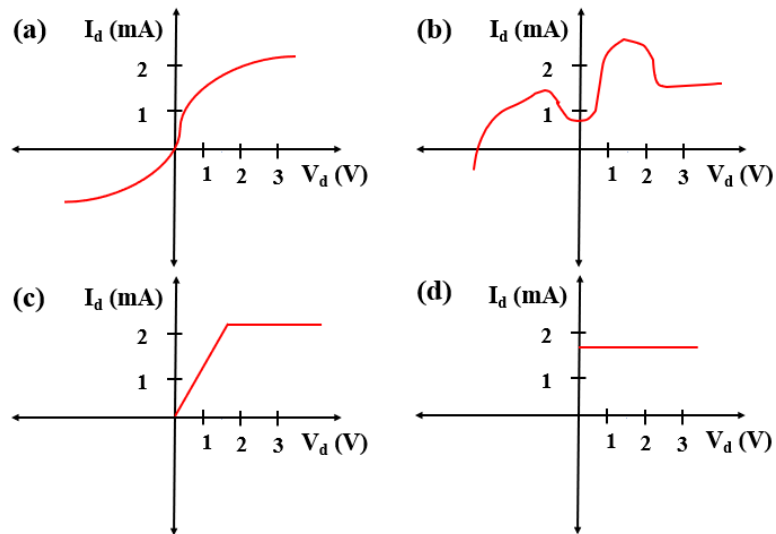


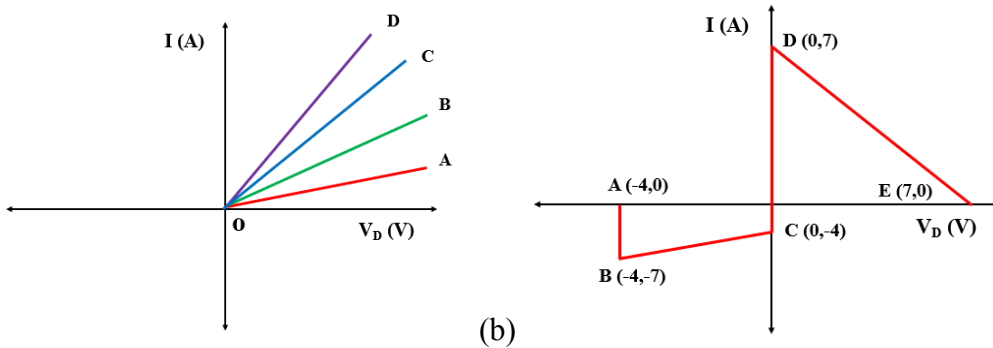
## Week 2

- Identify which of these I-V curves are Linear and which are Nonlinear:



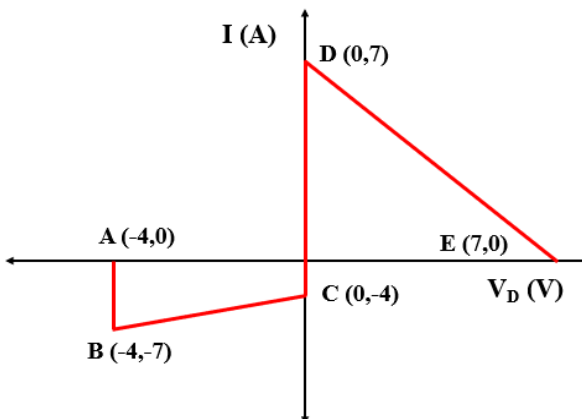
**Ans: Linear: (d)**

- Write down the slopes of these following regions in ascending order (you do not need to calculate the slopes)



Ans: (a)  $|OA| < |OB| < |OC| < |OD|$ , (b) Slopes of AB and CD are equal (infinity). The DE slope is negative. However, the value of slope is higher than BC here.  $|BC| < |DE| < |AB|$

- Find out the slope of the following curves



Answer: **Slope,  $|m| = \left| \frac{y_2 - y_1}{x_2 - x_1} \right|$**

$$|BC| = \left| \frac{y_2 - y_1}{x_2 - x_1} \right| = \left| \frac{-7 + 4}{-4 + 0} \right| = \frac{3}{4}$$

$$|DE| = \left| \frac{y_2 - y_1}{x_2 - x_1} \right| = \left| \frac{0 - 7}{7 - 0} \right| = 1$$

$$|AB| = \left| \frac{y_2 - y_1}{x_2 - x_1} \right| = \left| \frac{-7 - 0}{-4 + 4} \right| = \infty$$

- Calculate and Show 'C' and 'Io' in the figures

**[Hint: use  $-\frac{V_o}{R} = I_o = c$ ]**

- Draw the alternative circuit diagram, I-V curve and calculate the parameters with the following information:
  - $V_o = 5V$ ,  $m = 2/k\Omega$
  - $V_o = 3.5V$ ,  $m = -2.5/k\Omega$
  - $V_o = -5V$ ,  $m = 5/k\Omega$

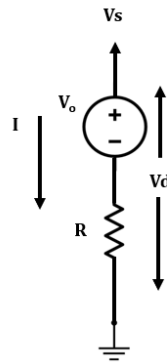
**Solution:**

i.  $|R| = \left| \frac{1}{m} \right|$  i.e.  $\frac{1}{2} k\Omega$ ,  $c = -\frac{V_o}{R} = -\frac{5}{0.5} mA = -2.5 mA$

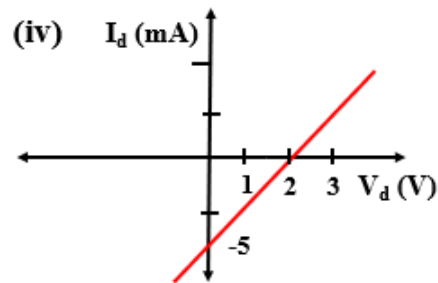
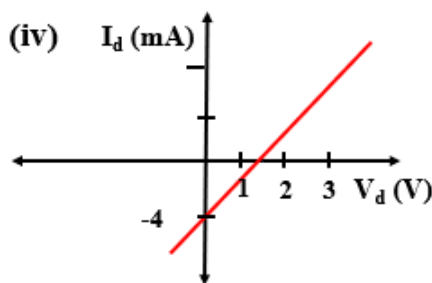
ii.  $|R| = \left| \frac{1}{m} \right|$  i.e.  $\frac{1}{2.5} k\Omega$ ,  $c = -\frac{3.5}{0.4} mA = -8.75 mA$

iii.  $|R| = \left| \frac{1}{m} \right|$  i.e.  $\frac{1}{5} k\Omega$ ,  $c = -\frac{-5}{0.2} mA = 25 mA$

**Alternative Diagram:**

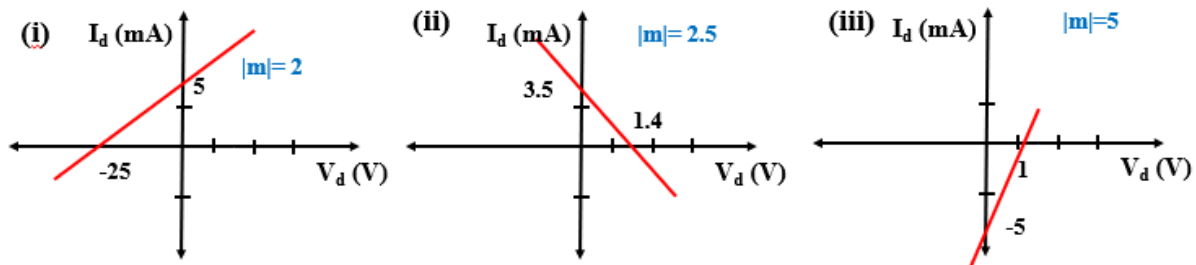


**I-V curve:**



- Calculate and Show 'C' and 'Vo' in the figures

[Hint: Use  $I_o R = -V_o$ ]



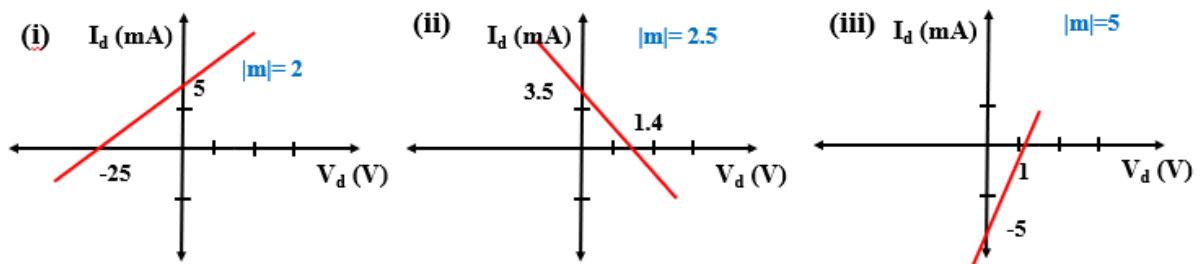
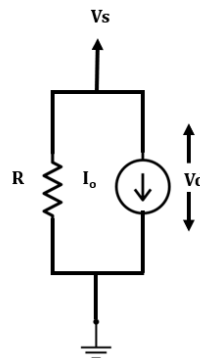
- Draw the alternative circuit diagram with the equivalent linear model, I-V curve and calculate the parameters with the following information:

- $I_o = 5$  mA,  $m = 2/k\Omega$
- $I_o = 3.5$  mA,  $m = -2.5/k\Omega$
- $I_o = -5$  mA,  $m = 5/k\Omega$

**Solution:**

- $|R| = |\frac{1}{m}|$  i.e.  $\frac{1}{2} k\Omega$ ,  $c = I_o = 5$  mA,  $V_o = -I_o R = -2.5$  V
- $|R| = |\frac{1}{m}|$  i.e.  $\frac{1}{2.5} k\Omega$ ,  $c = I_o = 3.5$  mA,  $V_o = -(-I_o R) = 1.4$  V ; as  $m$  is negative
- $|R| = |\frac{1}{m}|$  i.e.  $\frac{1}{5} k\Omega$ ,  $c = I_o = -5$  mA,  $V_o = -I_o R = 1$  V

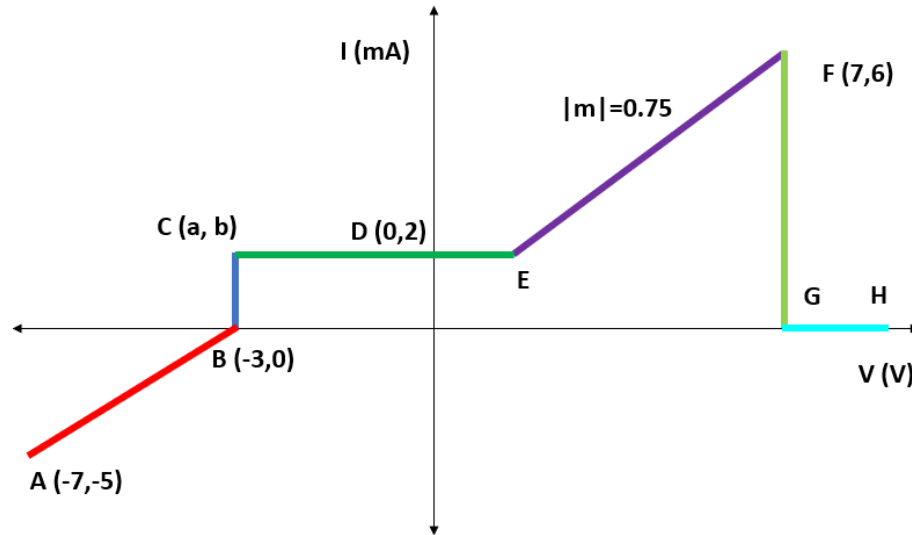
**Alternative diagram:**



**I-V:**

- From the I-V curve-
  - state the device model for each region,
  - find the parameters and write down necessary equations

iii. draw the equivalent linear model for each region. Clearly label anode and cathode. If there is more than one model, use either one.



### Solution:

i.

AB: Voltage source in series with a resistor/ Current source in parallel with a resistor

BC: Voltage source

CD: Current source

EF: Voltage source in series with a resistor/ Current source in parallel with a resistor

FG: Voltage source

ii.

**AB: Parameters: R, Vo, Io**

Voltage source in series with a resistor: R, Vo

$$|m| = \left| \frac{y_2 - y_1}{x_2 - x_1} \right| = \left| \frac{-5 - 0}{-7 - (-3)} \right| = \frac{5}{4}$$

$$|R| = \left| \frac{1}{m} \right| \text{ i.e. } \frac{4}{5} \text{ k}\Omega$$

Vo = -3 V [From x intersection in the figure]

**BC: Parameters: Vo**

Vo = -3 V [From x intersection in the figure]

**CE: Parameters: Io**

Io = 2 mA [From y intersection in the figure]

**EF: Parameters: R, Vo, Io**

$$|R| = \left| \frac{1}{m} \right| \text{ i.e. } \frac{1}{0.75} \text{ k}\Omega$$

Voltage source in series with a resistor:

$$y = mx + c;$$

$$I = \frac{1}{R} \cdot V_S - \frac{V_o}{R}$$

$$\Rightarrow I = 0.75 V_S - 1.75 V_o$$

This equation is satisfied by F(7,6)

$$6 = 0.75 \cdot 7 - 1.75 V_o$$

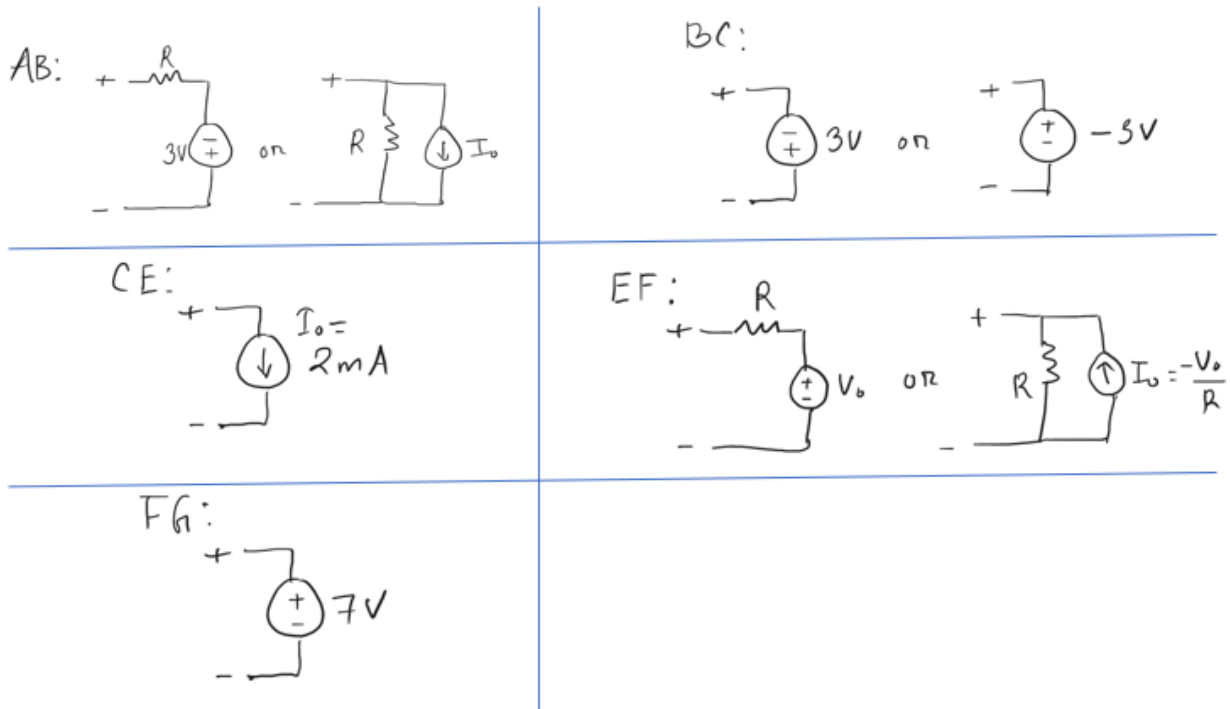
$$\Rightarrow V_o = 2.5$$

**FG: Parameters:  $V_o$**

$$V_o = 7V$$

**GH: No parameters**

iii.



- A Voltage Source,  $V_o = 10V$  in series with a resistor of  $R = 3k\Omega$ .
  - Write down the equation representing this curve
  - Determine the unknown parameters
  - Label the I-V curve

**Solution:**

i.  $y = mx + c$

Or,  $I = m \cdot V_s - \frac{V_o}{R}$

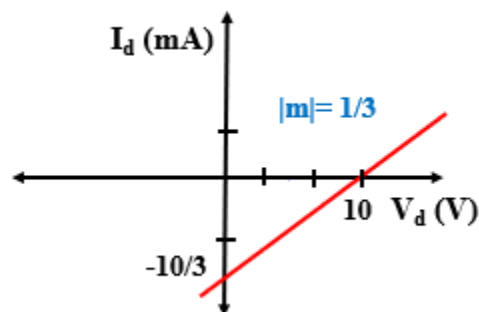
ii.  $V_o = 10V$ ,  $R = 3k\Omega$

$$|m| = \left| \frac{1}{R} \right| = \frac{1}{3}$$

Y axis intersection:  $c = -\frac{V_o}{R} = -\frac{10V}{3k\Omega} = -\frac{10}{3}mA$

X axis intersection:  $V_o = 10V$

iii.



- A Voltage Source,  $V_o = -10\text{ V}$  in series with a resistor of  $R = 3\text{ k}\Omega$ .
  - Write down the equation representing this curve
  - Determine the unknown parameters
  - Label the I-V curve

**Solution:**

i.  $y = mx + c$

Or,  $I = m \cdot V_s - \frac{V_o}{R}$

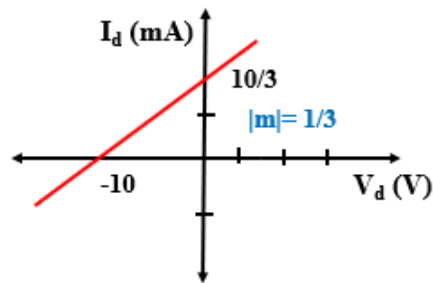
ii.  $V_o = 10\text{ V}$ ,  $R = 3\text{ k}\Omega$

$|m| = \left| \frac{1}{R} \right| = \frac{1}{3}$

Y axis intersection:  $c = -\frac{V_o}{R} = -\frac{-10\text{V}}{3\text{k}\Omega} = \frac{10}{3}\text{ mA}$

X axis intersection:  $V_o = -10\text{ V}$

iii.



- A Current Source,  $I_o = 5\text{ mA}$  in parallel with a resistor of  $R = 5\text{ k}\Omega$ .
  - Write down the equation representing this curve
  - Determine the unknown parameters
  - Label the I-V curve

**Solution:**

i.  $y = mx + c$

Or,  $I_s = \frac{V_s}{R} + I_o$

ii.  $V_o = 10\text{ V}$ ,  $R = 5\text{ k}\Omega$

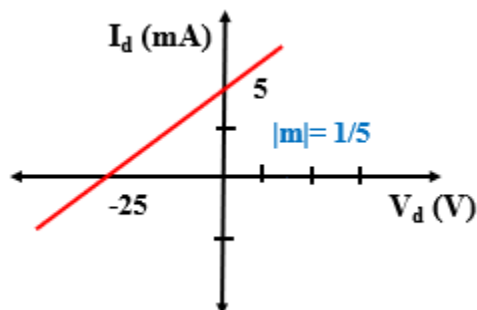
$|m| = \left| \frac{1}{R} \right| = \frac{1}{5}$

Y axis intersection :  $c = I_o = 5\text{ mA}$

X axis intersection:  $I_o R = -V_o$

Or,  $V_o = -5 \times 5\text{ V} = -25\text{ V}$

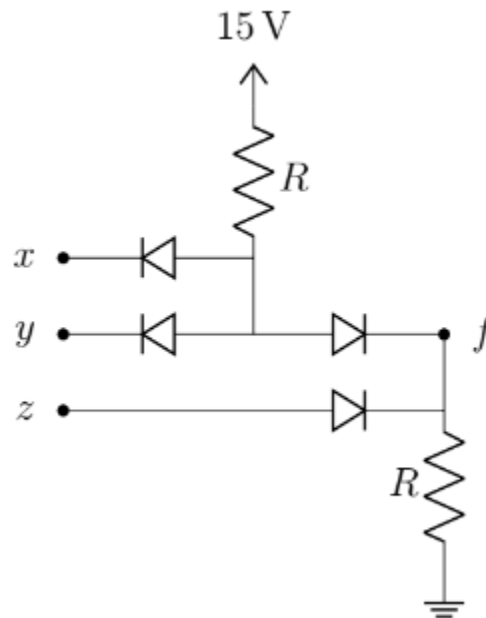
iii.



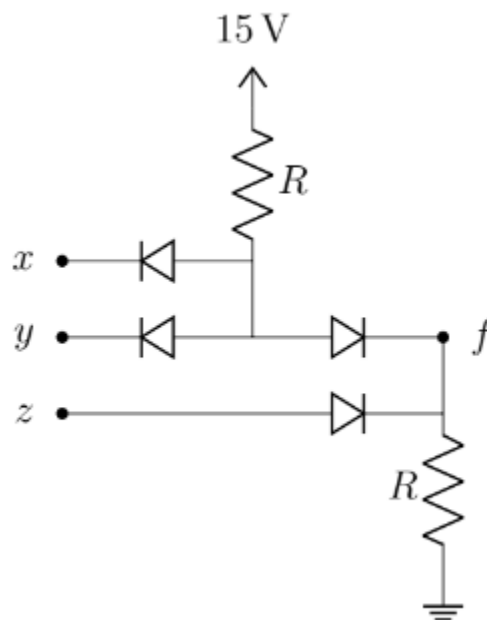
## Week 3

- Assuming  $x$ ,  $y$ ,  $z$  are boolean variables, analyze the circuits below to find an expression of " $f$ " in terms of  $x$ ,  $y$ , and  $z$ .

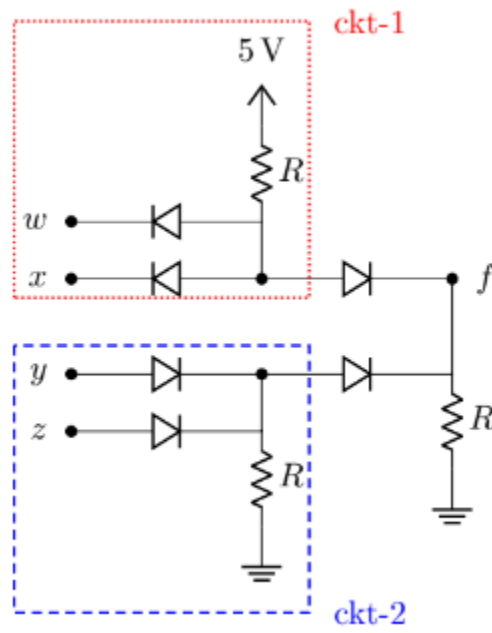
i.



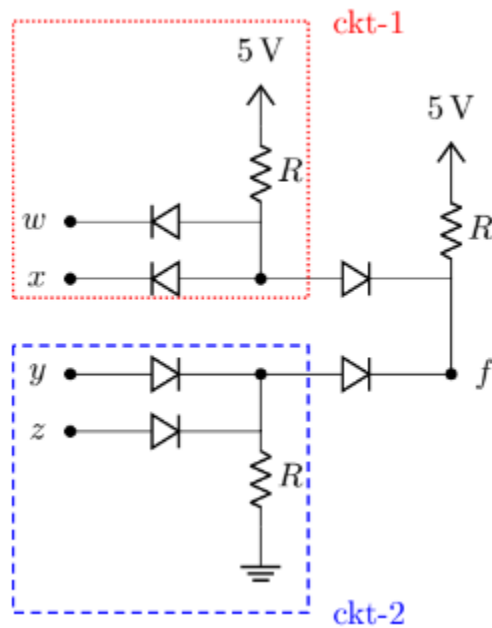
ii.



iii.



iv.



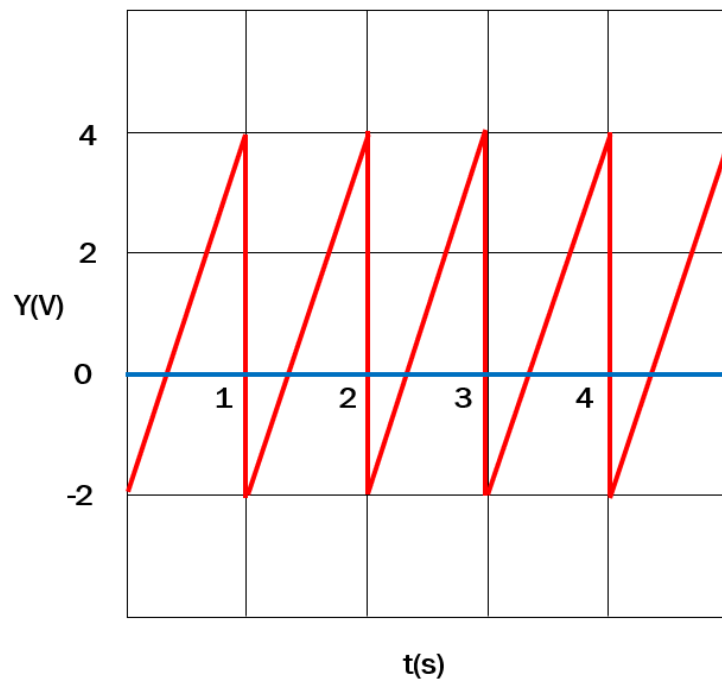
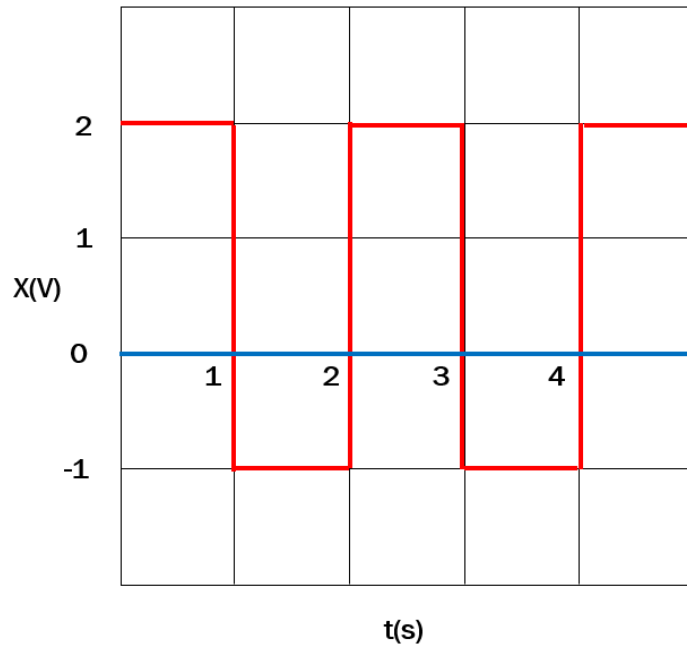
- Implement the following expressions using ideal diodes:
  - $xy + yz$
  - XOR
  - XNOR
  - $(A+B)XY$
- Design a 4 input AND gate using ideal diodes
- Design a 3 input OR gate using ideal diodes
- There will be 5 questions from 5 different topics in your exam and you will have to answer 4 out of these. You will need to fulfill the following conditions-
  - You **must** answer 3 questions from topic “A”, “B” and “C”



ii. You can answer one question from **either** “D” or “E”

Deduce the logic function using boolean variables A,B,C,D and E to implement your algorithm for choosing the questions.

- W, X,Y and Z are boolean variables where  $W= 2V$ ,  $Z= 5V$ . X and Y are expressed with the following graphs-

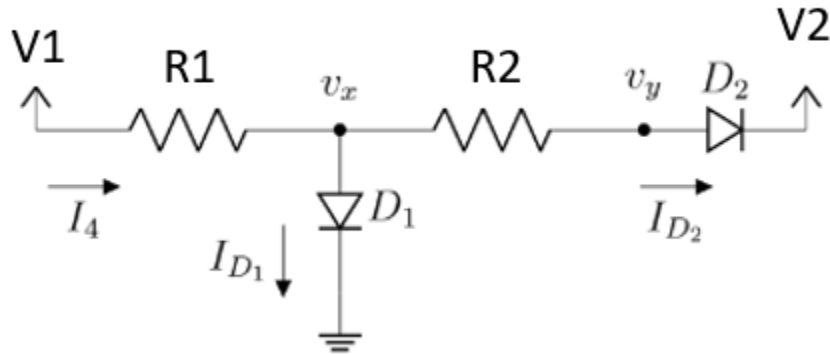


Draw the output graphs for the following functions assuming all the diodes are ideal:

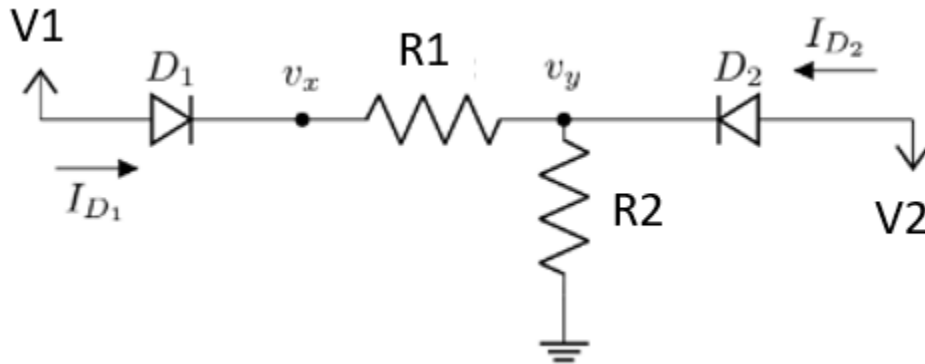
- $xy + yz$
- $wz(x+y)$
- $(w+z+x)y$

## Week 4

For the following circuits (a) Analyze the following circuit to find the values of  $I_{D1}$ ,  $I_{D2}$ ,  $V_x$  and  $V_y$ . Here, use the Method of Assumed State using the CVD model of diode with  $V_{D0} = 0.3 \text{ V}$ . (b) Validate your assumptions about the states of the diodes.



- i.  $V1 = 10 \text{ V}$ ,  $V2 = -10 \text{ V}$ ,  $R1 = 10 \text{ K}$ ,  $R2 = 20 \text{ K}$
- ii.  $V1 = -5 \text{ V}$ ,  $V2 = 20 \text{ V}$ ,  $R1 = 10 \text{ K}$ ,  $R2 = 20 \text{ K}$



- i.  $V1 = 5 \text{ V}$ ,  $V2 = -3.5 \text{ V}$ ,  $R1 = 1 \text{ K}$ ,  $R2 = 10 \text{ K}$
- ii.  $V1 = 5 \text{ V}$ ,  $V2 = -3.5 \text{ V}$ ,  $R1 = 10 \text{ K}$ ,  $R2 = 10 \text{ K}$

- Please find some other examples here: [Week 4 \(Method of Assumed State Examples\).pdf](#)

## Week 5

- The input of a full-wave rectifier is a cosine voltage with peak  $V_M = 5 \text{ V}$  and frequency  $60 \text{ Hz}$ , and output load resistance is  $R = 2 \text{ k}\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.7 \text{ V}$ .

(a) Briefly explain the purpose of a rectifier and describe its operation.

(b) Show the input and output waveforms.

(c) Calculate the DC value of the output voltage.

Now after connecting a capacitor in parallel with the load, the output becomes a ripple voltage  $V_{out} = V_{DC} \pm 0.2 \text{ V}$

V

(d) Calculate the peak-to-peak ripple voltage, and from that, the value of the capacitor.

(e) Calculate the average of the output voltage  $V_{DC}$  after connecting the capacitor. Compare this with the DC value determined in 'c' and comment on the difference between these two.

- The input of a **Half-wave rectifier** is a sine voltage with peak  $V_M = 10$  V and frequency 55 Hz, and output load resistance is  $R = 2.5$  k $\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.4$  V.

(a) Calculate the DC value of the output voltage.

Now after connecting a capacitor in parallel with the load, the output becomes a ripple voltage  $V_{out} = V_{DC} \pm 0$  V.

(d) Calculate the **peak-to-peak ripple voltage**, and from that, the value of the capacitor.

(e) Calculate the average of the output voltage  $V_{DC}$  after connecting the capacitor. Compare this with the DC value determined in 'c' and comment on the difference between these two.

(f) Draw the **Voltage Transfer Characteristic (VTC) curve**

- The input of a **full-wave rectifier** is expressed by,  $V_s(t) = 7\sin(400\pi t)$ , and output load resistance is  $R = 5$  k $\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.3$  V.

(a) Calculate the input and output wave frequency.

(b) Show the input and output waveforms.

(c) Calculate the DC value of the output voltage.

Now after connecting a capacitor,  $C = 100$   $\mu$ F in parallel with the load.

(d) Calculate the peak-to-peak ripple voltage.

(e) Calculate the average of the output voltage  $V_{DC}$  after connecting the capacitor. Compare this with the DC value determined in 'c' and comment on the difference between these two.

(f) How can you provide better filtering for the output waves?

(g) What is the frequency of the Ripple voltage?

- The input of a **Half-wave rectifier** is a **Square** wave voltage with peak  $V_M = 15$  V and frequency 0.5 Hz, and output load resistance is  $R = 5$  k $\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.7$  V.

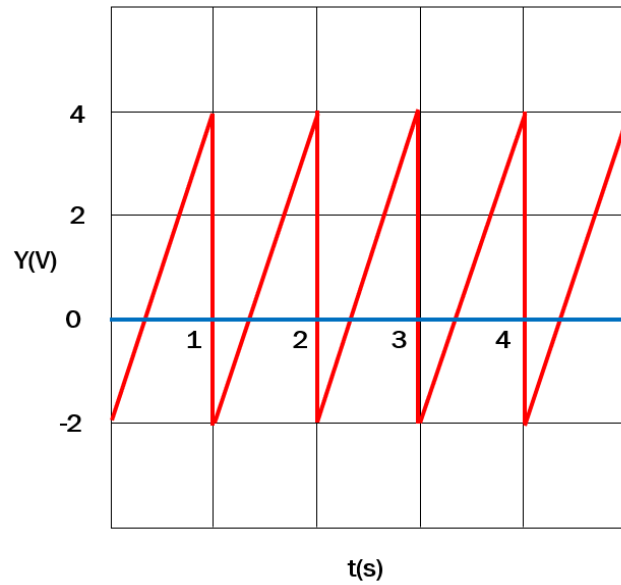
i. Show the input and output waveforms.

ii. Draw the **VTC** curve

- The input of a **full-wave rectifier** is a **Square** wave voltage with peak  $V_M = 15$  V and frequency 0.5 Hz, and output load resistance is  $R = 5$  k $\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.7$  V.

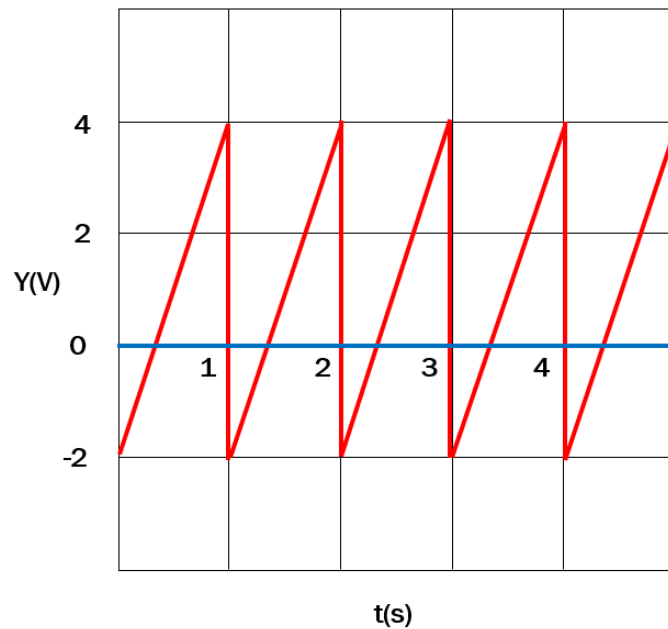
i. Show the input and output waveforms.

ii. Draw the **VTC** curve



The input of a Half-wave rectifier is exhibited in the Figure above and output load resistance is  $R = 5 \text{ k}\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.7 \text{ V}$ .

- Show the input and output waveforms.
- Draw the VTC curve



The input of a full-wave rectifier is exhibited in the Figure above and output load resistance is  $R = 5 \text{ k}\Omega$ . Silicon diodes are used in this circuit for which the forward drop is  $V_{D0} = 0.7 \text{ V}$ .

- Show the input and output waveforms.
- Draw the VTC curve