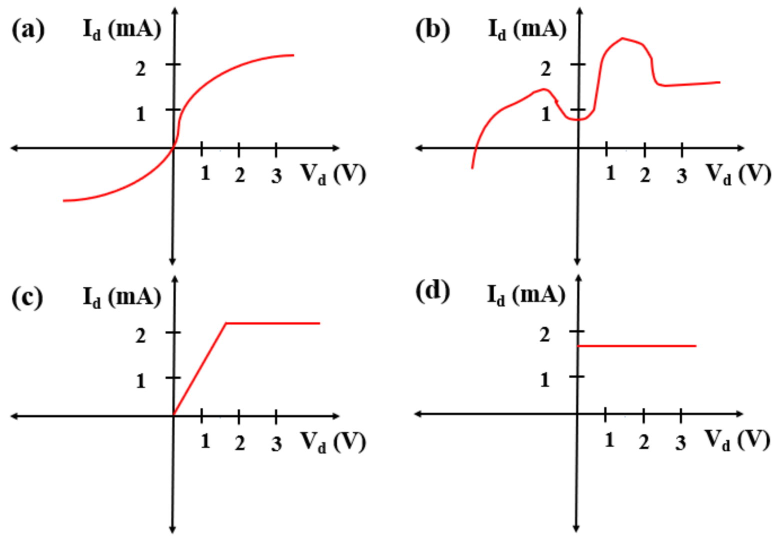
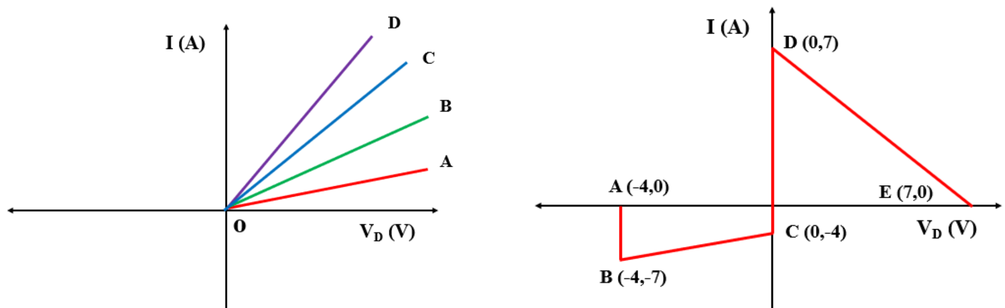
Week 2

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



Ans: Linear: (d)

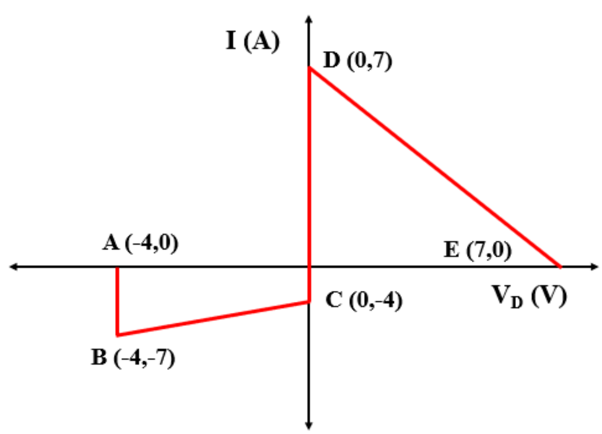
- Write down the slopes of these following regions in ascending order (you do not need to calculate the slopes)



(a) (b)

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|=** $\left|\frac{y_2-y_1}{x_2-x_1}\right|$

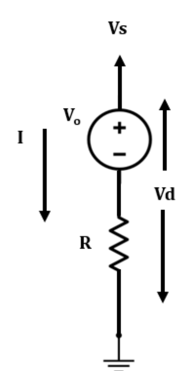
|BC|= $\left|\frac{y_2-y_1}{x_2-x_1}\right| = \left|\frac{-7+4}{-4+0}\right| = \frac{3}{4}$

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

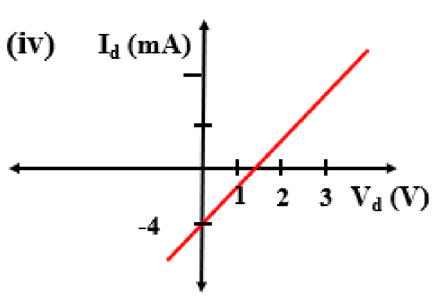
|AB|= $\left|\frac{y_2-y_1}{x_2-x_1}\right| = \left|\frac{-7-0}{-4+4}\right| = \infty$

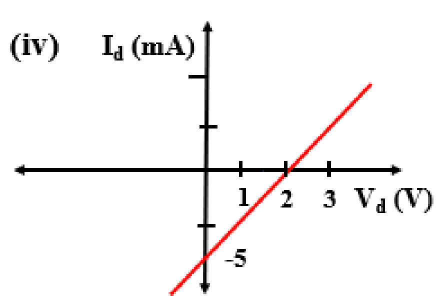
- Calculate and Show ‘C’ and ‘Io’ in the figures
  [Hint: use $-\frac{Vo}{R} = Io$**=c]**
- Draw the alternative circuit diagram, I-V curve and calculate the parameters with the following information:
  i. Vo= 5V, m= 2 $/k\Omega$
  ii. Vo= 3.5 V, m= -2.5$/k\Omega$
  iii. Vo= -5V, m= 5$/k\Omega$
  Solution:
  i. $|R|= |\frac{1}{m}|$ i.e. $\frac{1}{2}\, k\Omega,\ c = -\frac{Vo}{R} = -\frac{5}{0.5}mA = -\ 2.5\ mA$
  ii. $|R|= |\frac{1}{m}|$ i.e. $\frac{1}{2.5}\, k\Omega,\ c = -\frac{3.5}{0.4}mA = -\ 8.75\ mA$
  iii. $|R|= |\frac{1}{m}|$ i.e. $\frac{1}{5}\, k\Omega,\ c = -\frac{-5}{0.2}mA = \ 25\ mA$

Alternative Diagram:

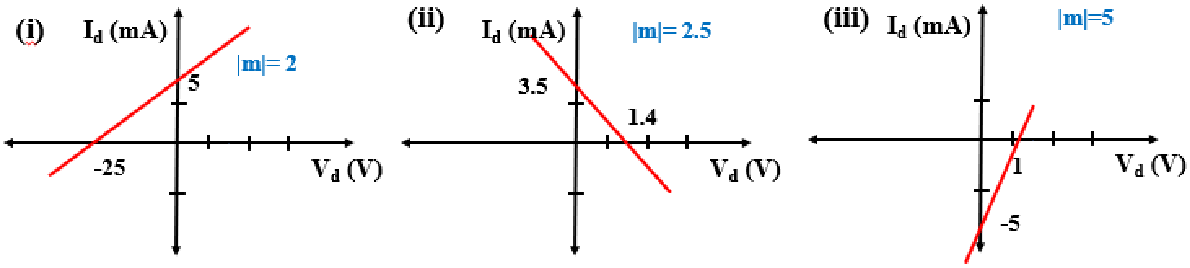


I-V curve:





- Calculate and Show ‘C’ and ‘Vo’ in the figures
  [Hint: Use $IoR = -Vo$]



- Draw the alternative circuit diagram with the equivalent linear model, I-V curve and calculate the parameters with the following information:
  i. Io= 5 mA, m= $2/k\Omega$
  ii. Io= 3.5 mA, m= -2.5 $/k\Omega$
  iii. Io= -5 mA, m= 5 $/k\Omega$

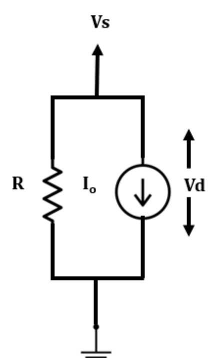
Solution:

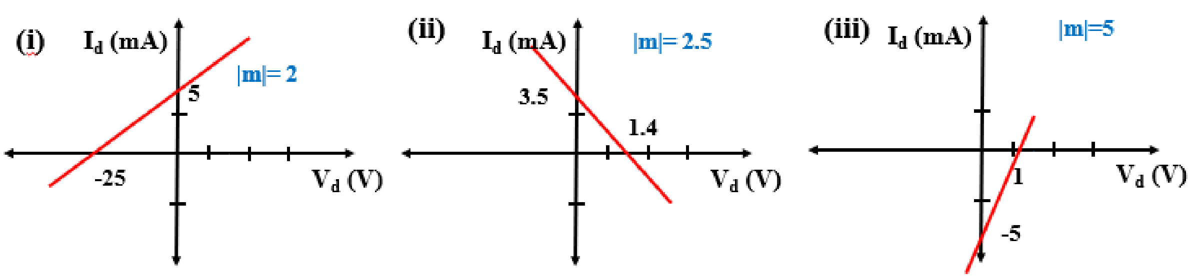
i. $|R|= |\frac{1}{m}|$ i.e. $\frac{1}{2}\,k\Omega,\ c = Io = 5\,mA, Vo = -\ IoR = -\ 2.5\,V$

ii. $|R|= |\frac{1}{m}|$ i.e. $\frac{1}{2.5}\,k\Omega,\ \ c = Io = 3.5\,mA,\ \ Vo = -\ (-\ IoR) = 1.4\,V$; as m is negative

iii. $|R|= |\frac{1}{m}|$ i.e. $\frac{1}{5}\,k\Omega, c = Io = -\ 5\,mA, Vo = -\ IoR = 1\,V$

Alternative diagram:

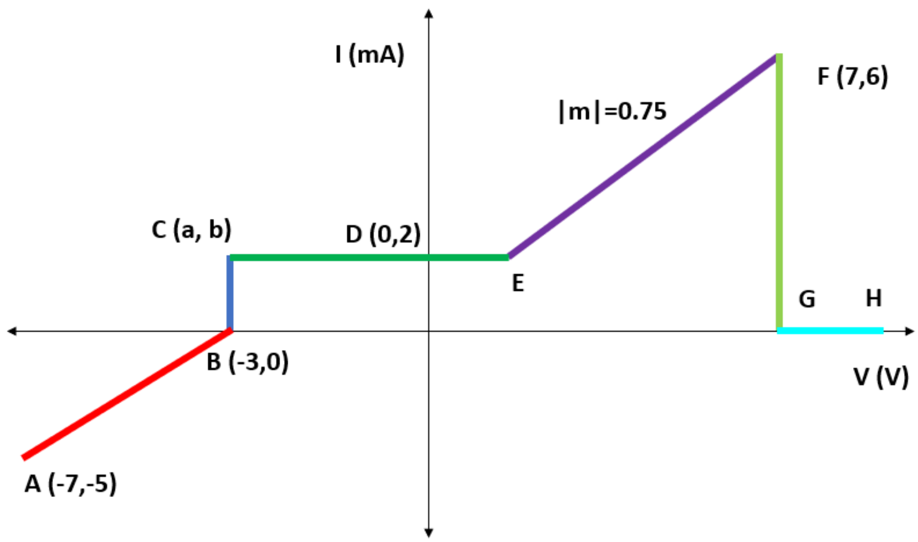




I-V:

- From the I-V curve-
  i. state the device model for each region,
  ii. 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

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

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

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

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

Voltage source in series with a resistor:

y=mx+c;

$I = \frac{1}{R}.\,Vs - \frac{Vo}{R}$

=> $I = 0.75\,Vs - 0.75\,Vo$

This equation is satisfied by F(7,6)

$6 = 0.75 * 7 - 1.75\,Vo$

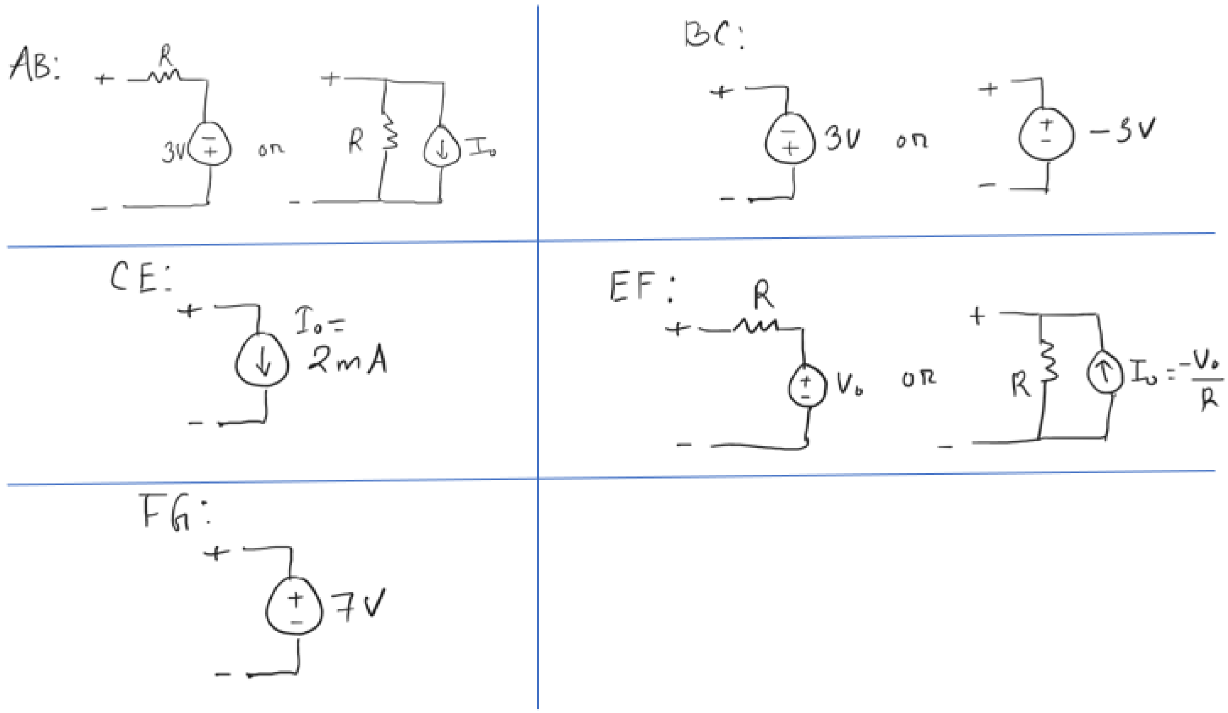
=> $Vo = 2.5$

FG: Parameters: Vo

Vo= 7V

GH: No parameters

iii.



- A Voltage Source, Vo= 10 V in series with a resistor of R= 3 $k\Omega$.

  i. Write down the equation representing this curve

  ii. Determine the unknown parameters

  iii. Label the I-V curve

<u>Solution:</u>

i. y= mx+c

Or, I= m. Vs$-\frac{Vo}{R}$

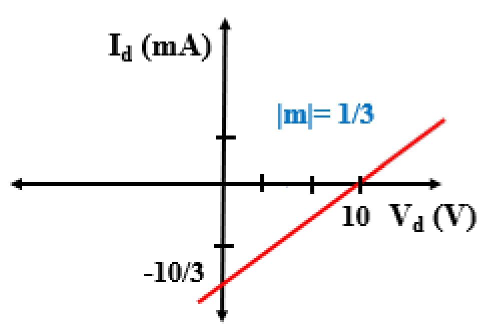
ii. Vo= 10 V, R=3 $k\Omega$

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

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

X axis intersection: Vo= 10 V

iii.



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

Solution:

i. y= mx+c

Or, I= m. Vs$-\frac{Vo}{R}$

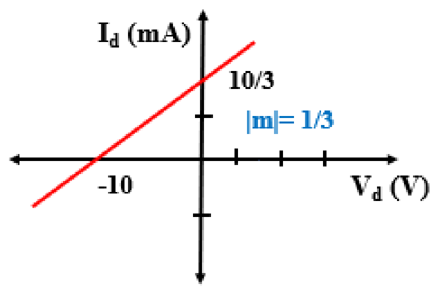
ii. Vo= 10 V, R=3 $k\Omega$

$|\mathbf{m}| = |\frac{1}{R}| = \frac{1}{3}$

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

X axis intersection: Vo= -10 V

Iii.



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

Solution:

i. y= mx+c

Or, $Is = \frac{Vs}{R} + Io$

ii. Vo= 10 V, R=5 $k\Omega$

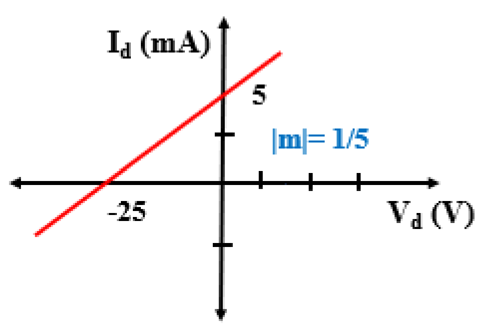
$|\mathbf{m}| = |\frac{1}{R}| = \frac{1}{5}$

Y axis intersection : c= Io= 5 mA

X axis intersection: $IoR = - Vo$

Or, Vo= -5*5 V= -25V

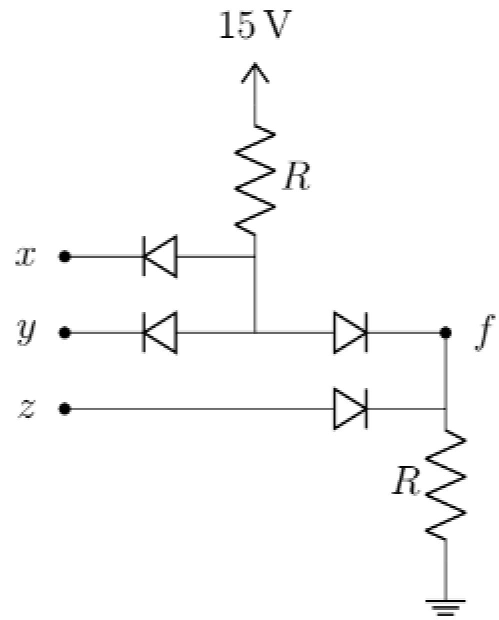
iii.



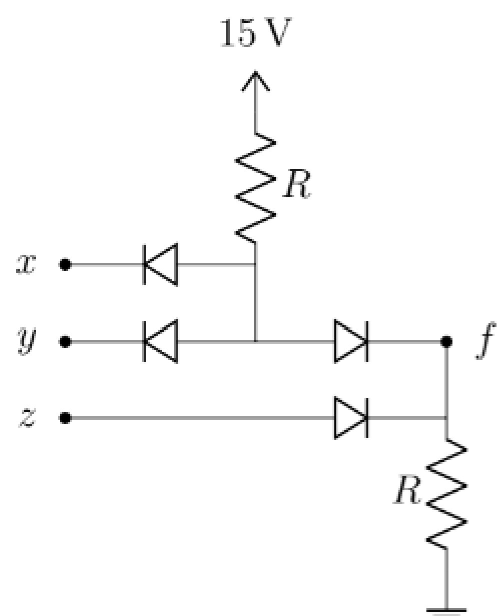
Week 3

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

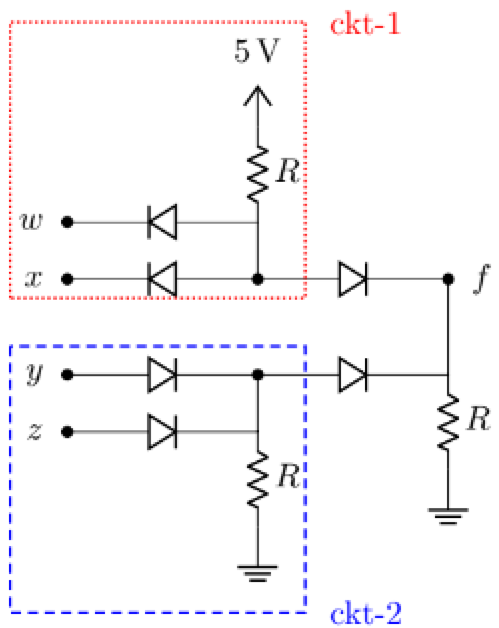
  i.



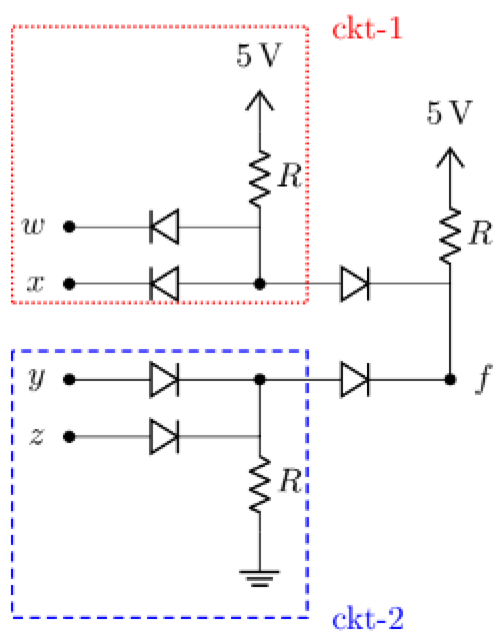
  ii.



iii.



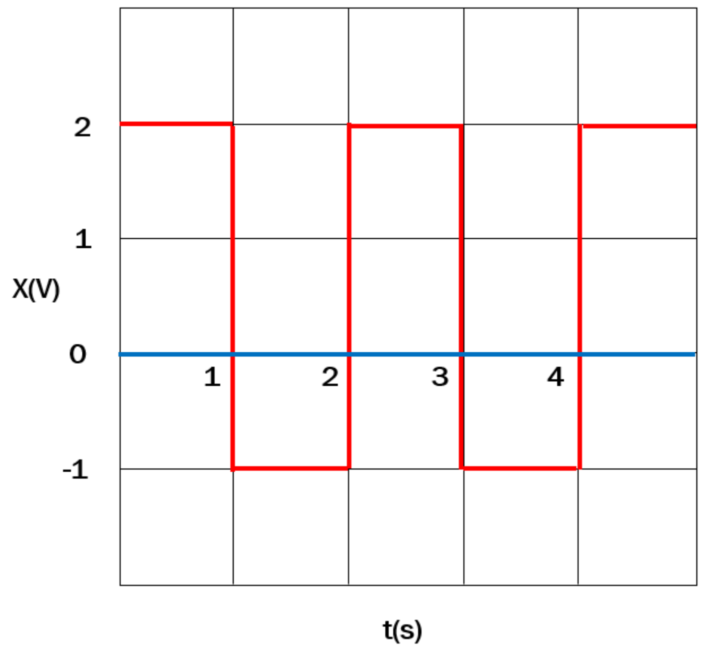
iv.

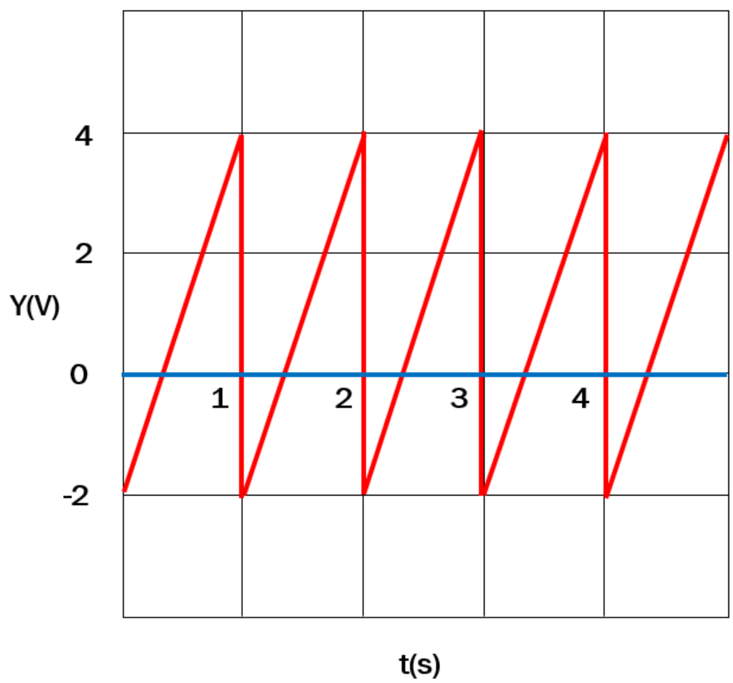


- Implement the following expressions using ideal diodes:
  i. xy+ yz
  ii. XOR
  iii. XNOR
  iv. (A+B)XY
- Design a 4 input AND gate using ideal diodes
- Design a 3 input OR gate using ideal diodes
- There will be 5 questions from 5 different topics in your exam and you will have to answer 4 out of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

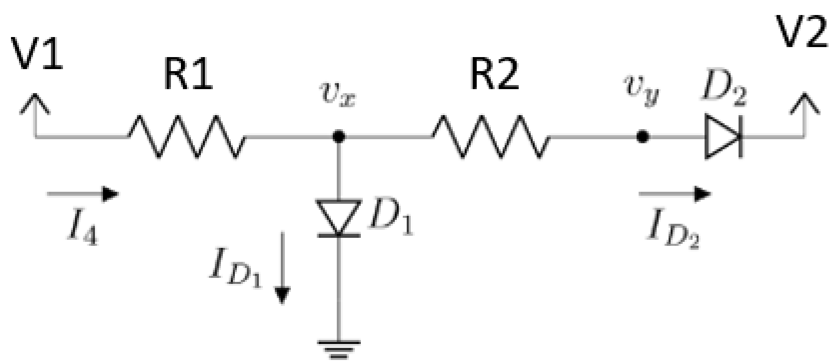




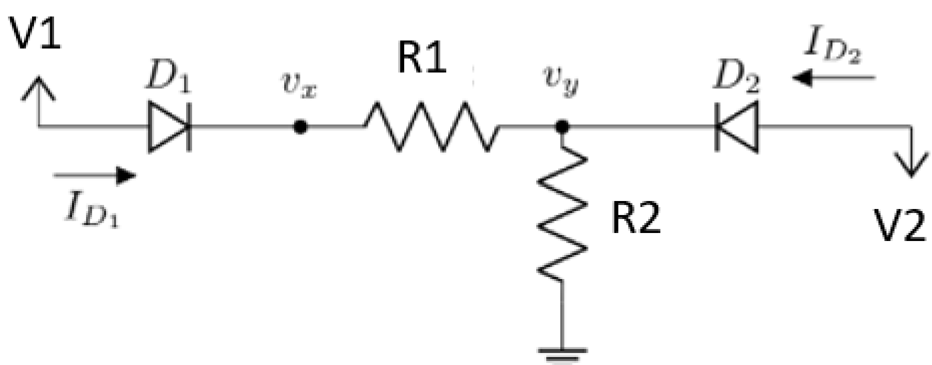
Draw the output graphs for the following functions assuming all the diodes are ideal:
i. xy+ yz
ii. wz(x+y)
iii. (w+z+x)y

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 V. (b) Validate your assumptions about the states of the diodes.

- 

  i. V1= 10 V, V2= -10 V, R1= 10 K, R2= 20K
  ii. V1= -5 V, V2= 20 V, R1= 10 K, R2= 20K

- 

  i. V1= 5 V, V2= -3.5 V, R1= 1 K, R2= 10K
  ii. V1= 5 V, V2= -3.5 V, R1= 10 K, R2= 10K

- 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 V and frequency 60 Hz, and output load resistance is R = 2 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 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 **Vout =** V_{DC} **±0.2 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 rectifie**r is a sine voltage with peak VM = 10 V and frequency 55 Hz, and output load resistance is R = 2.5 kΩ. 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 **Vout =** V_{DC} **±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, Vs(t)= 7sin(400πt), and output load resistance is R = 5 kΩ. 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 µF 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 kΩ. 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 kΩ. 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

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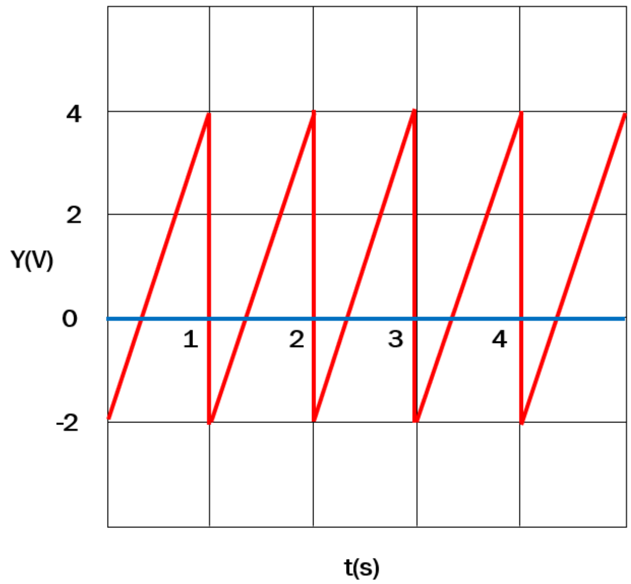
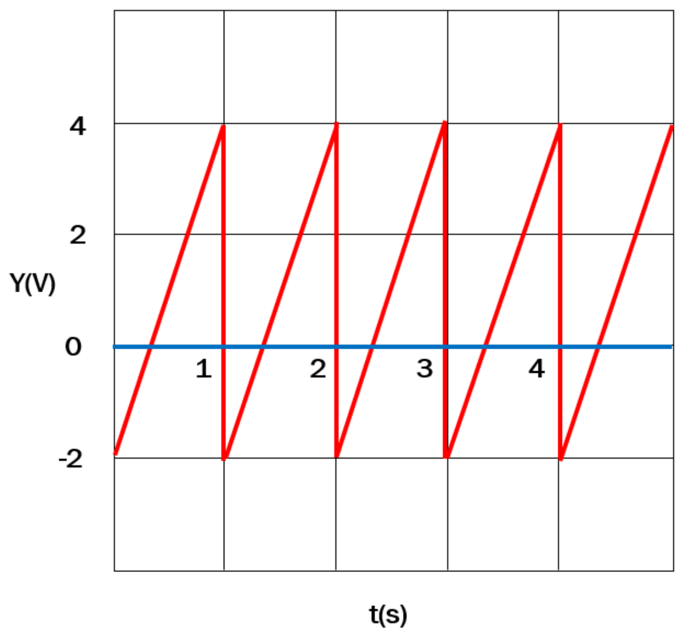


The input of a Half-wave rectifier is exhibited in the Figure above and output load resistance is R = 5 kΩ. Silicon diodes are used in this circuit for which the forward drop is V_{D0} = 0.7 V.

i. Show the input and output waveforms.
ii. Draw the VTC curve



The input of a **full-wave rectifier** is exhibited in the Figure above and output load resistance is R = 5 kΩ. 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