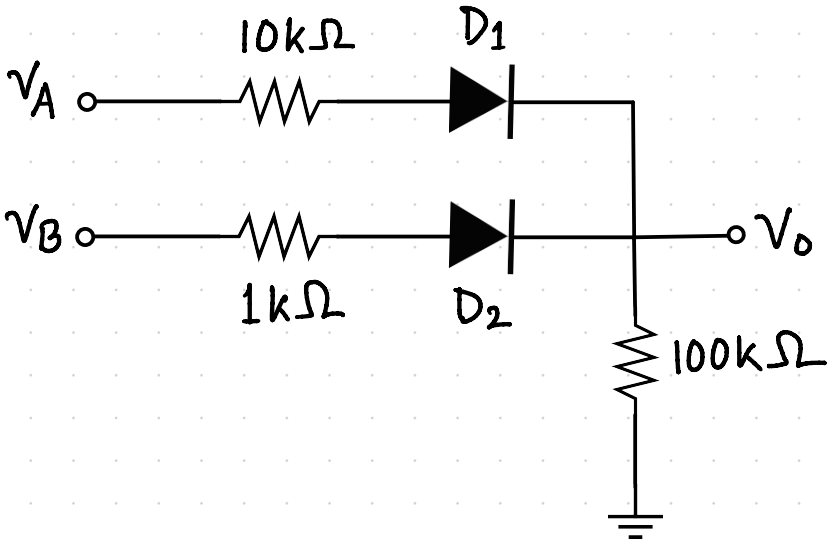
Week 1
Diode Logic

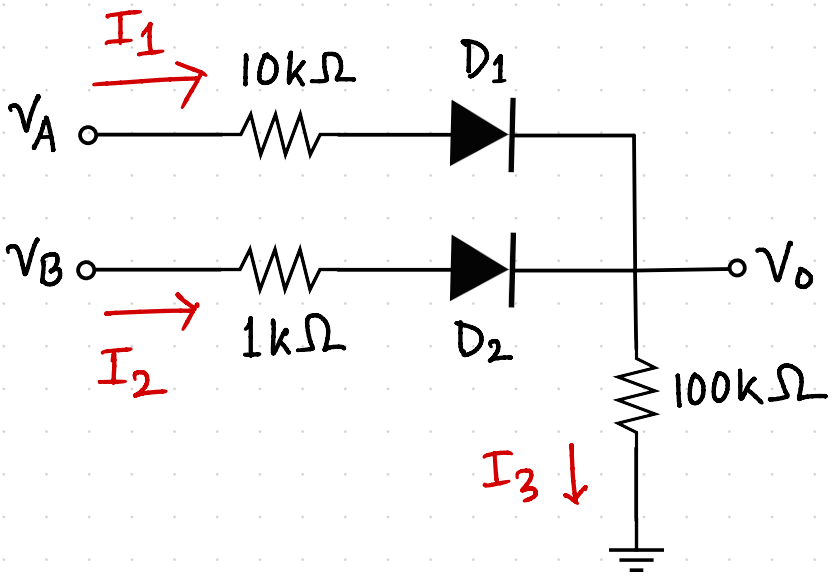
Question 1



Solve the circuit to find the output voltage for each of the input combinations.

Calculate the average power dissipation.

Solution:



Case 1 :

$A = B = 0\,V$

Both diodes D_1 and D_2 are OFF

$V_o = 0\,V$

Case 2 : $A = 5\,V$, $B = 0\,V$

Diode D_1 will be ON, D_2 will be OFF

Nodal Analysis =)

$$I_1 + I_2 = I_3$$

$$\Rightarrow \frac{5-(V_o+0.7)}{10k} + 0 = \frac{V_o - 0}{100k}$$

$$\Rightarrow V_o = 3.91\,V$$

Case 3: $A = 0\,V$, $B = 5\,V$

Diode D_1 will be OFF, D_2 will be ON

Nodal Analysis =)

$$I_1 + I_2 = I_3$$

$$\Rightarrow 0 + \frac{5-(V_0+0.7)}{1k} = \frac{V_0 - 0}{100k}$$

$$\Rightarrow V_0 = 4.25\,V$$

Case 4: $A = 5\,V$, $B = 5\,V$

Both diode D_1 and D_2 will be OFF

Nodal Analysis =)

$$I_1 + I_2 = I_3$$

$$\Rightarrow \frac{5-(V_0+0.7)}{10k} + \frac{5-(V_0+0.7)}{1k} = \frac{V_0 - 0}{100k}$$

$$\Rightarrow V_0 = 4.26\,V$$

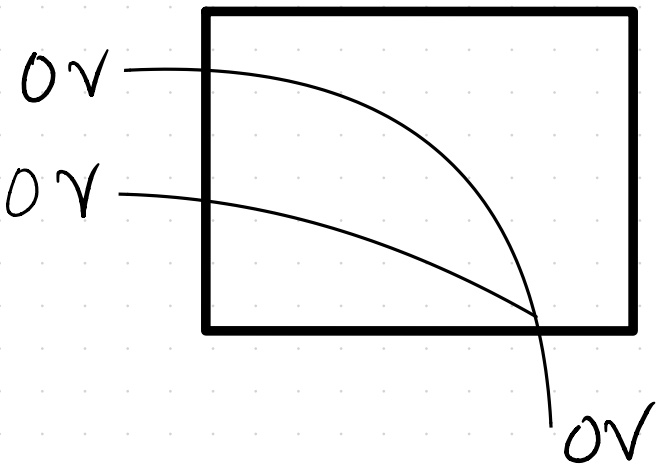
Power Dissipation

Case 1:

$$P = \sum \Delta V I$$

$$= (0-0) \times 0$$

$$= 0 \text{ W}$$

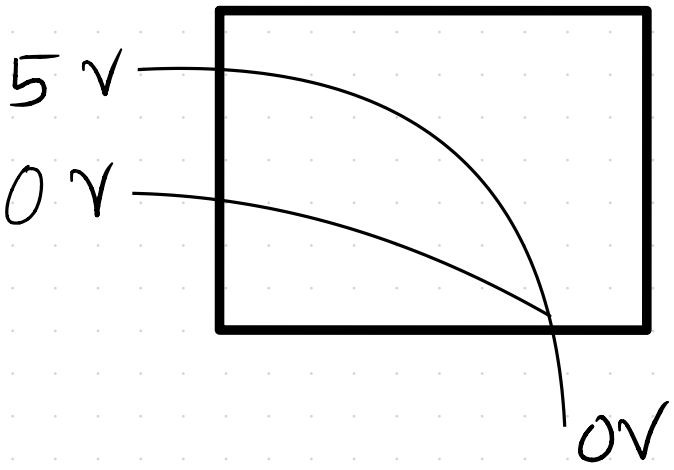


Case 2:

$$P = \sum \Delta V I$$

$$= (5-0) \times \frac{3.91}{100k}$$

$$= 0.195 \text{ mW}$$

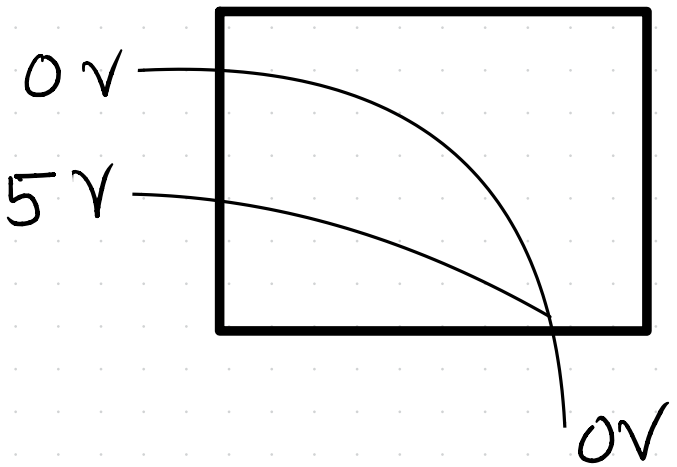


Case 3:

$$P = \sum \Delta V I$$

$$= (5-0) \times \frac{4.25}{100k}$$

$$= 0.2125 \text{ mW}$$

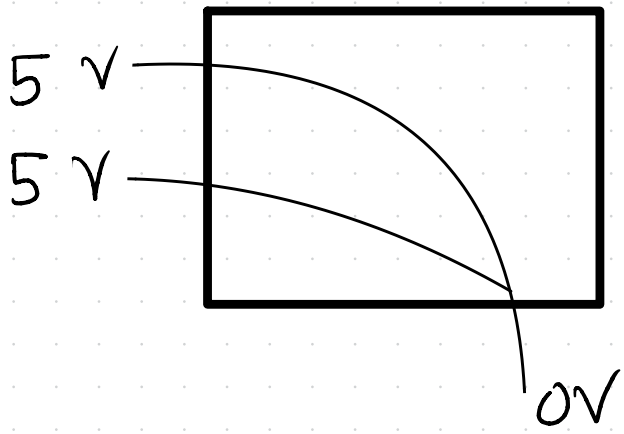


Case 4:

$$P = \sum \Delta V I$$

$$= (5-0) \times \frac{4.26}{100k}$$

$$= 0.213 \text{ mW}$$



Alternate approach

$$P = \sum \Delta V I$$

$$= (5-0) \times \frac{5-(4.26+0.7)}{10k} + (5-0) \times \frac{5-(4.26+0.7)}{1k}$$

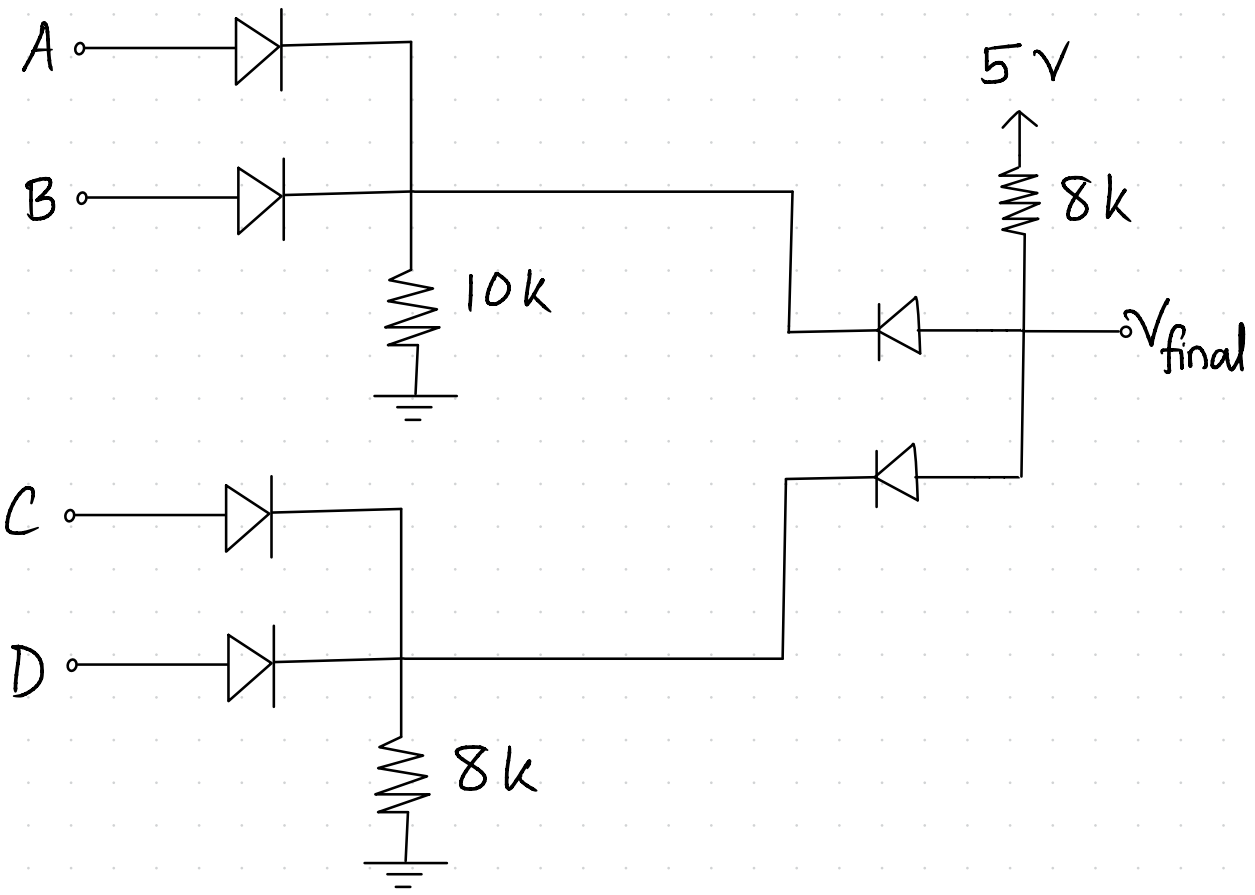
$$= 0.213 \text{ mW}$$

$\therefore$ Average power dissipation

$$= \frac{0+0.195+0.2125+0.213}{4}$$

$$= 0.155 \text{ mW}$$

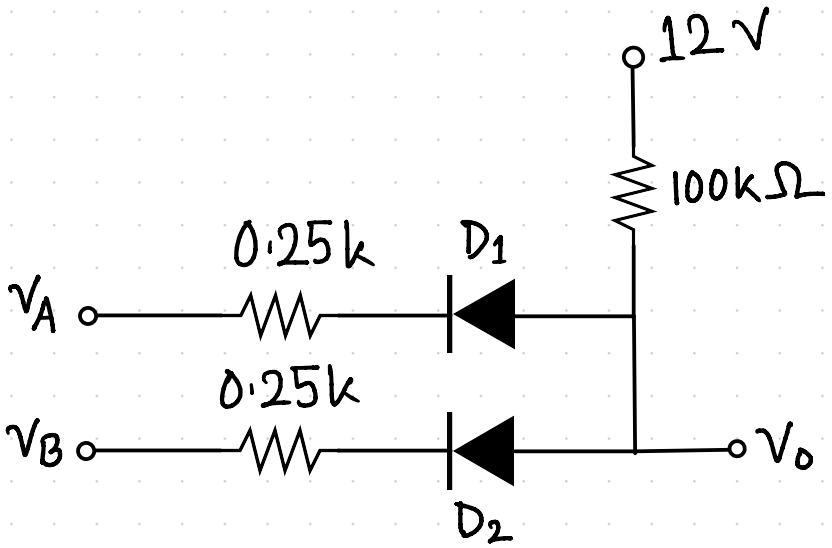
Question 2



Determine the boolean expression of V_{final} in terms of input A, B, C, D

Solution: $V_{final} = (A+B).(C+D)$

Question 3



Find out the output voltage levels for all input combinations.

Calculate the maximum power dissipation.

Solution:

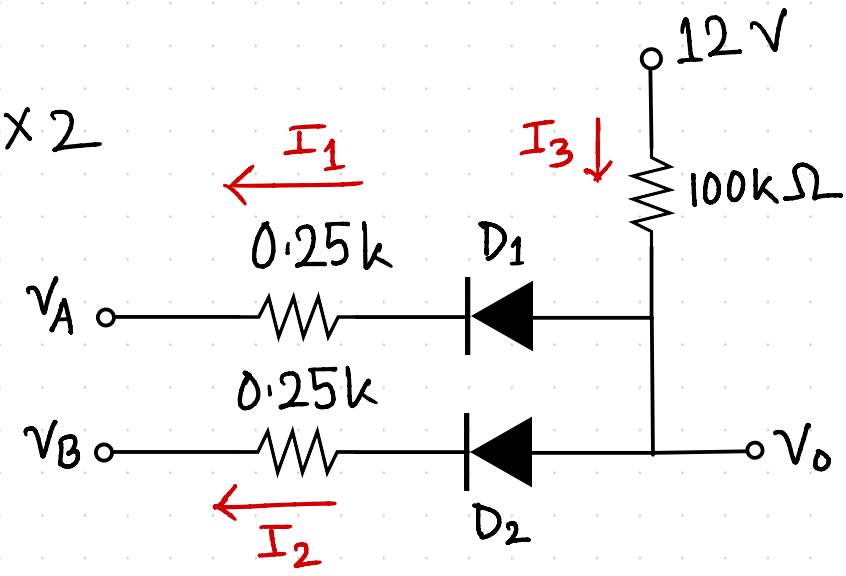
Case 1: For $V_A = 0\ V$, $V_B = 0\ V$

Both diodes D_1 and D_2 will conduct.

$\therefore I_3 = I_1 + I_2$

$\Rightarrow \frac{12 - V_0}{100k} = \frac{(V_0 - 0.7) - 0}{0.25k} \times 2$

$\Rightarrow V_0 = 0.714\ V$



Case 2 and 3 are identical

when any one input V_A or V_B is 0 V, Any one diode will conduct.

$\therefore I_3 = I_1 + I_2$

$\Rightarrow \frac{12 - V_0}{100k} = \frac{(V_0 - 0.7) - 0}{0.25k}$

$\Rightarrow V_0 = 0.728\ V$

Case 4: For $V_A = 12\ V$ and $V_B = 12\ V$

Both diodes will be OFF.

$\therefore I_3 = 0, I_2 = 0, I_1 = 0$

$\therefore V_o = 12\ V$

Maximum power dissipation happens when current is maximum i.e. case 1

$$P = \Delta V I$$

$$= (12 - 0) \times \frac{12 - 0.714}{100k}$$

$$= 1.354\ mW$$