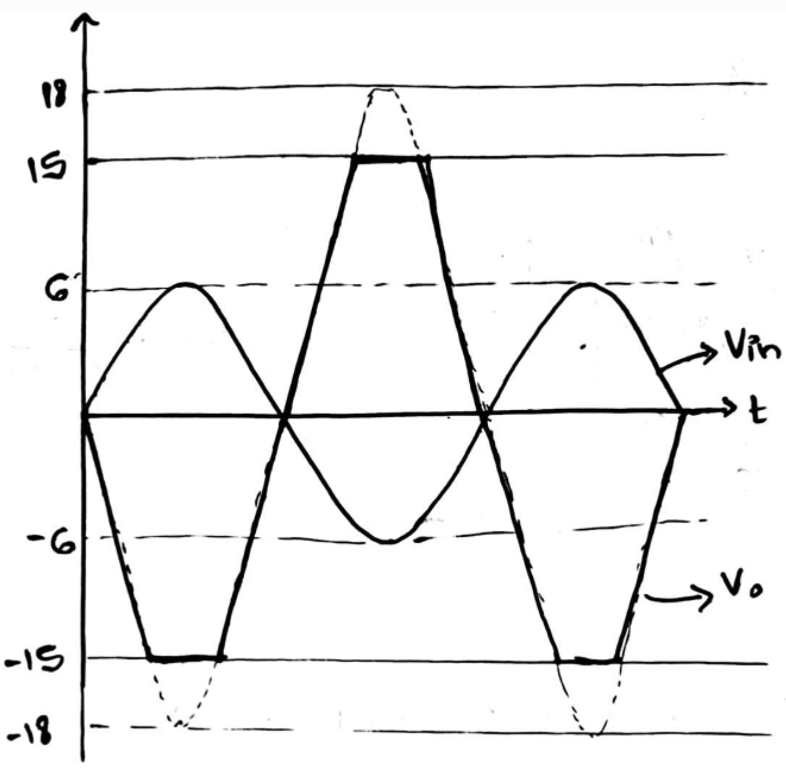
Set B :



(c)



$V_o = -3V_{in}$



correct eqn - 1 mark
correct graph - 1 mark

total - 2 marks

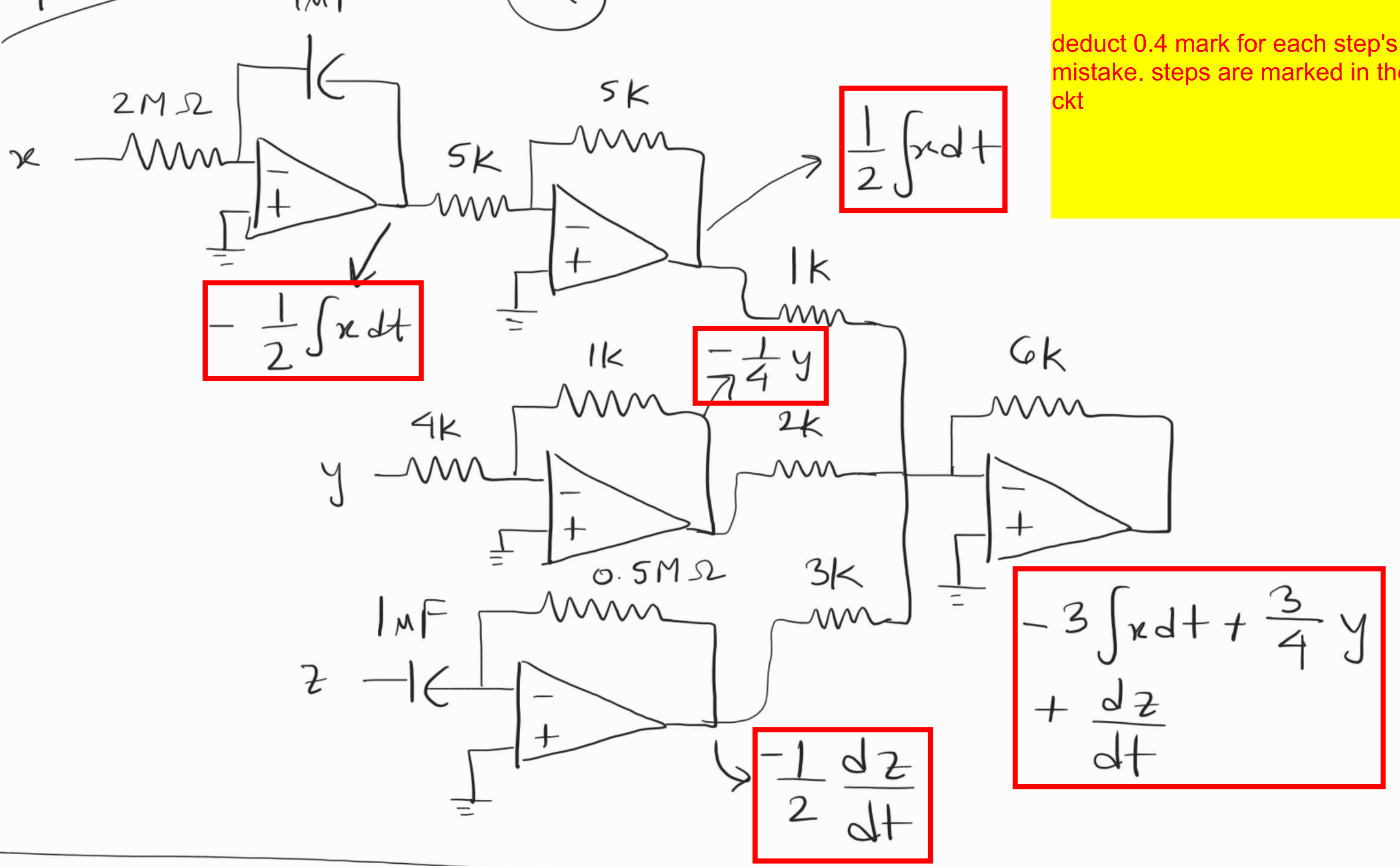
if the graph is not labeled correctly - deduct 0.5 mark

Q3

(a)

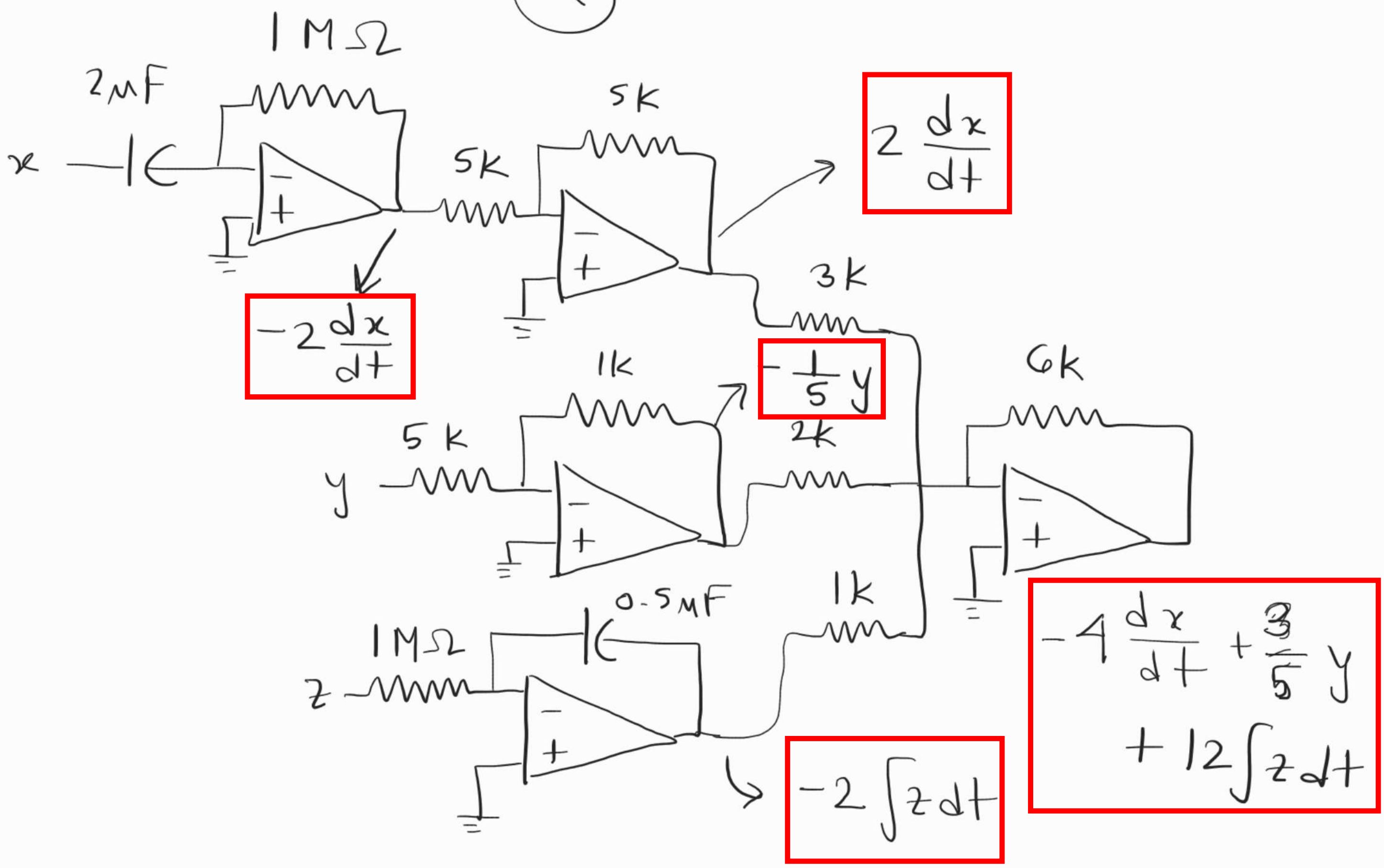
total - 2 marks = 0.4 mark * 5

deduct 0.4 mark for each step's mistake. steps are marked in the ckt



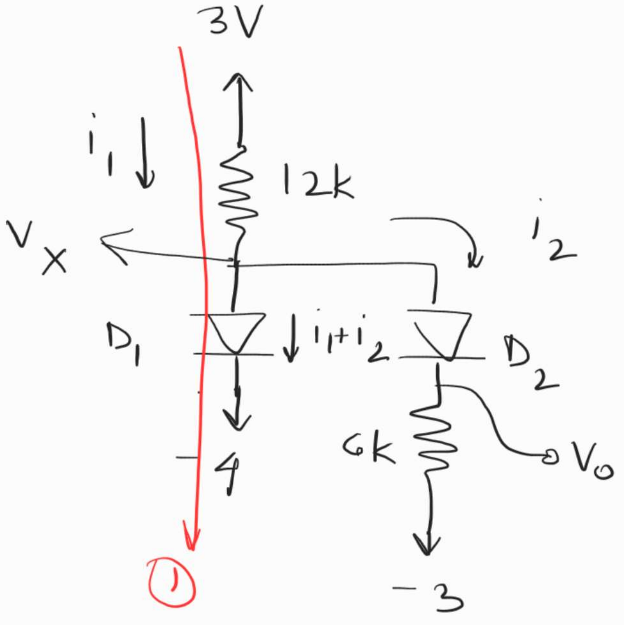
(b)

(a)



(b)

(A)



If D_1, D_2 ON:

$V_o = -4V$,

impossible for D_2 ON.

Then, D_1 ON, D_2 OFF:

① , $12i_1 + 0.7 = 3+4$

$\Rightarrow i_1 = \frac{6.3}{12} = 0.525\ mA > 0$ ✓ D_1 ON

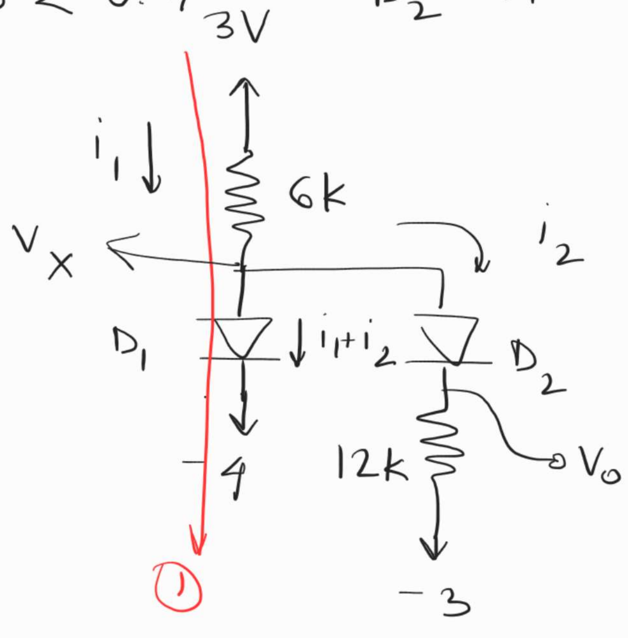
I_D1 - 1 mark, I_D2 - 1 mark, V_O - 1 mark
Verification - 1 mark

total 4 marks, if the initial assumption is wrong but the procedure is ok, give 2 marks

$V_X = 3 - 12 \times i_1 = -3.3V$

$V_{D_2} = -3.3 - (-3) = -0.3 < 0.7$ D_2 OFF

(B)



If D_1, D_2 ON:

$V_o = -4V$,

impossible for D_2 ON.

Then, D_1 ON, D_2 OFF:

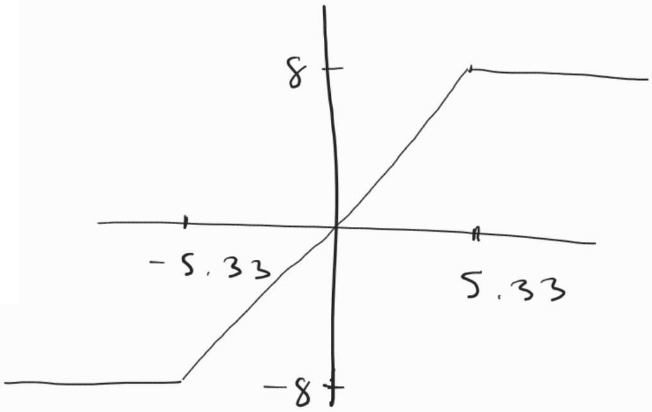
① , $6i_1 + 0.7 = 3+4$

$\Rightarrow i_1 = \frac{6.3}{6} = 1.05\ mA > 0$ ✓ D_1 ON

$V_X = 3 - 6 \times i_1 = -3.3V$

$V_{D_2} = -3.3 - (-3) = -0.3 < 0.7$ ✓ D_2 OFF

(c)



$V_o = 1.5 V_{in}$

$V_o = 8 \therefore \quad V_{in} = 5.33V$

$V_o = -8 \mid \quad V_{in} = -5.33V$

Correct graph - 1 mark
Correct label - 0.5 mark

total - 1.5 marks

Q-4 **Set-01**

1 mark
no partial

(a) $V_o = A(V_+ - V_-) = AV_d$

(b) Linear amplifier is an amplifier whose output is proportional to it's input.

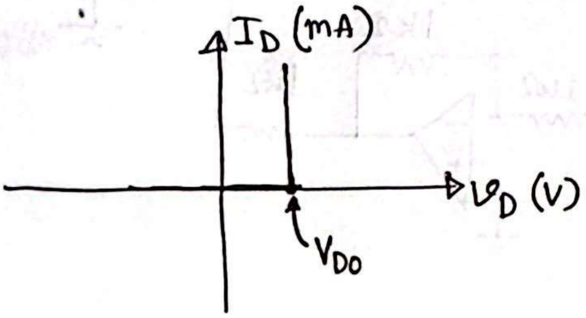
========== Alternative definition ==========
A linear amplifier is a device that follows this equation--
Output = k x Input
here, k is a constant

Reason for saturation $\longrightarrow$ power supply to the amplifier.

definition - 1 mark
reason - 1 mark

total - 2 marks

(c)



correct graph - 1 mark
proper label - 1 mark

total - 2 marks

Set-02

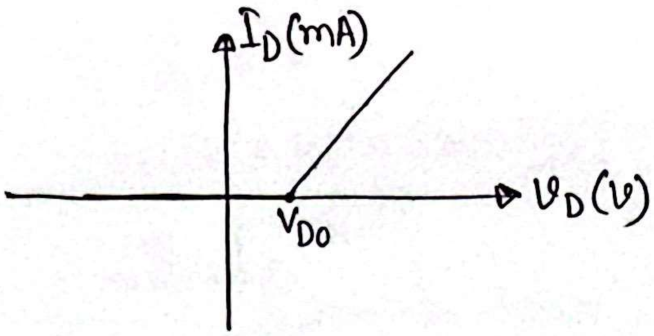
4.

(a) Same as set-01

(b) Same as set-01

====Rubric====
same as set-1

(c)



Set-01

5 (a) $V_{in} = 10\cos(t)$

$V_o = 5\sin(t)$ [By inspection]

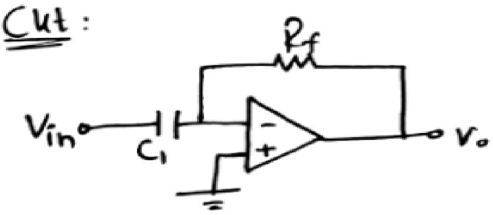
gain $= 5/10 = 0.5$

Differentiating $\cos(t)$ gives $-\sin(t)$;

Differentiator gain, $R_f C_1 = 0.5$

$C_1 = \frac{1}{2R_f}$ $\longrightarrow$ Let $R_f = 0.5$, $\therefore C_1 = 1$ } set complementary units ($M\Omega \times \mu F$, $k\Omega \times mF$...)

Ckt:



where, $R_f = \cancel{5M}\ 0.5M\Omega$

$C_1 = 1\mu F$

(Double check -

$V_o = -0.5M\Omega \times 1\mu F \times \frac{d}{dt} 10\cos(t)$

$= -\frac{10}{2}(-\sin(t))$

$= +5\sin(t)$)

identifying differentiation - 1 mark
ckt implementation - 2 marks

total - 3 marks

(b) Same as 'set-02' 5(b)

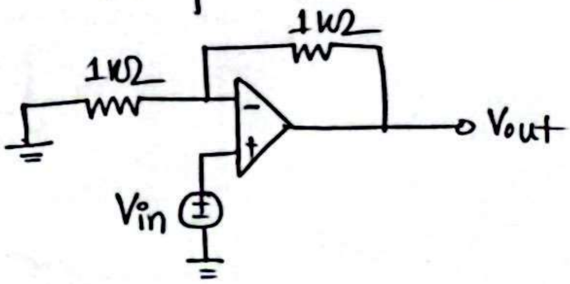
$\boxed{6.}$ (a) Non-inverting amplifier-

$|\text{Slope}| = \left|\frac{\Delta V_{out}}{\Delta V_{in}}\right| = \left|\frac{10}{5}\right| = 2$

$\text{Slope} = 2 = \left(1 + \frac{R_f}{R_i}\right) = \text{gain}$

$\therefore \frac{R_f}{R_i} = 1$

$\therefore R_f = R_i = 1k\Omega$ [let's assume]



identifying ckt - 1 mark
ckt implementation - 1 mark

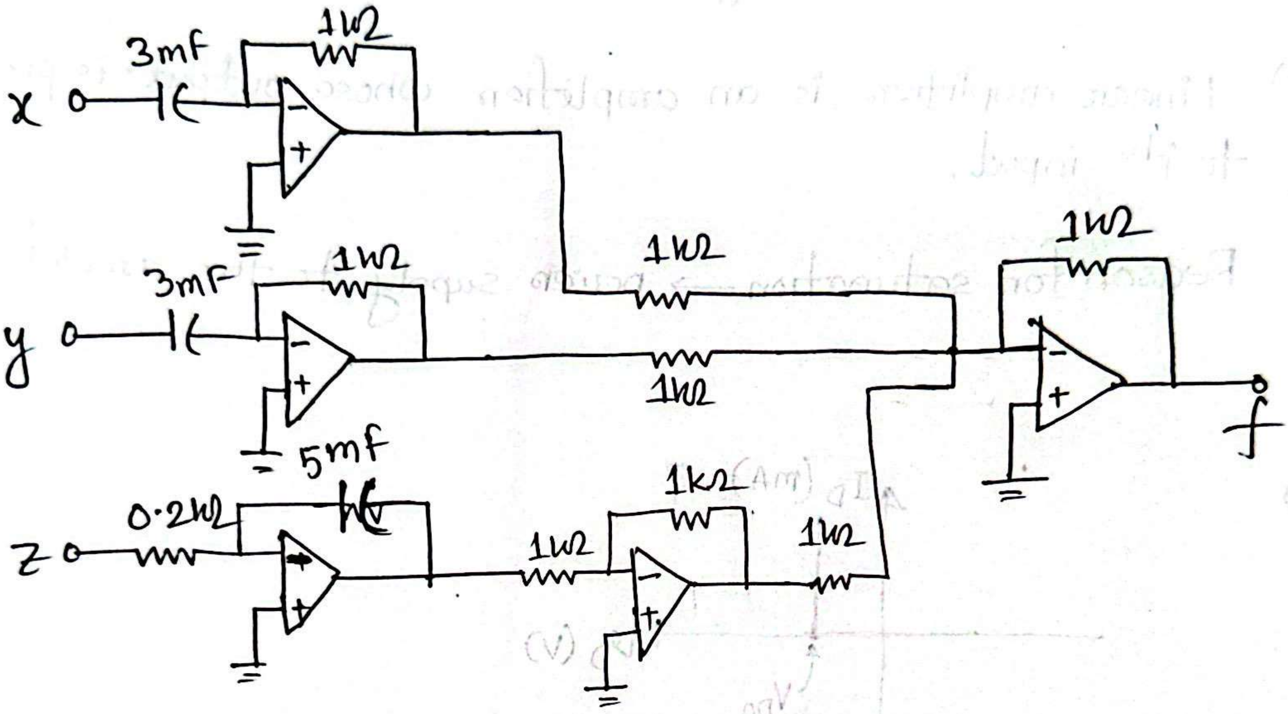
total - 2 marks

(b) $f = 3\frac{d}{dt}(x+y) - 5\int z\,dt$

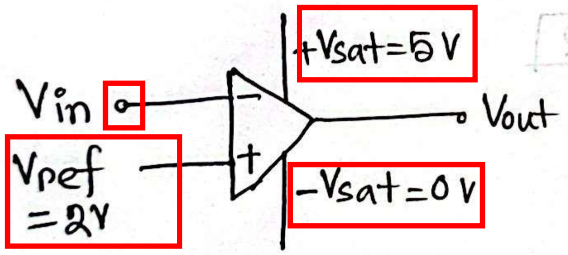
$= 3\frac{d}{dt}x + 3\frac{d}{dt}y - 5\int z\,dt$

Total - 3 marks

give partials according to your judgement



7. (a)



1 mark for each terminal

4 * 1 mark = 4 marks

(b) Not possible.

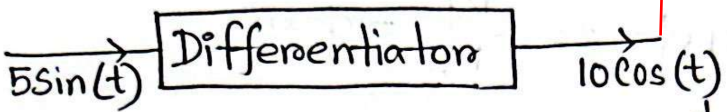
1 mark
no partial

$\boxed{\text{Set B}}$

$\boxed{5.}$ (a) Given.

$$V_{input} = 5\sin(t)$$
$$V_{output} = 10\cos(t)$$

Inverting Amplifier with gain = -1



$$= 2 \times 5 \frac{d}{dt}\sin(t)$$
$$= RC \times \frac{d}{dt}[5\sin(t)]$$

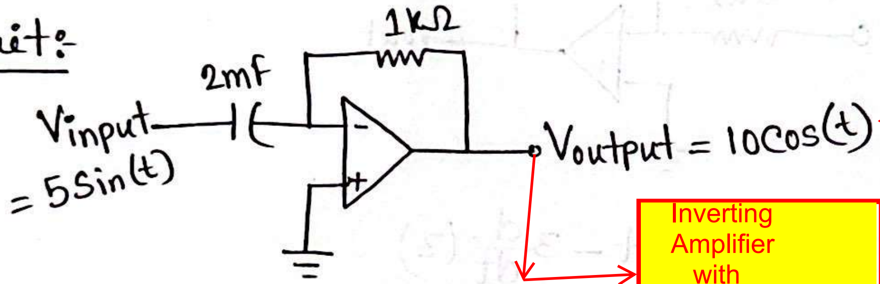
identifying differentiation - 1 mark
ckt implementation - 2 marks

total - 3 marks

$$\therefore RC = 2$$

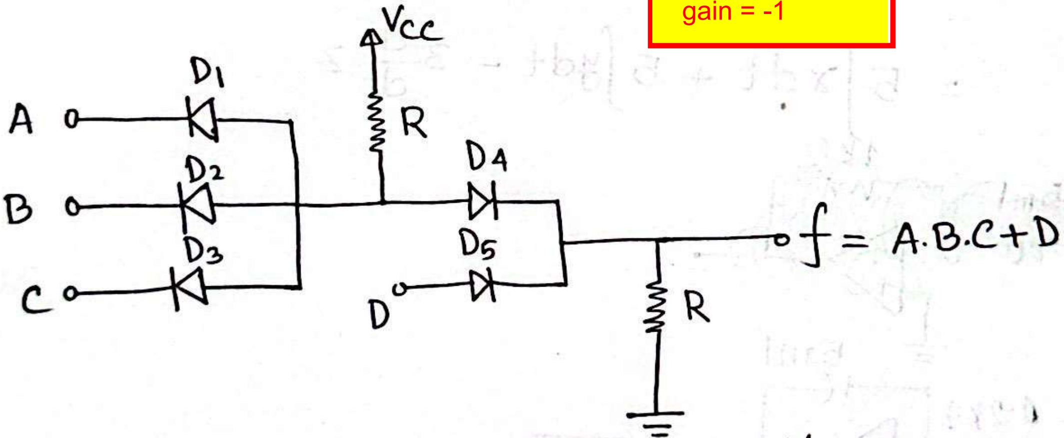
Let's assume, $R = 1k\Omega$; $C = 2mF$

Circuit:-



Inverting Amplifier with gain = -1

(b) (i)

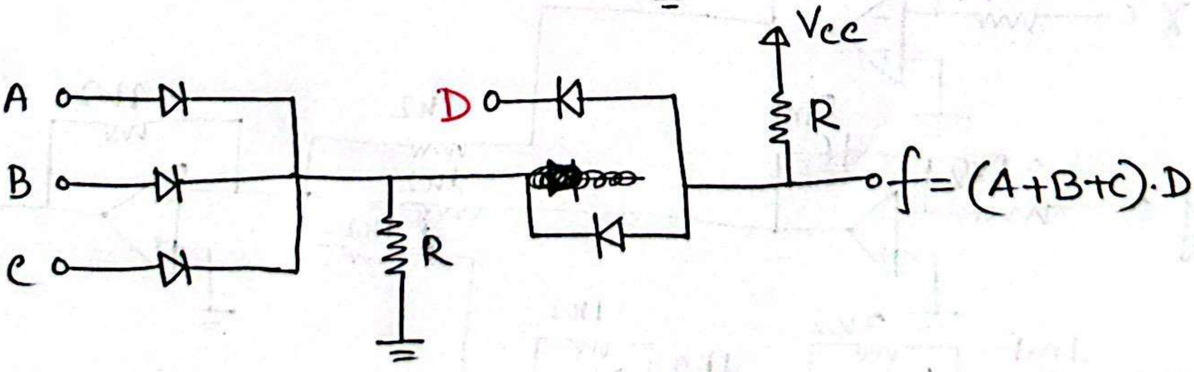


(i) - 1 mark
(ii) - 1 mark

Total - 2 marks

give partials according to your judgement

(ii)



6.

(a) Inverting Amplifier-

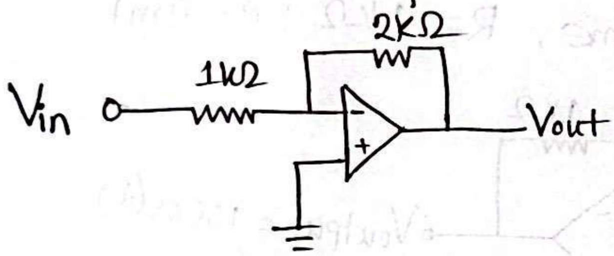
$$|\text{Slope}| = \left|\frac{\Delta V_{out}}{\Delta V_{in}}\right| = \left|\frac{10}{5}\right| = 2$$

$$|\text{Slope}| = 2 = \frac{R_f}{R_i} = \text{gain}$$

$$\therefore R_f = 2R_i$$

Let's assume, $R_i = 1k\Omega$

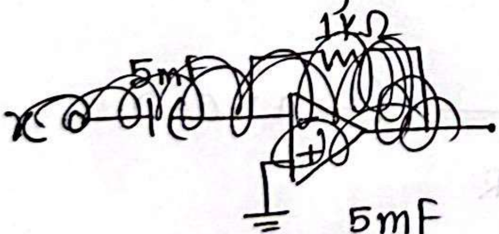
$$\therefore R_f = 2k\Omega$$

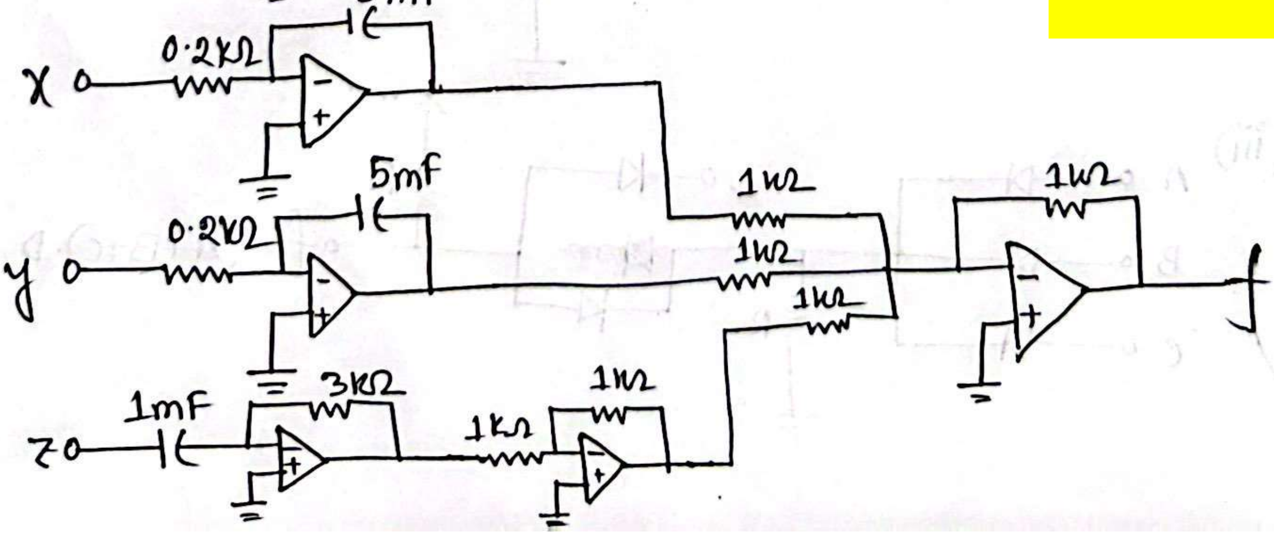


====Rubric====
same as set-1

(b) $$f = 5\int(x+y)dt - 3\frac{d}{dt}(z)$$

$$= 5\int x\,dt + 5\int y\,dt - 3\frac{d}{dt}z$$

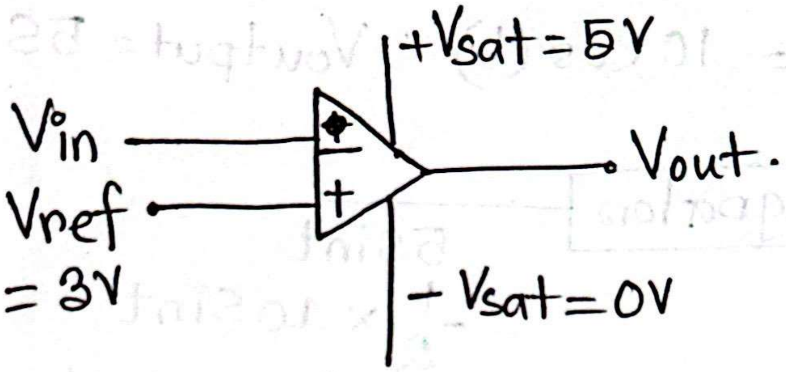




====Rubric====
same as set-1

7.

(a)



(b) Not possible.