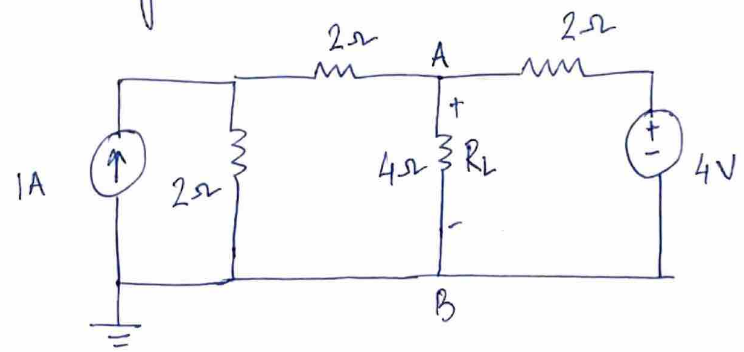
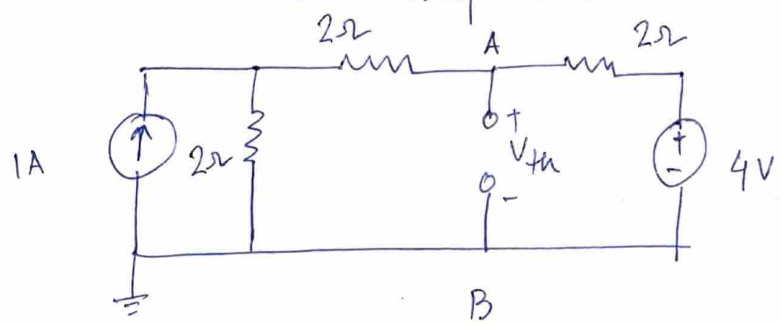
ECE 322 Fall 2021 Quiz 1 Practice Question Solutions

1) The given circuit:



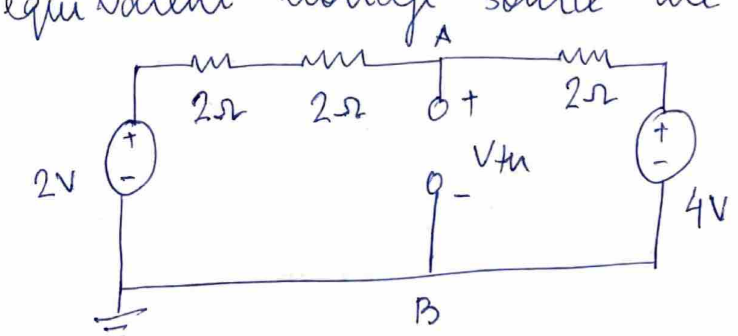
To calculate the Thevenin voltage, R_L is removed and the voltage V_{AB} is calculated.

The circuit is modified as:



The Thevenin voltage can be calculated using different methods (Source transformation, KCL, KVL etc)

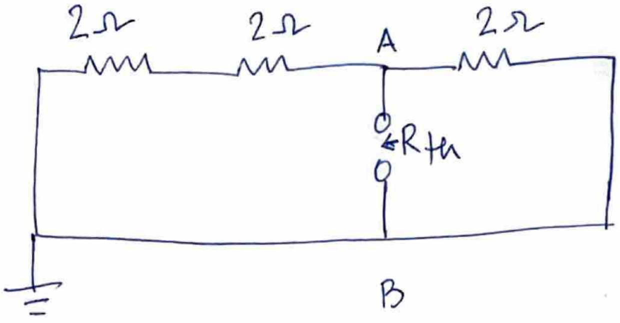
Converting the current source and the shunt resistor to an equivalent voltage source we get,



$$V_{th} = 4V - \frac{(4-2)V}{6\Omega} \times 2\Omega$$

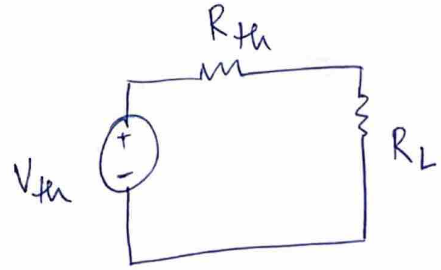
$$= \frac{10V}{3}$$

To calculate the Thevenin resistance, voltage sources are replaced by short circuits,



$$R_{th} = R_{AB} = 4\Omega \parallel 2\Omega = \frac{4}{3}\Omega$$

Hence the simplified Thevenin circuit,

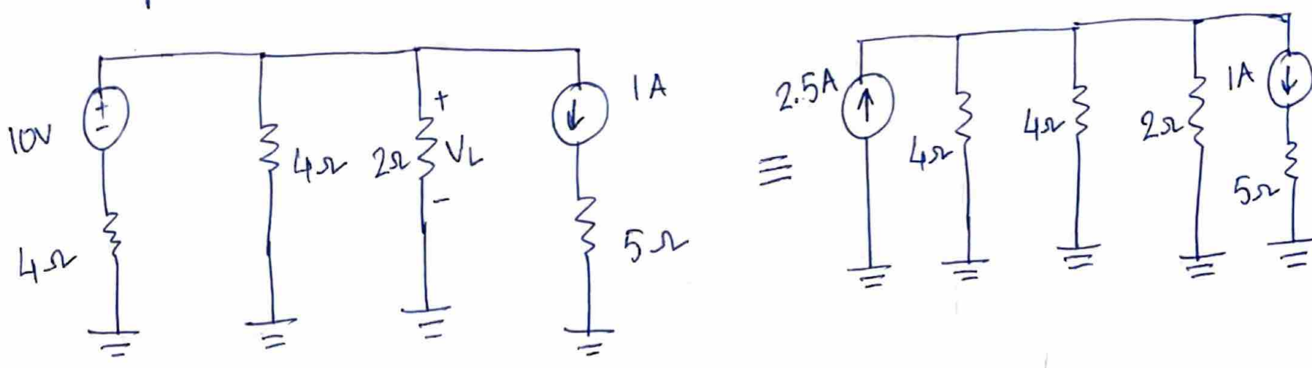


$V_{th} = \frac{10}{3}\,V$, $R_{th} = \frac{4}{3}\,\Omega$, $R_L = 4\Omega$

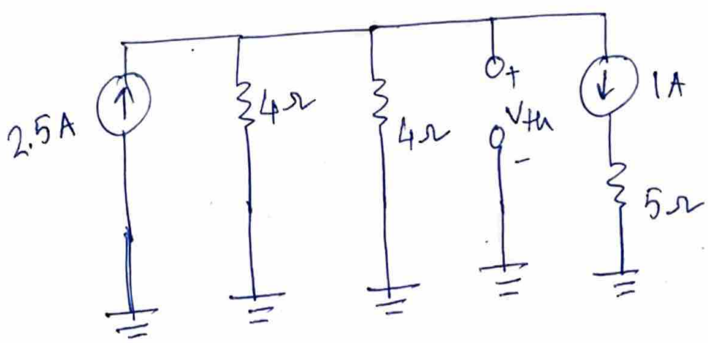
Hence $$V_L = \frac{V_{th}}{R_{th} + R_L} \times R_L = \left(\frac{\frac{10}{3}\,V}{\frac{4}{3}\Omega + 4\Omega} \right) \times 4\Omega$$

$$\Rightarrow \boxed{V_L = 2.5\,V}$$

2) The given circuit,

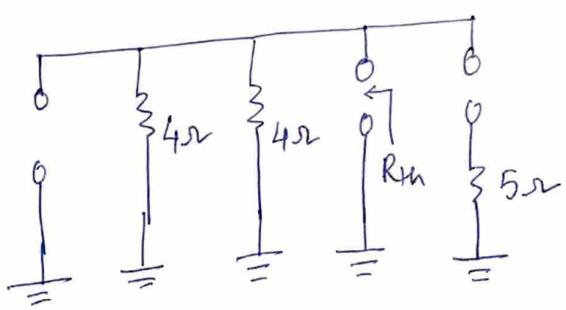


Thevenin voltage calculation :



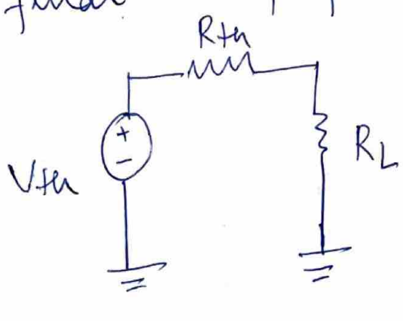
$$V_{th} = (2.5A - 1A)(4\Omega \parallel 4\Omega) = (1.5A)(2\Omega) = 3V$$

Thevenin resistor calculation :



$$R_{th} = (4\Omega \parallel 4\Omega) = 2\Omega$$

The final simplified circuit :

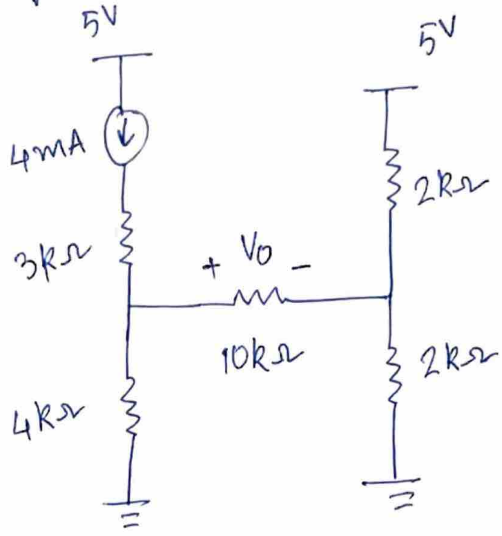


$V_{th} = 3V$, $R_{th} = 2\Omega$, $R_L = 2\Omega$

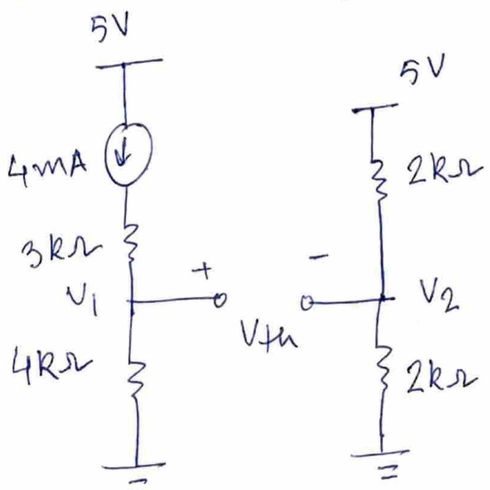
$$\therefore V_L = \left(\frac{V_{th}}{R_{th} + R_L}\right) R_L = 1.5V$$

$\Rightarrow$ $V_L = 1.5V$

3) The given circuit,



Thevenin circuit,



$V_{th} = V_1 - V_2$

where,

$V_1 = (4mA)(4k\Omega)$

$\Rightarrow V_1 = 16V$

$V_2 = \frac{5V}{(2k\Omega + 2k\Omega)} \times 2k\Omega$

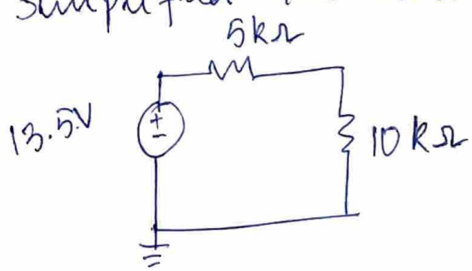
$= 2.5V$

$\Rightarrow V_{th} = 16V - 2.5V = 13.5V$

To calculate Thevenin resistor, voltage sources are short circuited and current sources are open circuited.

$R_{th} = (4k\Omega) + (2k\Omega \parallel 2k\Omega) = 5k\Omega$

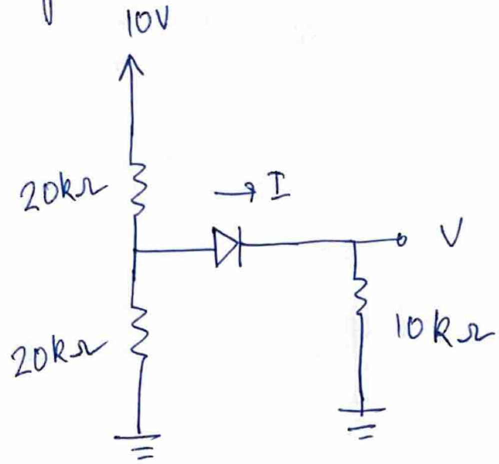
Simplified Thevenin circuit,



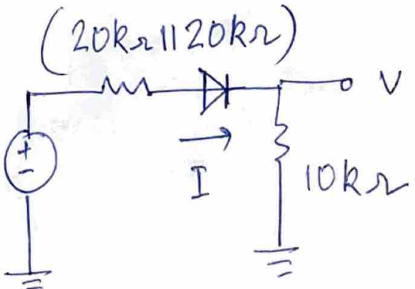
$V_o = \frac{13.5V}{(5k\Omega + 10k\Omega)} \times 10k\Omega = 9V$

$\Rightarrow$ $V_o = 9V$

4) The given circuit,



The simplified circuit,



$10\left(\frac{20k\Omega}{40k\Omega}\right) = 5V$

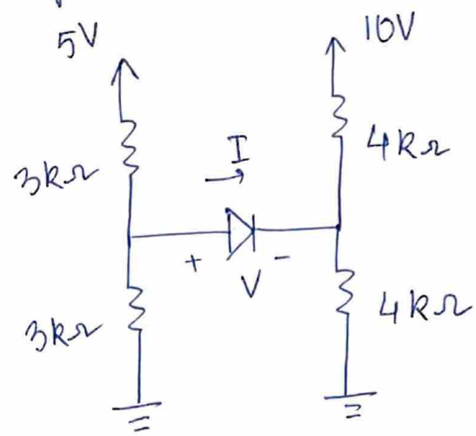
$$I = \frac{5V}{(20k\Omega \parallel 20k\Omega) + 10k\Omega}$$

$$\Rightarrow I = \frac{5V}{10k\Omega \times 2}$$

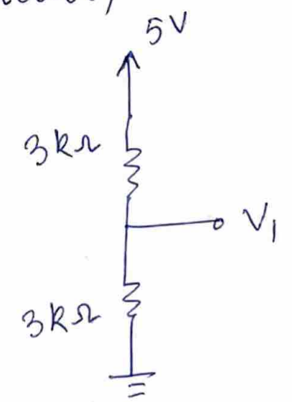
$$\Rightarrow I = ~~0.25~mA~~ = 0.25~mA$$

$$V = I \times 10~k\Omega = 2.5~V$$

5) The given circuit,

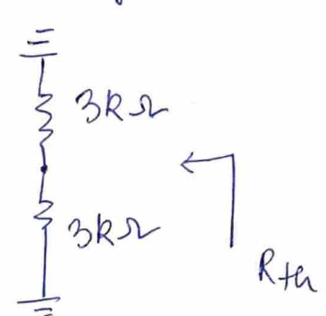


Applying Thevenin's theorem to the left hand side of the circuit,



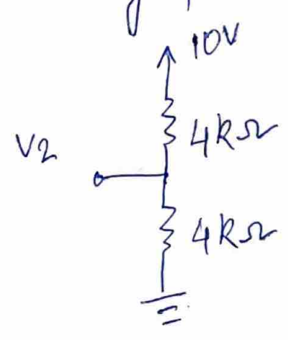
$$V_1 = \frac{5\,V}{(3k\Omega + 3k\Omega)} \times 3k\Omega = 2.5V$$

For calculating R_{th} for the left hand side of the circuit,



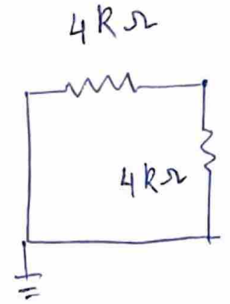
$$R_{th} = (3k\Omega \parallel 3k\Omega) = 1.5k\Omega$$

Similarly for the right hand side of the circuit,



$$V_2 = \frac{10V}{(4k\Omega + 4k\Omega)} \times 4k\Omega = 5V$$

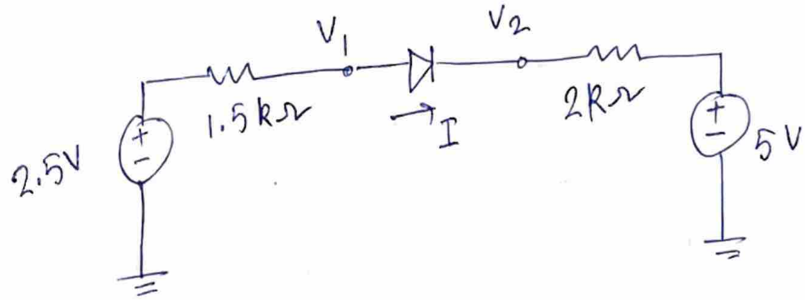
For calculating R_{th} for the right hand side of the circuit,



$R_{th} = (4k\Omega \parallel 4k\Omega)$

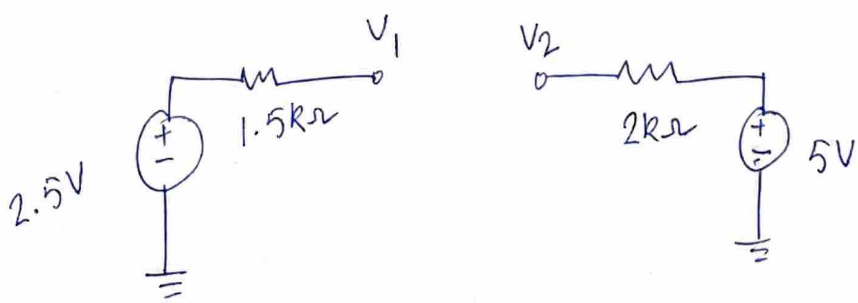
$= 2k\Omega$

Hence the complete simplified circuit,



Since $V_1 < V_2$, the diode is reverse biased. $I = 0$

Thus the circuit reduces to,



~~V_1 and~~ Nodes 1 and 2 are electrically isolated.

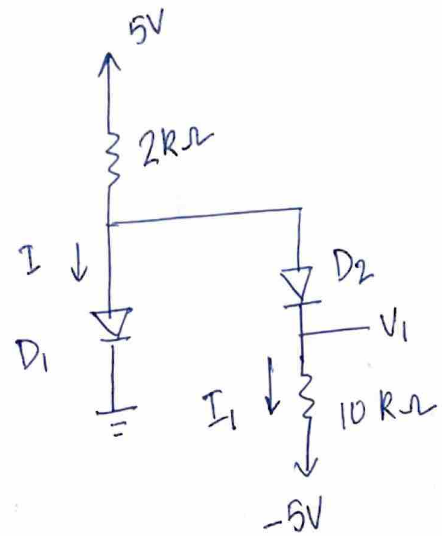
$\therefore \; V = V_1 - V_2 = 2.5V - 5V = -2.5V$

2) Diode is reverse biased

$V = -2.5V$

$I = 0$

6) The given circuit,



Assuming both the diodes are forward biased.

$\therefore \quad V_1 = 0V$

$$I_1 = \frac{V_1 - (-5V)}{10\,k\Omega} = \frac{5V}{10k\Omega} = 0.5\,mA$$

With $V_1 = 0V$, the initial assumption is also satisfied.

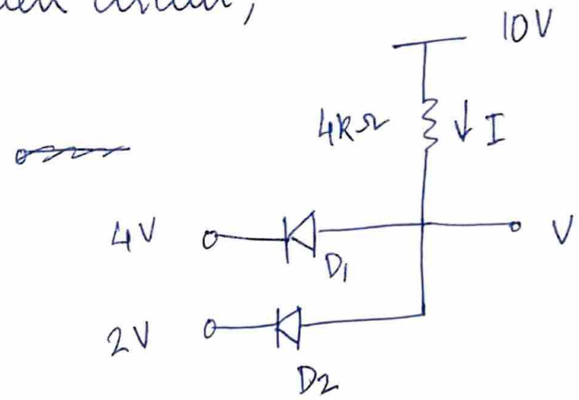
Current through the diode D_1,

$$I = \frac{5V}{2k\Omega} - I_1 = 2\,mA$$

Hence, $V_1 = 0V$

$I_1 = 0.5\,mA$

7) The given circuit,



Since the value of the voltage V is unknown, we cannot estimate the operating condition of D_1 and D_2 ~~inst~~ intuitively.

There can be four possible cases, depending on the biasing condition of each diode.

Case 1: D_1 is off, D_2 is off

⇒ both the paths are open circuit, so not a feasible configuration.

Case 2: D_1 is on, D_2 is on

⇒ The voltage V has to simultaneously be equal to 4V and 2V. This is also not a feasible option.

Case 3: D_1 is on, D_2 is off

⇒ $V = 4V$ ⇒ D_2 is on.

Hence there is a contradiction to the assumption

⇒ Not a feasible option

Case 4: D_1 is off, D_2 is on

⇒ $V = 2V$ ⇒ ~~D2~~ D_1 is off → Acceptable configuration

Hence,

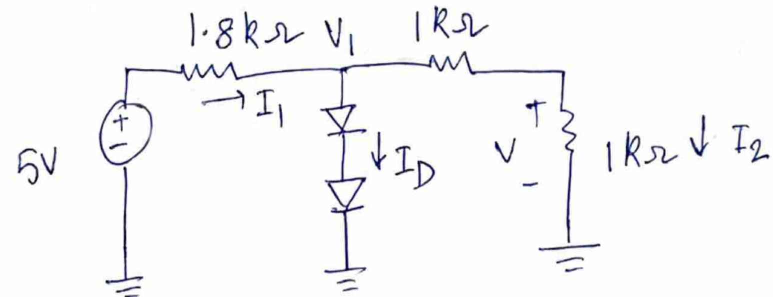
D_1 is off (reverse biased)

D_2 is on (forward biased)

$V = 2V$

$$I = \frac{10V - 2V}{4k\Omega} = 2\,mA$$

8) The given circuit,



Assuming both the diodes are forward biased.

$$V_1 = 2 \times 0.7V = 1.4V$$

$$I_1 = I_D + I_2 \quad (KCL)$$

$$I_1 = \frac{5V - V_1}{1.8\,k\Omega} = \frac{5V - 1.4V}{1.8\,k\Omega} = 2\,mA$$

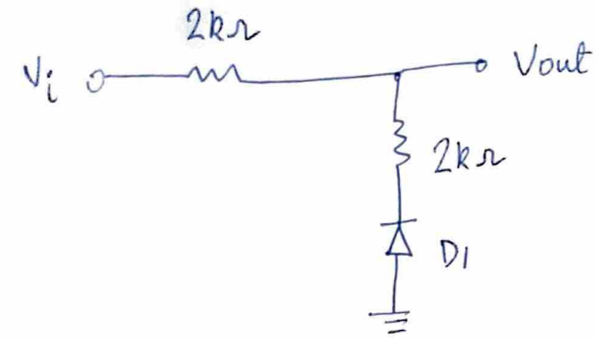
$$I_2 = \frac{V_1}{2K\Omega} = \frac{1.4V}{2K\Omega} = 0.7\,mA$$

Hence $I_D = I_1 - I_2 = 2mA - 0.7mA = 1.3\,mA$

$V = I_2 \times 1K\Omega = (0.7\,mA)(1\,k\Omega) = 0.7\,V$

Since $V_1 = 1.4V$, the initial approximation is satisfied.

9)

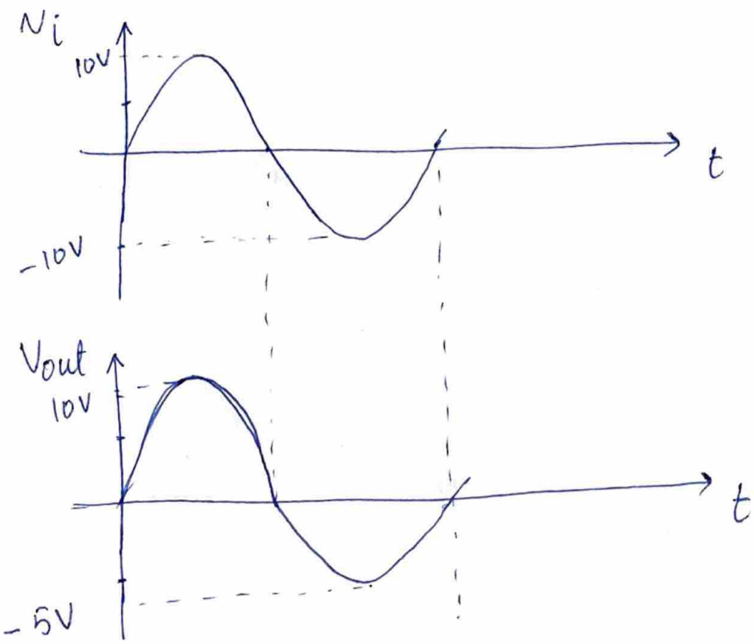


Region 1: $V_i > 0$ ⇒ D_1 is reverse biased.

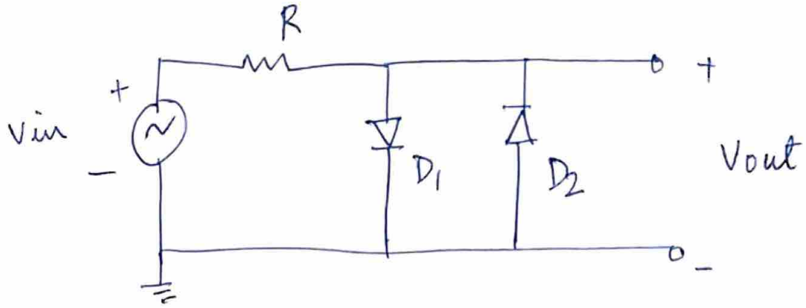
⇒ V_{out} follows V_i

Region 2: $V_i < 0$ ⇒ D_1 is forward biased.

$$\Rightarrow V_{out} = \frac{V_i}{(2k\Omega + 2k\Omega)} \times 2k\Omega = \frac{V_i}{2}$$



10) The given circuit,

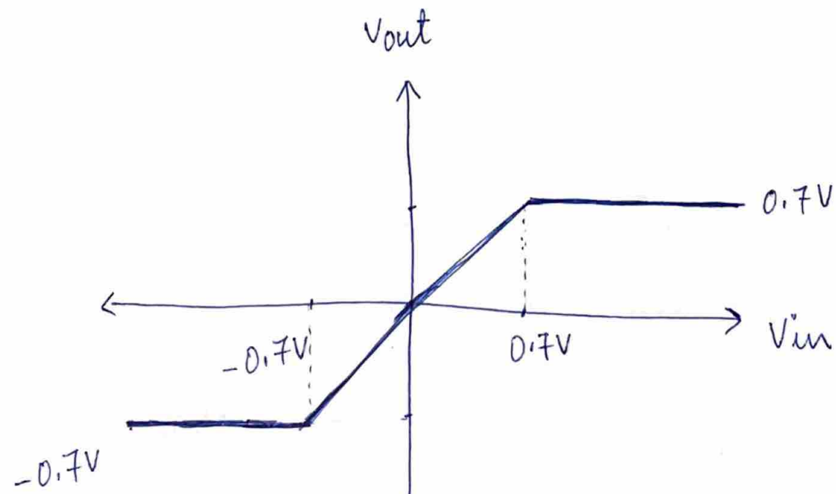


Region 1: Vin > 0.7 V ⇒ D_1 is forward biased. ⇒ Vout = 0.7

Region 2: Vin < - 0.7V ⇒ D_2 is forward biased ⇒ Vout = -0.7V

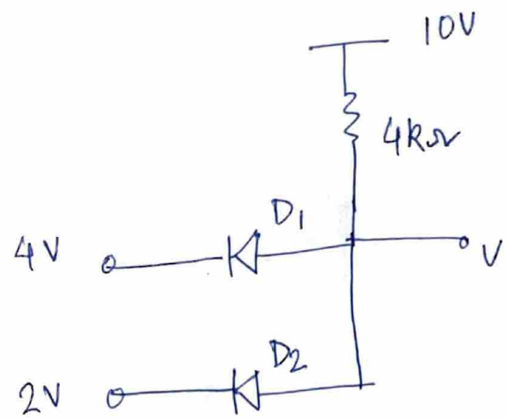
Region 3: ~~Vin~~ -0.7V < Vin < 0.7 V ⇒ Vout follows Vin
⇒ D_1 and D_2 are reverse biased.

Hence, the input output characteristics is given by,



Limiting Circuits

11) The given circuits,



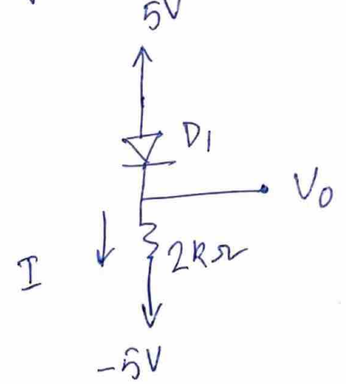
For real diodes, voltage drop across the diode in forward biased = 0.7 V

Referring to the solution for problem 7, we know that D_1 is reverse biased and D_2 is forward biased.

$$V = 2V + 0.7V = 2.7V$$

$$I = \frac{10V - 2.7V}{4k\Omega} = 1.825\ mA$$

12) The given circuit,



Assuming D_1 is forward biased,

$$V_O = 5V - 0.7V = 4.3V$$

$$I = \frac{4.3V - (-5V)}{2k\Omega} = 4.65\ mA$$