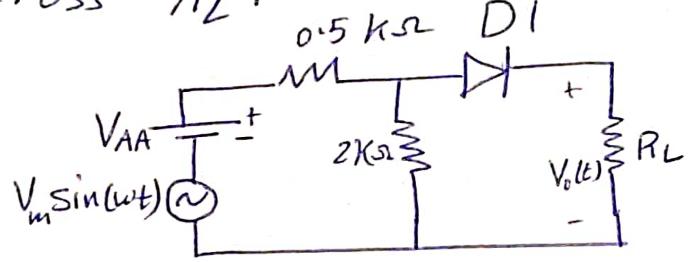
Sheet #3

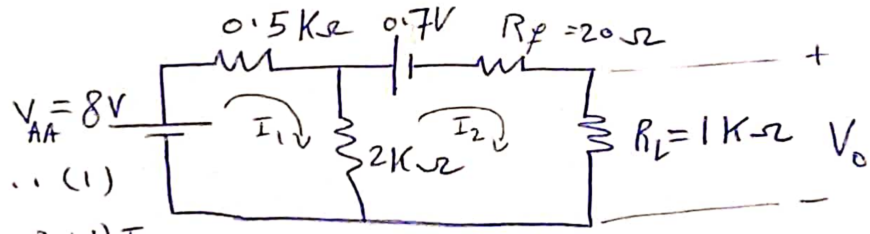
1. For the ct. shown $V_{AA} = 8V$, $V_m = 0.5V$ & $R_L = 1K\Omega$.
In the Large signal model of the diode $V_\gamma = 0.7V$, $R_f = 20\Omega$ & $\eta = 2$, Determine:
a) The alternating component of voltage across R_L.
b) The Total voltage across R_L.



Sol:

* Dc analysis using Large signal Model:

-> Assuming D1 is on.



Loop 1:
$\Rightarrow 8 = 0.5 I_1 + 2(I_1 - I_2)$
$\Rightarrow 8 = 2.5 I_1 - 2 I_2 \quad \dots (1)$

Loop 2:
$\Rightarrow 0 = 2(I_2 - I_1) + 0.7 + (0.02 + 1) I_2$
$\Rightarrow 0 = 3.02 I_2 - 2 I_1 + 0.7$

(In DC analysis we consider only DC-sources)

$\Rightarrow I_1 = \frac{1}{2}(3.02 I_2 + 0.7) \quad \dots (1)$

sub. by (1) in (2):

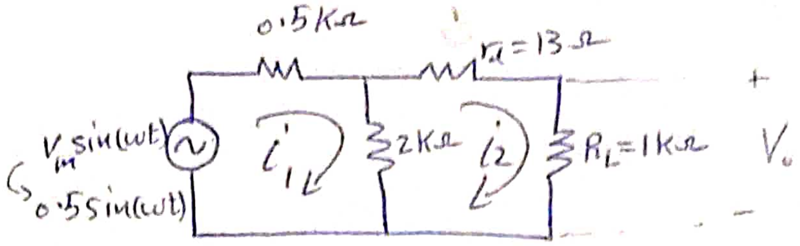
$\Rightarrow 8 = [\frac{1}{2}(3.02 I_2 + 0.7)(2.5) - 2 I_2]$
$\Rightarrow I_2 = 4.014 \text{ mA} = I_{D1}$ (In the same direction of diode)
↳ Assumption is true (D1 ON)

$\Rightarrow V_o = I_2 R_L = 4.014$ Volt

* AC Analysis using small signal Model:

$\therefore r_d = \frac{\eta V_T}{I_D}$ (small signall resistance of the diode)

$$= \frac{(2)(0.026)}{(4.014)} = 0.0129 \text{ K}\Omega \simeq 13\,\Omega$$



Loop 1:

$\Rightarrow 0.5\sin(wt) = i_1(0.5) + 2(i_1 - i_2)$

$\Rightarrow 0.5\sin(wt) = 2.5 i_1 - 2 i_2 \quad \dots (3)$

Loop 2:

$\Rightarrow 0 = i_2(0.013) + i_2(1) + 2(i_2 - i_1)$

$\Rightarrow 0 = 3.013\, i_2 - 2 i_1$

$\Rightarrow i_1 = \frac{3.013 i_2}{2} \quad \dots (4)$

- sub by (4) in (3):

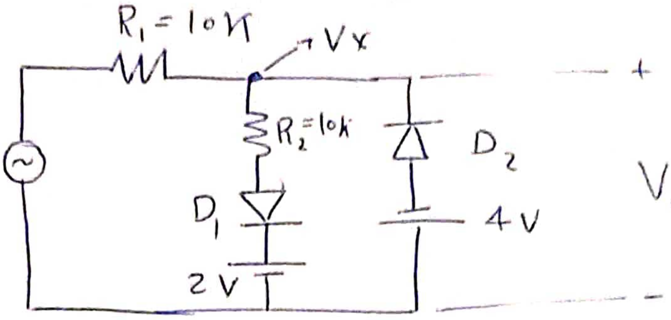
$\Rightarrow 0.5\sin(wt) = 2.5\left(\frac{3.013}{2}\right) i_2 - 2 i_2$

$\Rightarrow i_2 = 0.283\sin(wt)$ mA

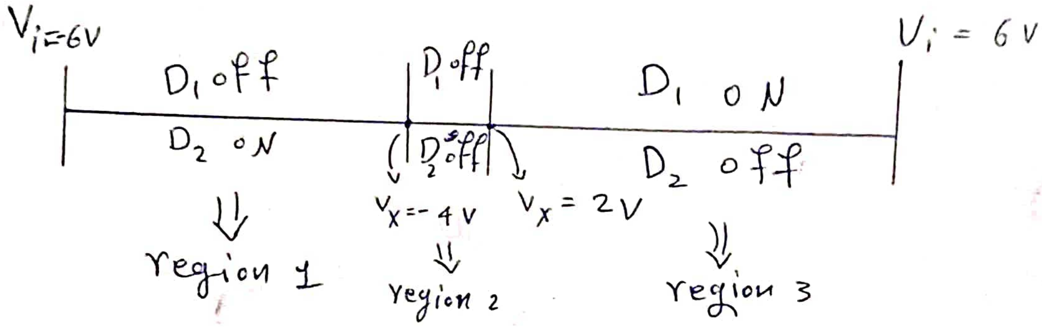
a) $\Rightarrow v_o(t) = i_2 R_L = 0.283\sin(wt)$ mA

b) $\Rightarrow V_{o\,Total}(t) = V_o + v_o(t) = 4.014 + 0.283\sin(wt)$ Volt

2) * Assuming ideal diodes.



- The sine wave flactuates from $-6V$ to $+6V$.

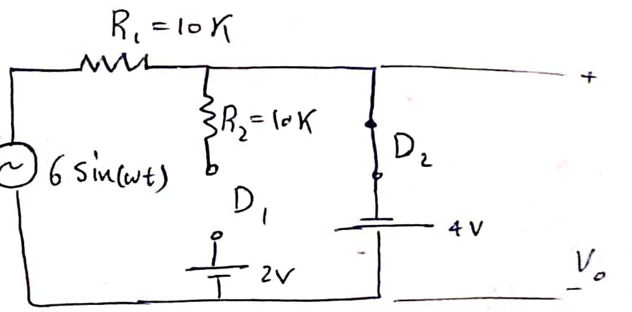


* Region 1 : (D_1 off , D_2 ON)

$-6 \leq V_i \leq -4$

$\boxed{V_X = -4V}$

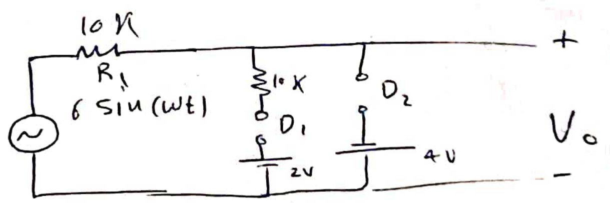
$\Rightarrow \boxed{V_o = V_X = -4V}$



* Region 2 : (D_1 off , D_2 off)

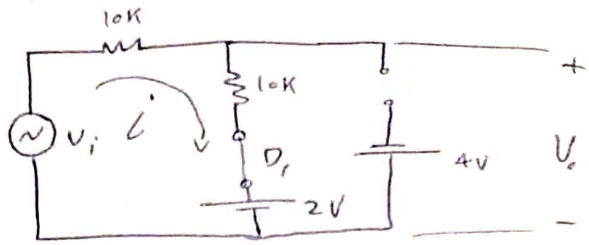
$-4 \leq V_i \leq 2$

$\hookrightarrow -4 \leq V_X \leq 2$



$\Rightarrow V_o = V_i = V_X$ ($\because$ no current is flowing through R_1)

* Region 3 : (D_1 ON , D_2 off)



$2 \le V_i \le 6$

$\Rightarrow V_o = V_X$

$\Rightarrow V_o = 10 i + 2$

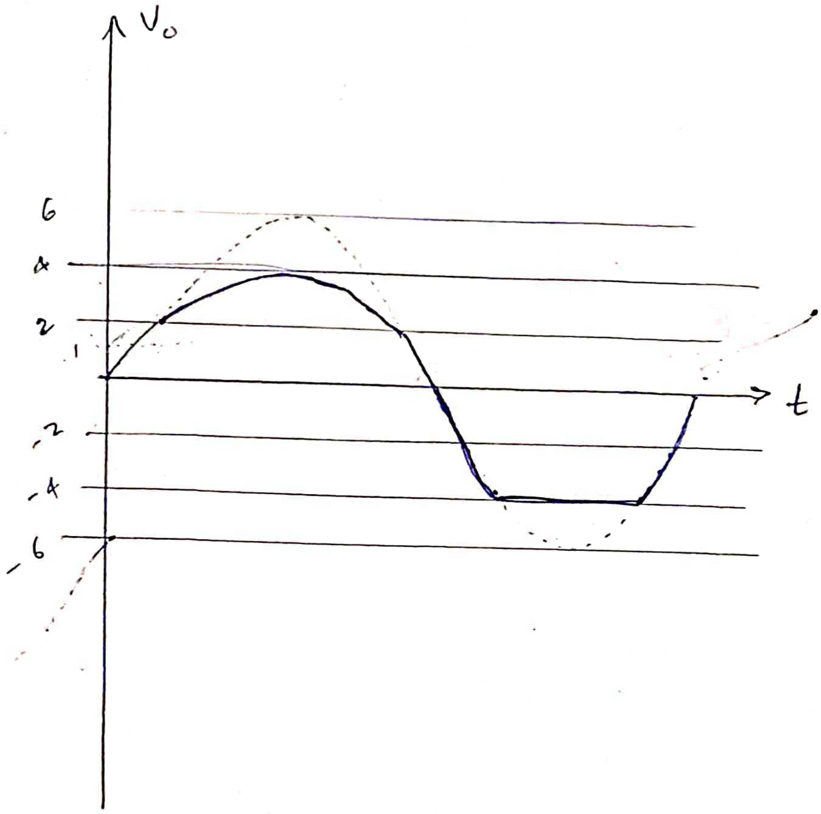
$\Rightarrow V_o = \cancel{16}\left(\frac{V_i - 2}{\cancel{20}}\right) + 2$

$\Rightarrow V_o = \frac{1}{2} V_i - 1 + 2$

$V_o = \frac{1}{2} V_i + 1$ $\quad (V_i = 6 \sin(\omega t))$

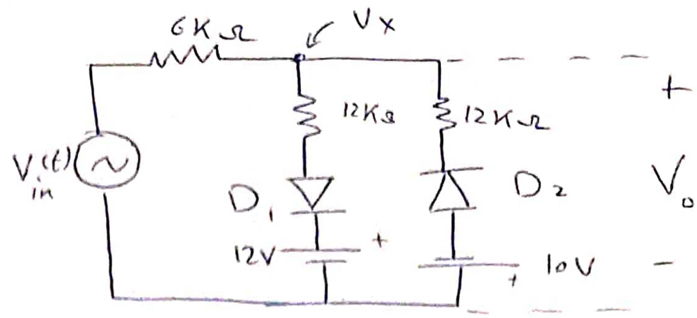
$\Rightarrow V_o = 3 \sin(\omega t) + 1$

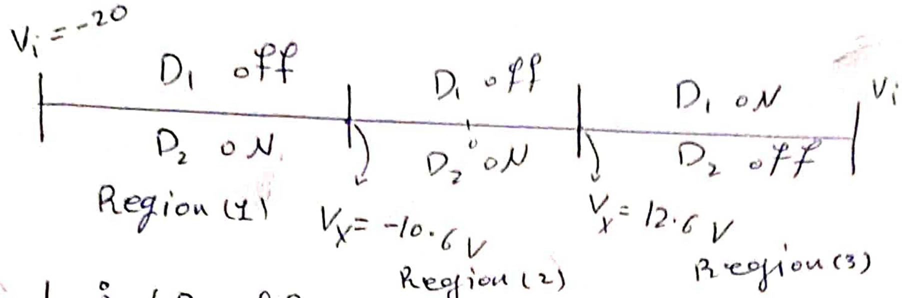
$$\Rightarrow V_o = \begin{cases} -4 & , -6 \le V_i \le -4 \\ 6 \sin(\omega t) & , -4 \le V_i \le 2V \\ 1 + 3\sin(\omega t) & , 2 \le V_i \le 6V \end{cases}$$



3) a) $V_\gamma = 0.6\,V$, $R_f = 0$

$V_{in} = 20 \sin(\omega t)$





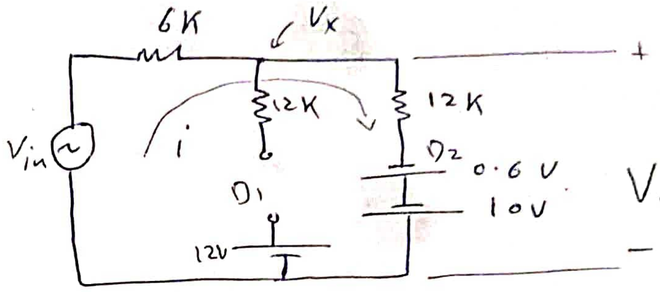
* Region 1 : (D_1 off , D_2 ON)

$-20V \le V_i \le -10.6\,V$

$V_x = V_o$

$\Rightarrow V_o = 12i - 10.6$

$i = \dfrac{V_{in} - (-10.6)}{18}$



$\Rightarrow V_o = 12\left(\dfrac{V_{in} + 10.6}{18}\right) - 10.6$

$\Rightarrow V_o = \frac{2}{3} V_{in} - 3.5333$

$\Rightarrow$ at $V_x = -10.6\,V \Rightarrow V_{in} = -10.6\,V$

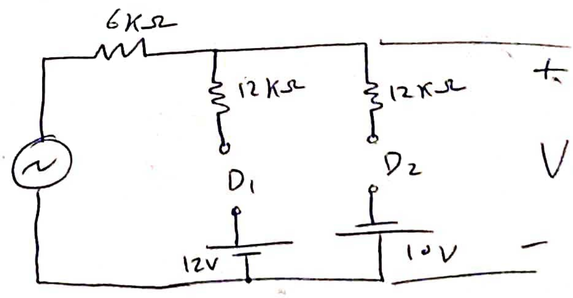
at $V_{in} = -20 \Rightarrow V_x = -16.87\,V$

$\hookrightarrow -20 \le V_o \le -16.87$

* Region 2 : (D_1 off , D_2 off)

$-10.6 \le V_i \le 12.6$

$-10.6 \le V_x \le 12.6$

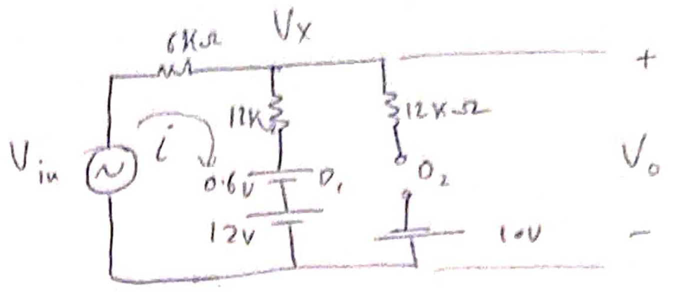


$\Rightarrow V_o = V_x = V_i$

$\hookrightarrow$ (no current through 6KΩ Resistor)

* Region 3 : (D_1 ON , D_2 off)

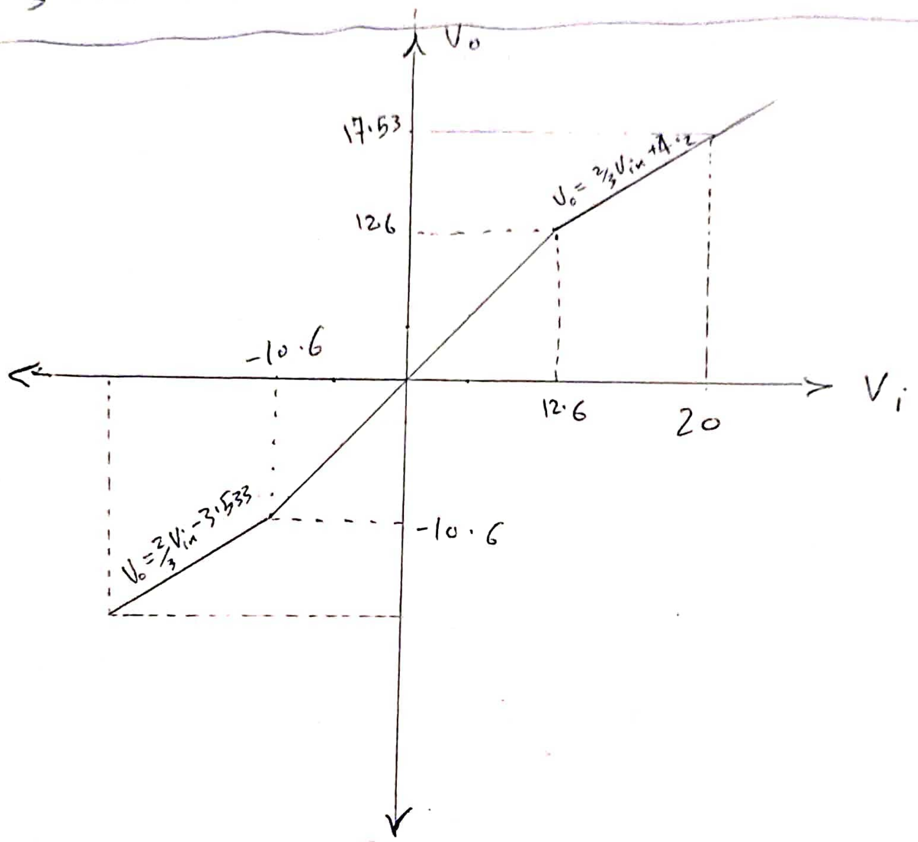
$12.6V \le V_{in} \le 20V$



$\Rightarrow V_o = V_x \quad \Rightarrow V_o = 12\,i + 12.6$

$\Rightarrow V_o = 12\left(\dfrac{V_{in} - 12.6}{18}\right) + 12.6$

$\Rightarrow V_o = \frac{2}{3} V_{in} + 4.2$



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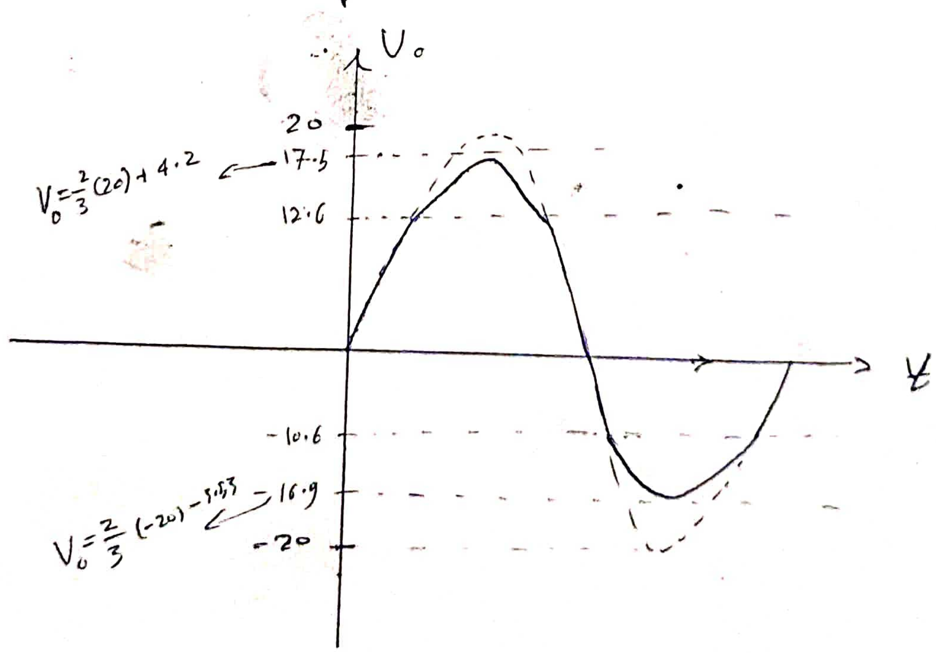
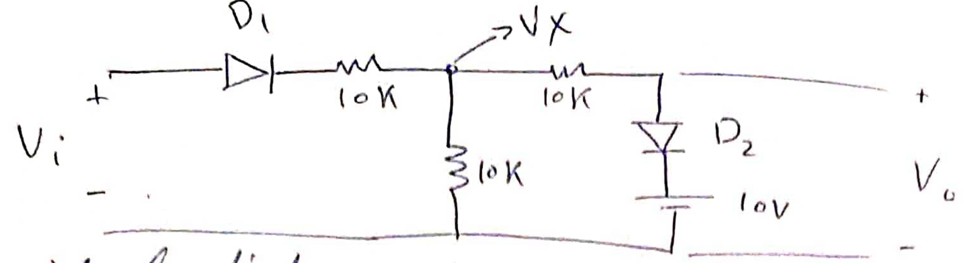


4)



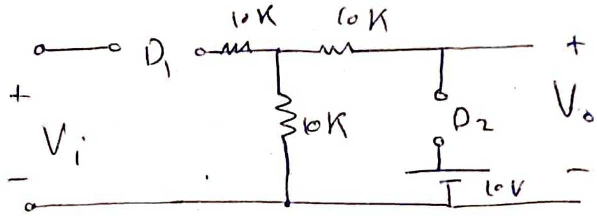
* *Assuming ideal diode:*

D_1 off / D_2 off	$V_i = 0$ — D_1 ON / D_2 off	$V_X = 10V$ — D_1 ON / D_2 ON
Region 1	Region 2	Region 3

* Region 1 (D_1 off & D_2 off):

$V_i \leq 0$

$\Rightarrow V_o = V_X = 0 \quad (i = 0)$



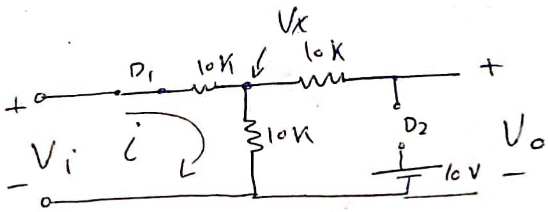
* Region 2 (D_1 ON, D_2 off):

$0 \leq V_i \quad , \quad 0 \leq V_X \leq 10$

$\Rightarrow V_o = V_X$

$\Rightarrow V_o = i(10) = \frac{V_i}{20}(10)$

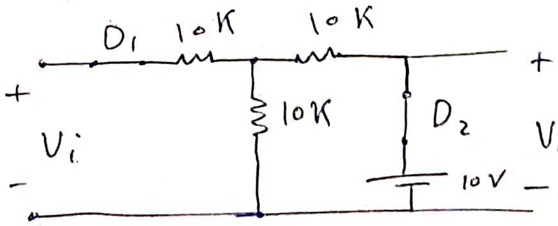
$\Rightarrow \boxed{V_o = \frac{1}{2} V_i} \longrightarrow 0 \leq V_i \leq 20$



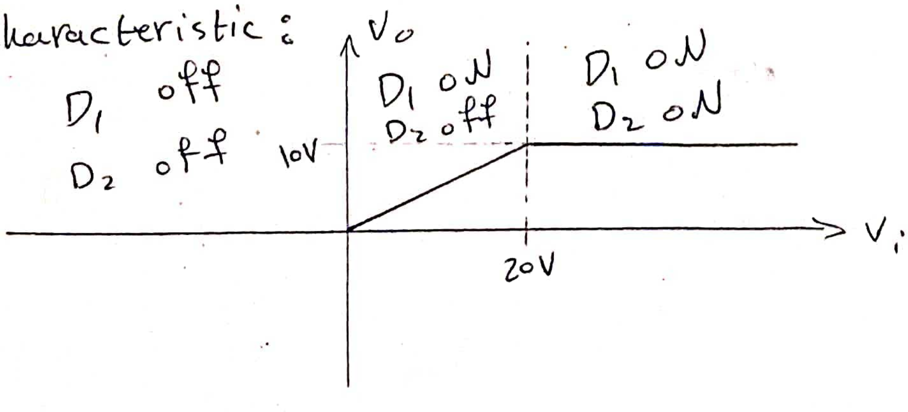
* Region 3 (D_1 ON, D_2 ON):

$20 \leq V_i \quad , \quad 10 \leq V_X$

$\Rightarrow \boxed{V_o = 10\ V}$

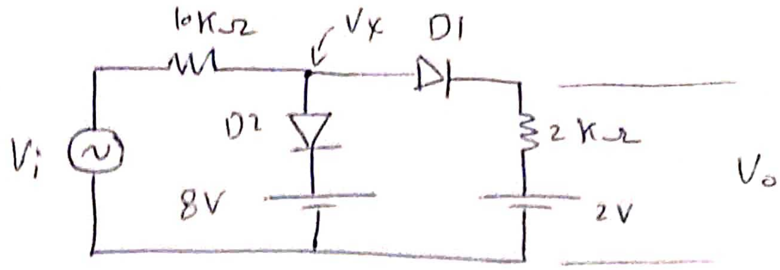


* Transfer characteristic:



5)

Assuming ideal diodes.



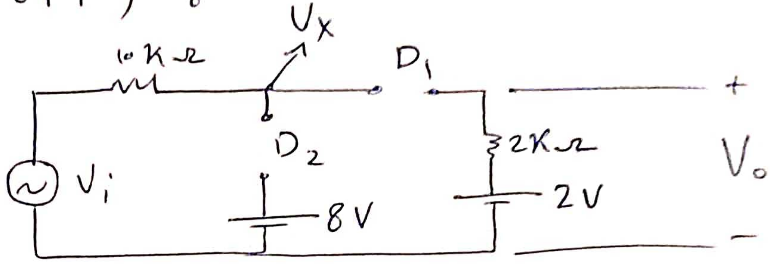
$V_i = 2V$		$V_x = 8V$	
D_1 off	D_1 ON		D_1 ON
D_2 off	D_2 off		D_2 ON
Region 1	Region 2		Region 3

* Region 1 (D_1 off , D_2 off) :

$V_i \leq 2V$

$V_x = V_i$

$V_x \leq 2$

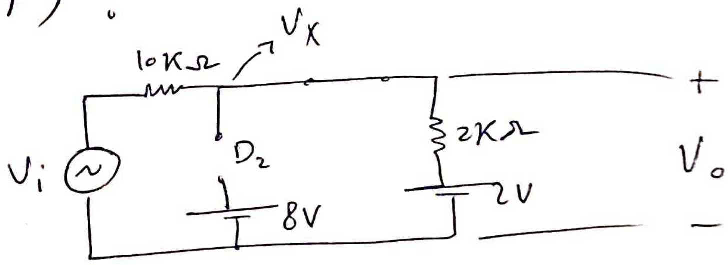


$\Rightarrow \quad V_o = 2V \qquad (i=0)$

* Region 2 (D_1 ON , D_2 off) :

$2 < V_i \qquad , 2 < V_x \leq 8$

$\Rightarrow V_o = V_x$



$\Rightarrow V_o = 2i + 2$

$\Rightarrow V_o = 2\left(\frac{V_i - 2}{12}\right) + 2$

$\Rightarrow V_o = \frac{V_i}{6} + 1.667$

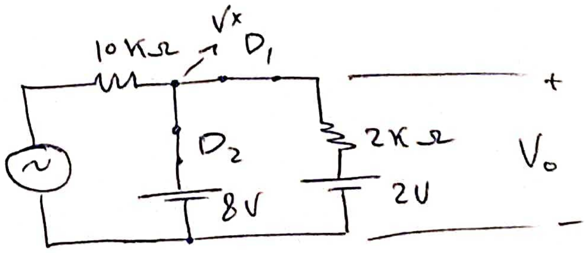
at $V_x = 8 = V_o \Rightarrow V_i = 38V$

$\Rightarrow 2 < V_i < 38$

* Region 3 : (D_1 ON , D_2 ON)

$38 \leq V_i \qquad , 8 < V_x$

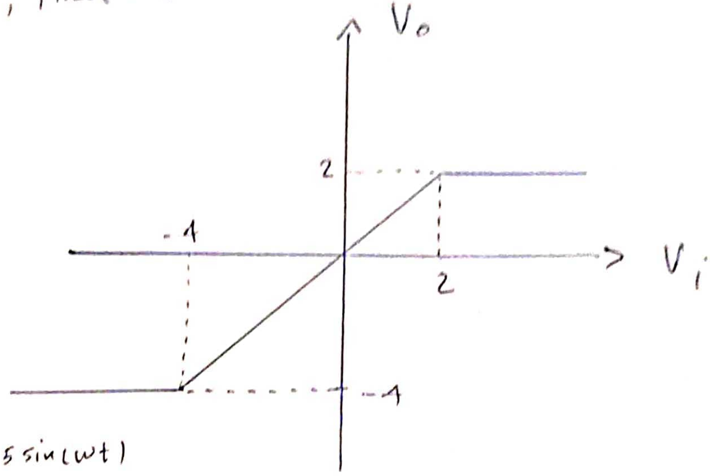
$\Rightarrow \quad V_o = V_x = 8V$

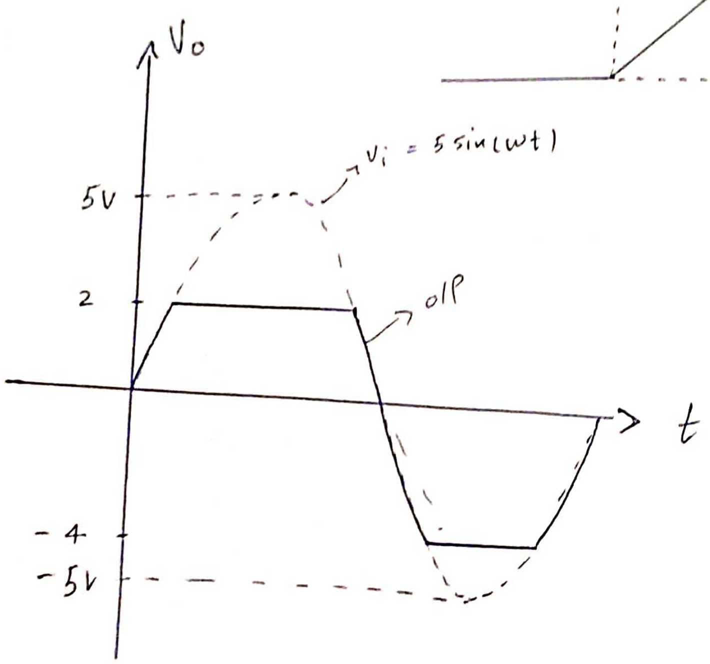


$$\Rightarrow V_o = \begin{cases} 2 & , \quad V_i \le 2 \\ \frac{1}{6} V_i + 1.667 & , \quad 2 < V_i \le 38 \\ 8 & , \quad 38 < V_i \end{cases}$$

6)

a) $V_i = 5\sin(wt)$, find V_{out}





b)