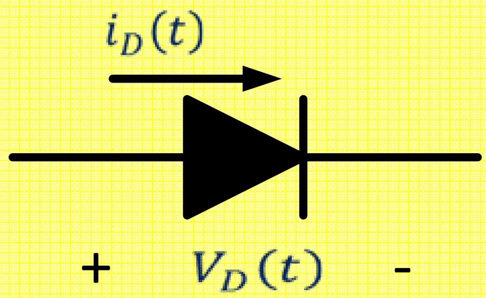
Diode Equation

$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}} - 1)$$



Is: Revers saturation current

Is= 10^{-12}, 10^{-14}A

η : eta

$$\eta = \begin{Bmatrix} 1\ for\ Ge \\ 2\ for\ Si\ (small\ current) \\ 1\ for\ Si\ (large\ current) \end{Bmatrix}$$

V_T= Thermal Voltage

$V_T = \frac{T}{11600}$;T in kelvin

At Room Temp. T=300k

∴ V_T = 25.69 mv at Room Temp.

$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}} - 1)$$

- The equation is a non linear equation

∴ The Diode is non linear Device

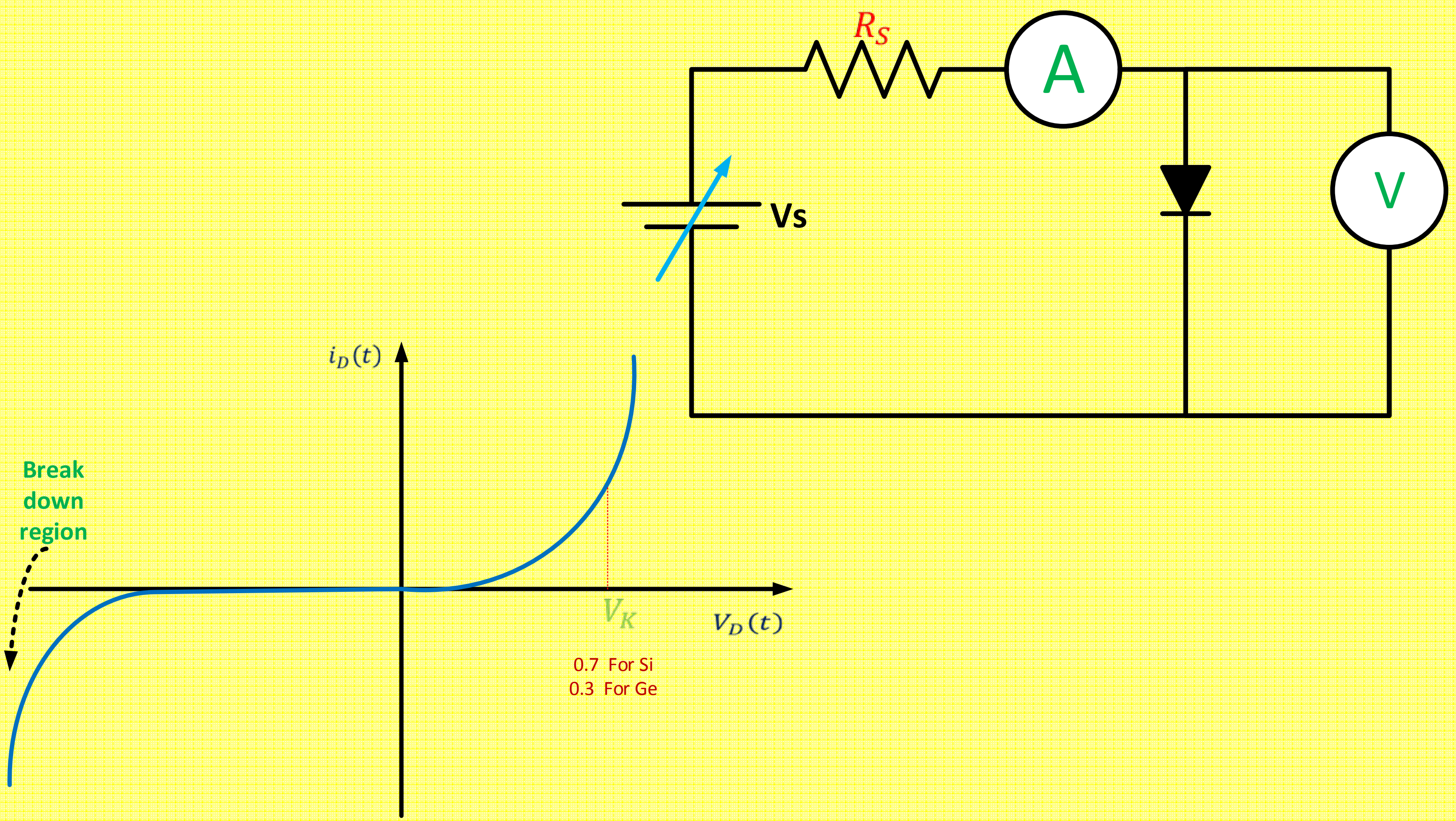
- For positive $V_D(t)$

$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}})$$

- For negative $V_D(t)$

$$i_D(t) = -I_S$$

Diode V-I Characteristic curve



Approaches to Diode Circuit Analysis

The rectifier diode is a non linear device .

There are essentially three basic approaches to the solution of such problem :

1- The use of non linear mathematics

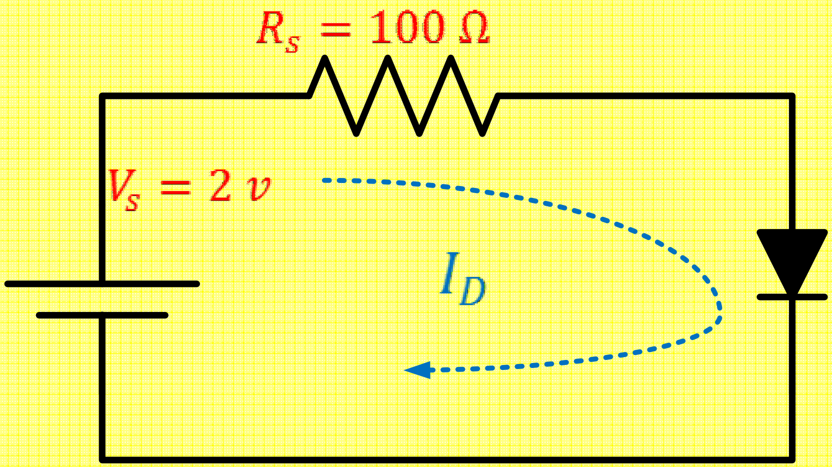
2- The use of graphical techniques

3- The use of equivalent circuit (models)

- Piece wise linear models

1)The use of non linear mathematic

- For the circuit shown, find I_D and V_D



Silicon:
η=1.1
I_S= 10^{-14} A

- KVL : $V_S = R_S I_D + V_D$

$$I_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right)$$

- Since the diode is forward biased , we could approximate

$$I_D = I_S\left(e^{\frac{V_D}{\eta V_T}}\right)$$

- Solving for $V_D = \eta\, V_T \ln \frac{I_D}{I_S}$

$\therefore$ We have two equations and two unknowns

$V_S = R_S I_D + V_D$ ……………1

$V_D = \eta\, V_T \ln \frac{I_D}{I_S}$ ……………2

$$\boxed{\therefore \quad V_S = R_S I_D + \eta\, V_T \ln \frac{I_D}{I_S}}$$

- non linear equation

Iterative Analysis

$$I_D = \frac{V_S - V_D}{R_S}$$

$$V_D = \eta \, V_T \ln \frac{I_D}{I_S}$$

1) Let $V_D = 0.7$v

   $I_D = \frac{2-0.7}{0.1k}$ = 13 mA

$V_D = 0.7882392$v The error is large

2) Let $V_D = 0.7882392$v

   I_D = 12.117608 mA

$V_D = 0.7862529$v The error is small

3) Let $V_D = 0.7862529$v

$I_D = 12.137471$ mA

$V_D = 0.7862991$v The error getting smaller

4) Let $V_D = 0.7862991$v

$I_D = 12.137009$mA

$V_D = 0.786298066$v

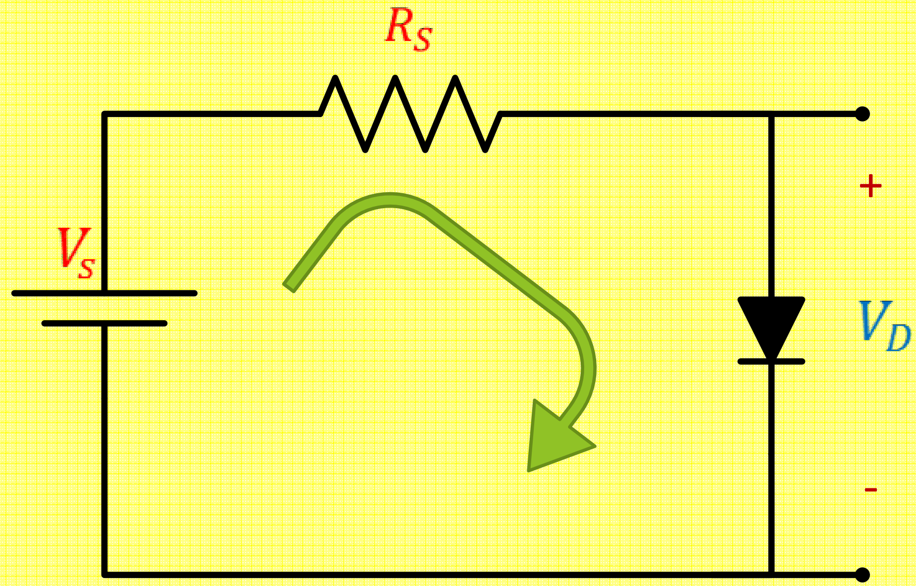
$I_D = 12.137$ mA

$V_D = 0.7863$v

2) The use of graphical techniques

$V_S = R_S I_D + V_D$ ……………….1

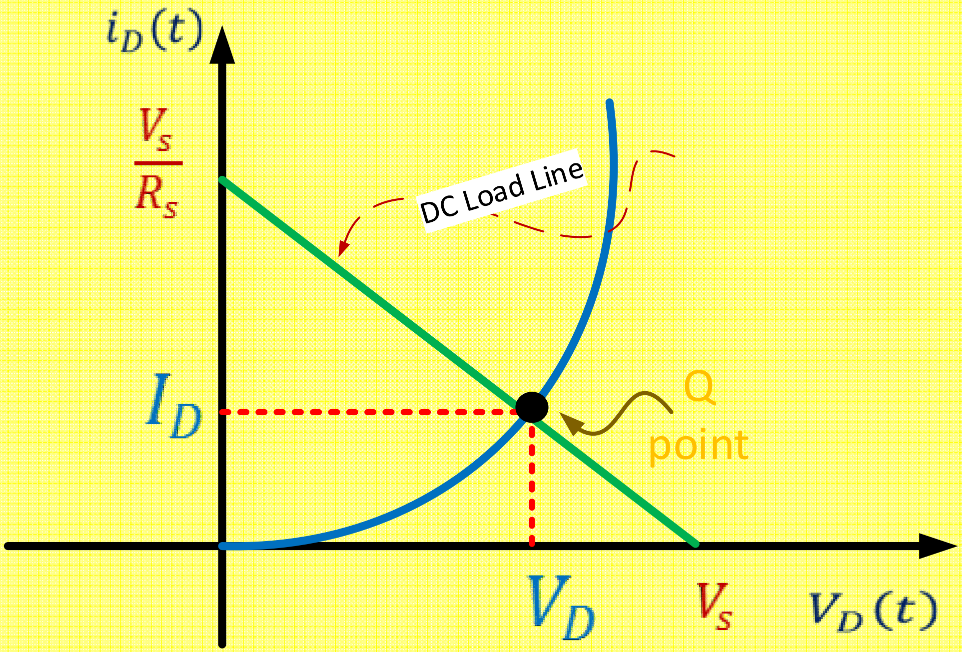
$I_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right)$ ………..2



- Using equation 1

$$I_D = -\frac{1}{R_S}V_D + \frac{V_S}{R_S}$$

Drawing the two equations



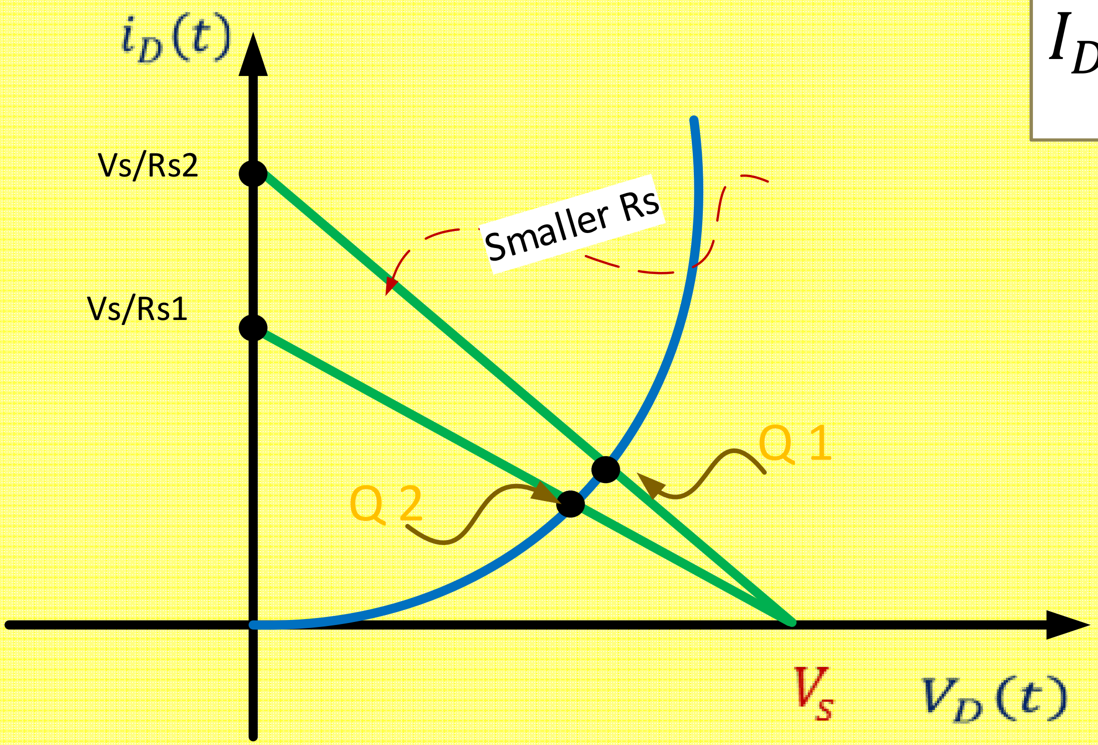
$$I_D = -\frac{1}{R_S} V_D + \frac{V_S}{R_S}$$

$$I_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right)$$

- Q point = $(I_{DQ}\ , V_{DQ}\ ) = \text{Quiescent point}$

The effect of Rs on the Q point

$$I_D = -\frac{1}{R_S} V_D + \frac{V_S}{R_S}$$



The effect of Vs on Q point

$$I_D = -\frac{1}{R_S} V_D + \frac{V_S}{R_S}$$