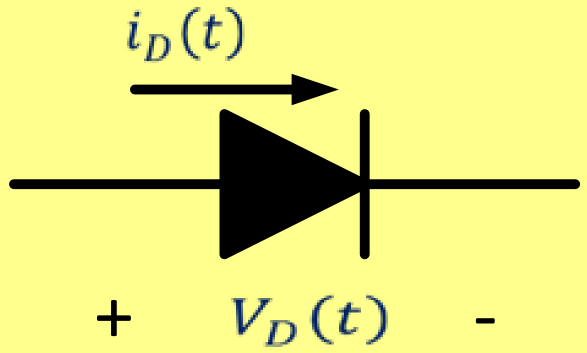
# Diode Equation

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




$Is$: Revers saturation current

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

$\eta$ : eta

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

$V_T$= 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

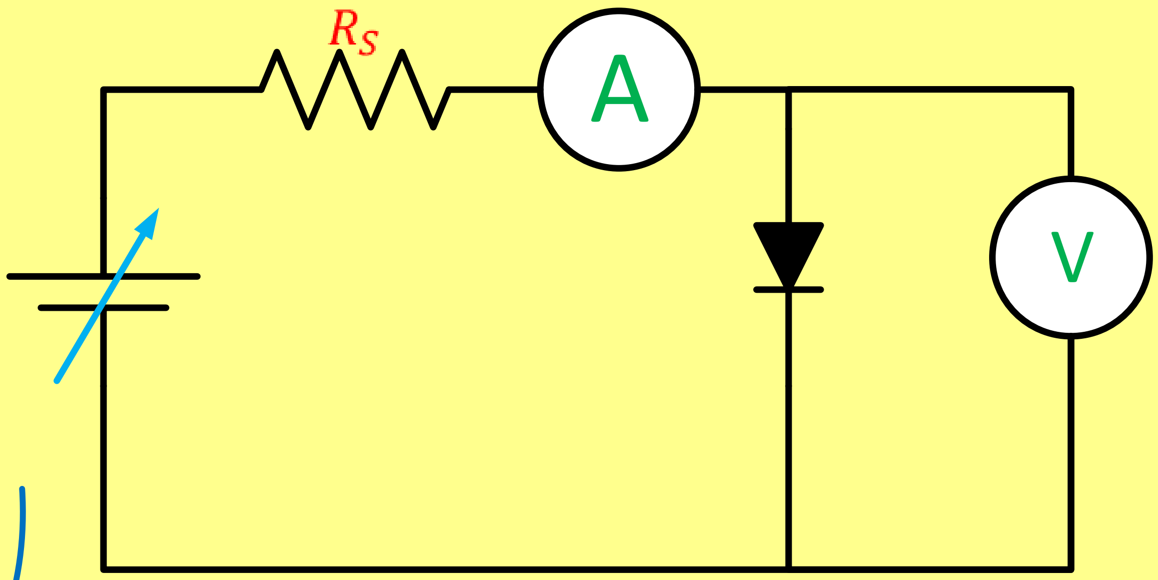
- For positive $V_D(t)$

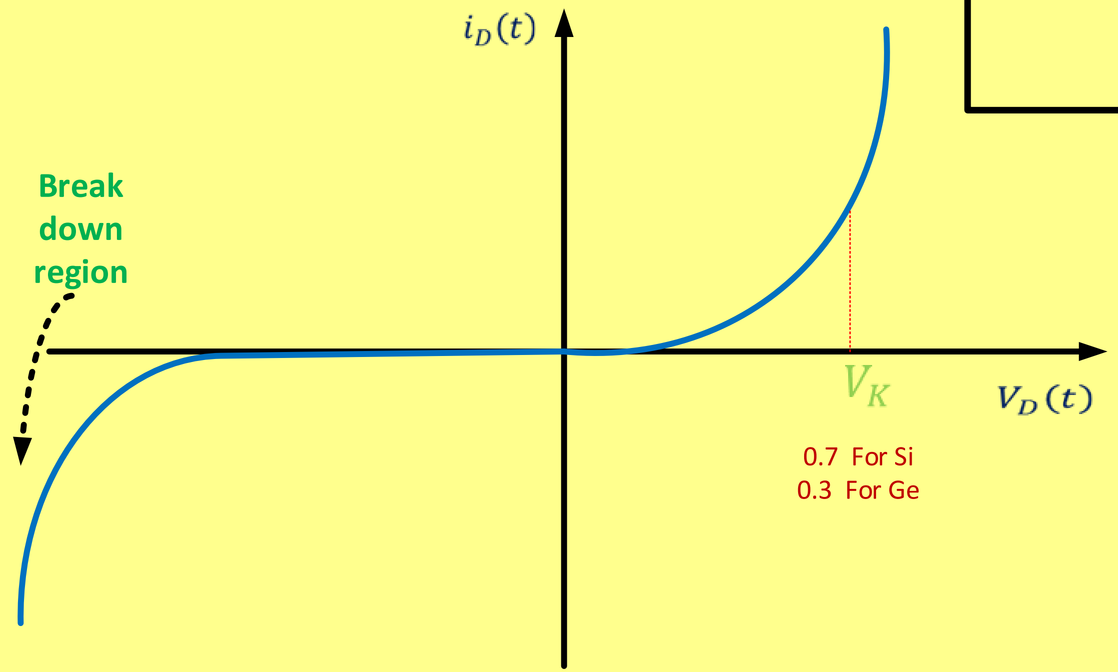
$$i_D(t) = I_S(e^{\frac{V_D(t)}{\eta V_T}})$$

- 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

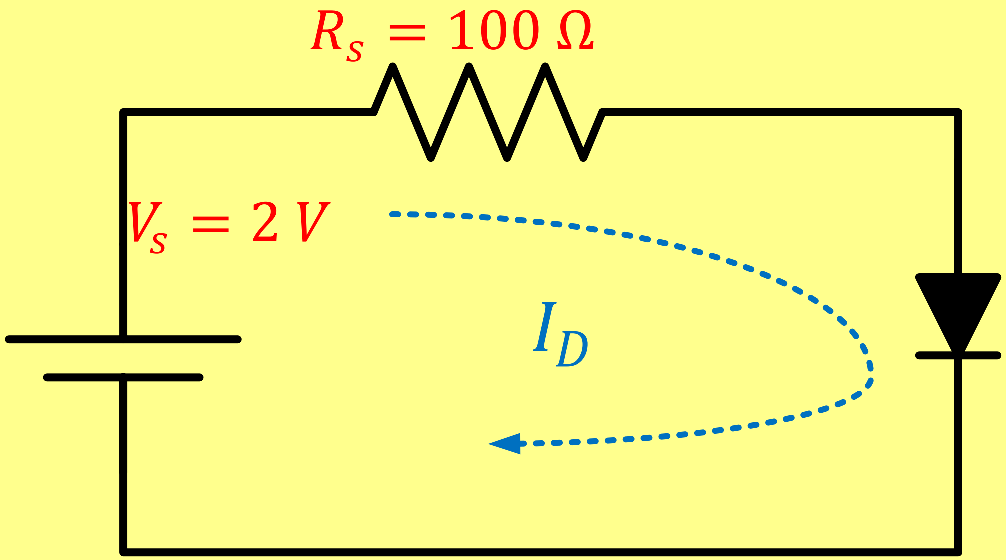
2- The use of graphical techniques

3- The use of equivalent circuit (models)

- Piece wise linear models

# 1)The use of non linear mathematatic

- For the circuit shown, find $\boldsymbol{I_D}$ and $\mathbf{V_D}$




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

# ∴ 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

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

- 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 $V_D = 0.7\text{V}$

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

$V_D = 0.7882392\text{V}$ The error is large

2) Let $V_D = 0.7882392\text{V}$

   $I_D = 12.117608$ mA

$V_D = 0.7862529\text{V}$ 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

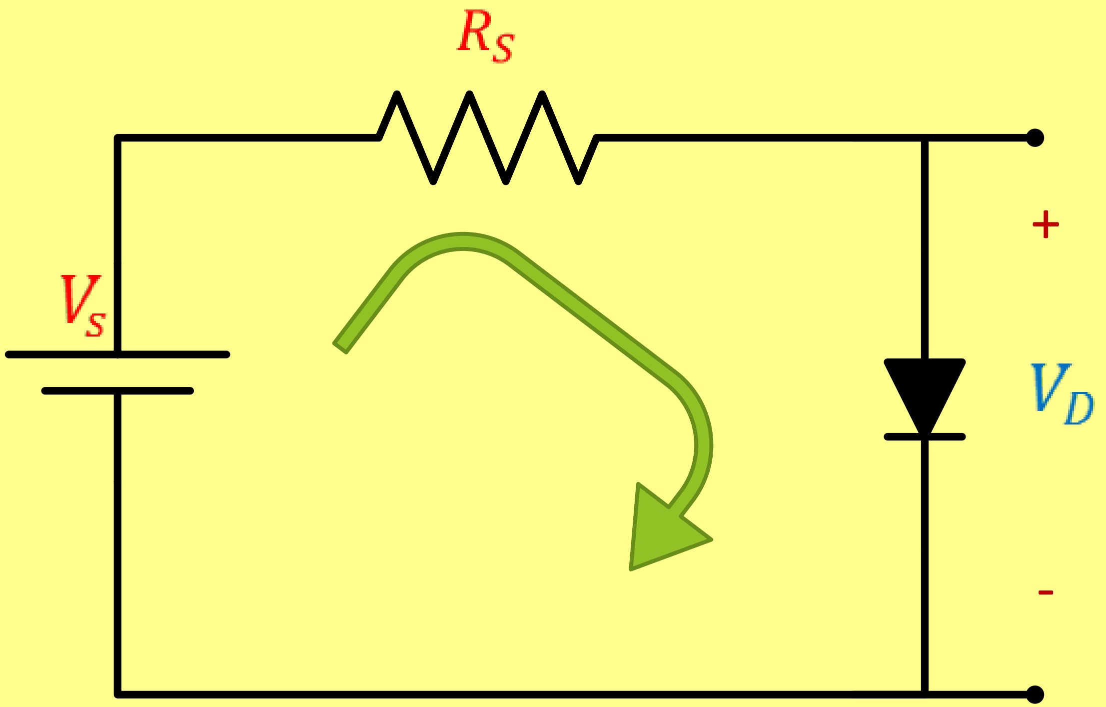
$I_D = 12.137$ mA

$V_D = 0.7863$V

# 2) The use of graphical techniques

$$V_S = R_S I_D + V_D \quad \text{..................1}$$

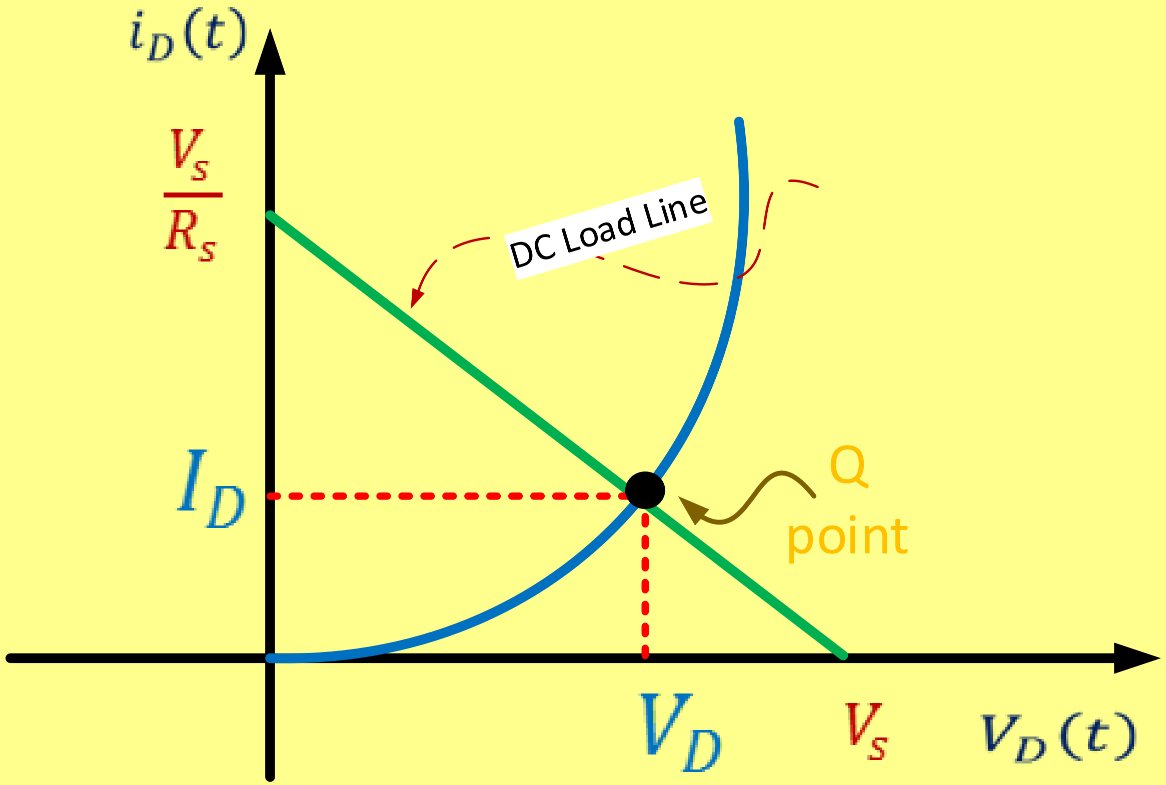
$$I_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right) \quad \text{............2}$$




- Using equation 1

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

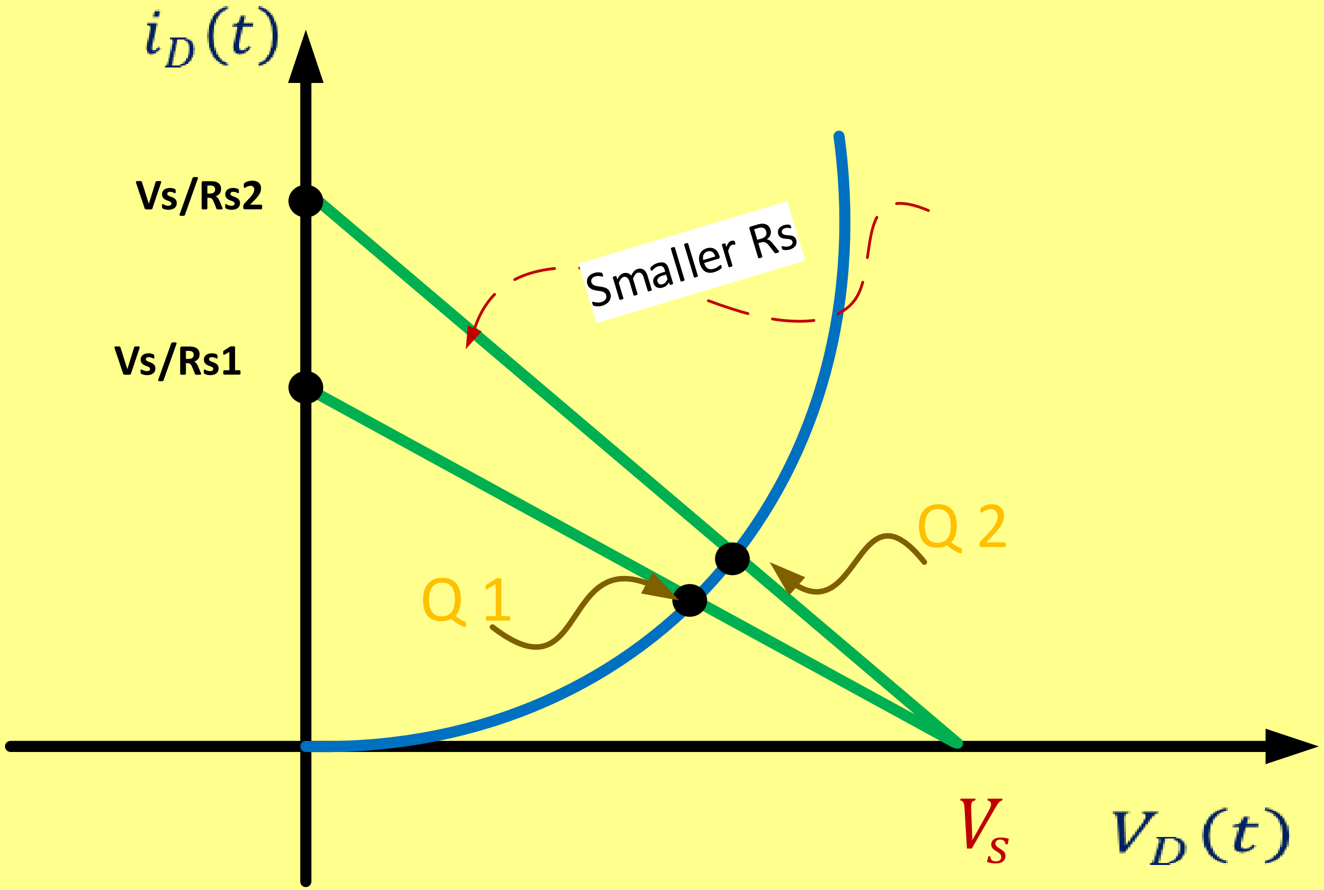
# Drawing the two equations




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

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

# The effect of Rs on the Qpoint



# The effect of Vs on Qpoint