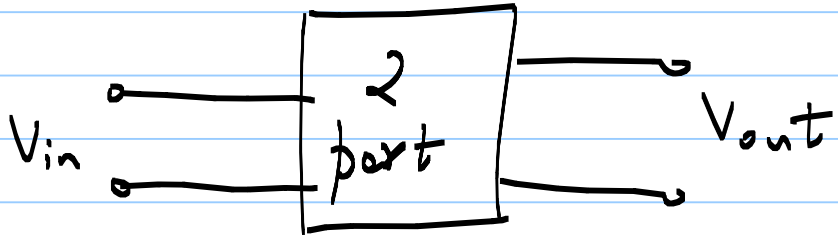
5/8/2020

Lecture 2

Note Title

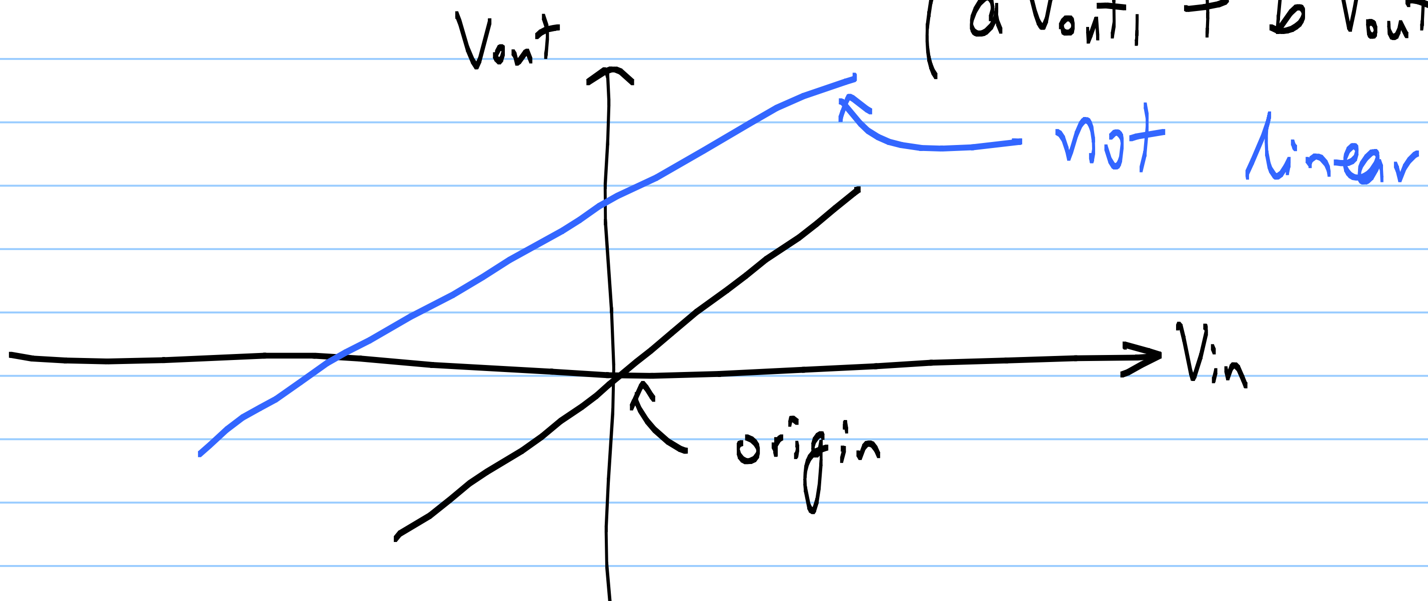
05-08-2020



Is this linear?

Based on <u>Superposition</u>

$$\left.\begin{array}{l} V_{in_1} \rightarrow V_{out_1} \\ V_{in_2} \rightarrow V_{out_2} \end{array}\right\} \quad (aV_{in_1} + bV_{in_2}) \downarrow (aV_{out_1} + bV_{out_2}) \quad \text{for all } a, b, V_{in_1}, V_{in_2}$$

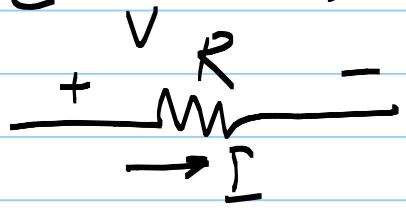


* LTI systems characterized by Impulse Response
* All practical systems are Non-linear

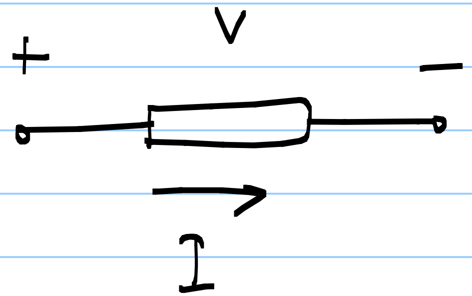
Linear Elements (2-terminal 1 port systems)
"elements"

linear elements: R, L, C → defined by V-I relationship

e.g.



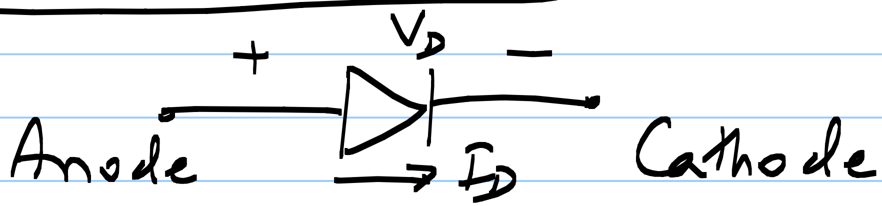
$$I = \frac{V}{R}$$



$$I = f(V)$$

Nonlinear 2-T element

Diode :



From SSD theory:

$$I_D = I_S \left[\exp\left(\frac{V_D}{V_t} \right) - 1 \right]$$

I_S ← saturation current

V_t ← thermal voltage

$$V_t = \frac{kT}{q} \approx 25\,mV \text{ @ } 300K$$

If $V_D > 0 \Rightarrow$ Diode is "forward biased"

$V_D < 0 \Rightarrow$ "reverse biased"

Some approximations :

1) If $V_D \gg$ few V_t.

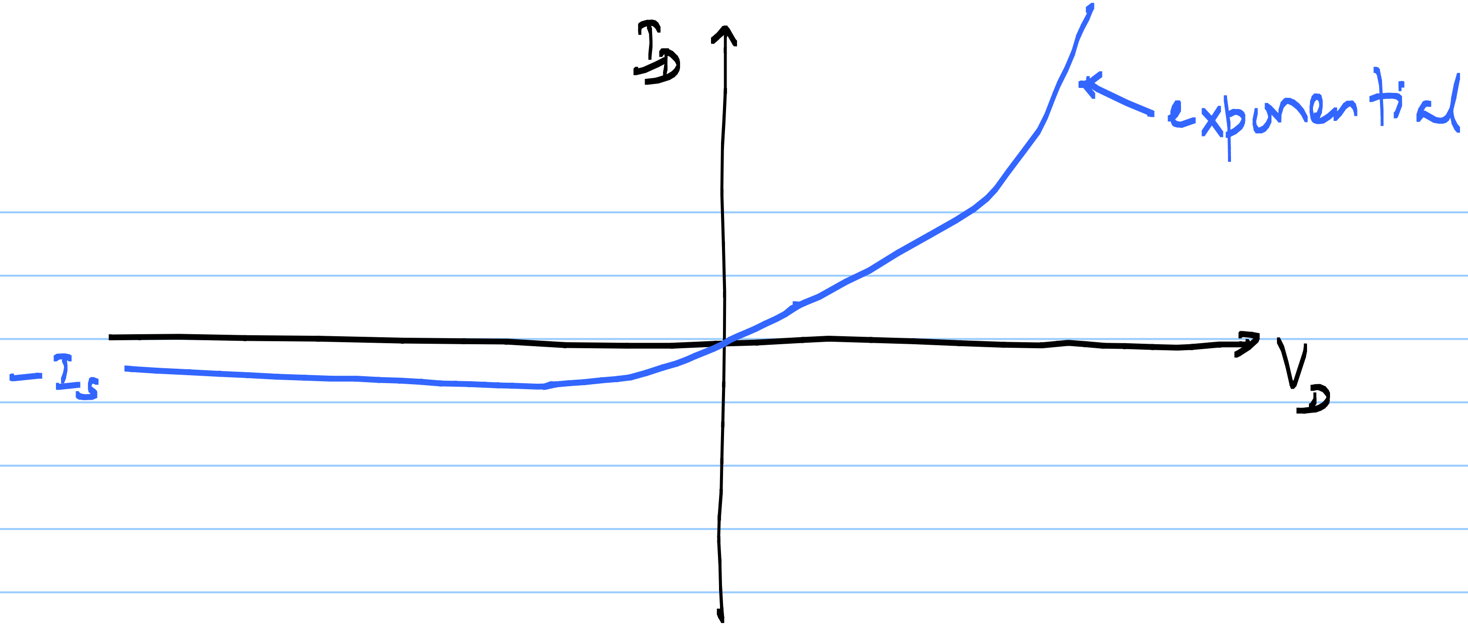
$$\exp\left(\frac{V_D}{V_t}\right) \gg 1$$

$$I_D \approx I_s \exp\left(\frac{V_D}{V_t}\right)$$

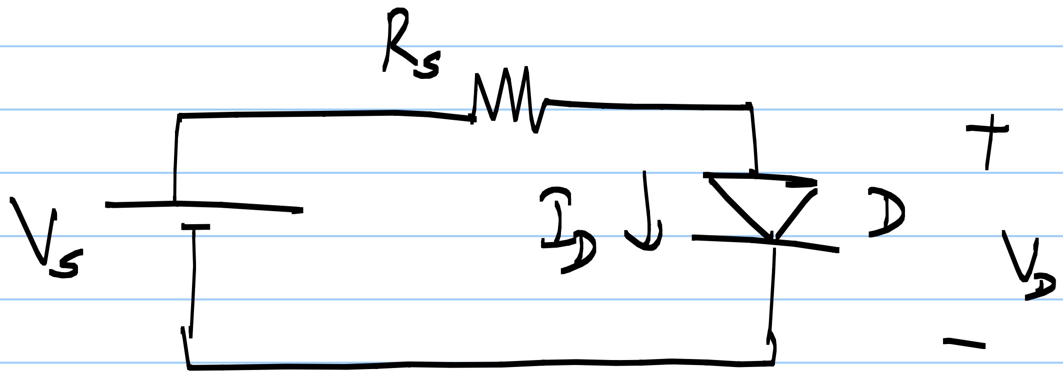
$$V_D = V_t \ln\left(\frac{I_D}{I_s}\right)$$

2) If $\frac{V_D}{V_t} \ll 0$, $\exp\left(\frac{V_D}{V_t}\right) \ll 1$

$$\Rightarrow \quad I_D \approx -I_s$$



Circuit Analysis w/ diodes



KVL :

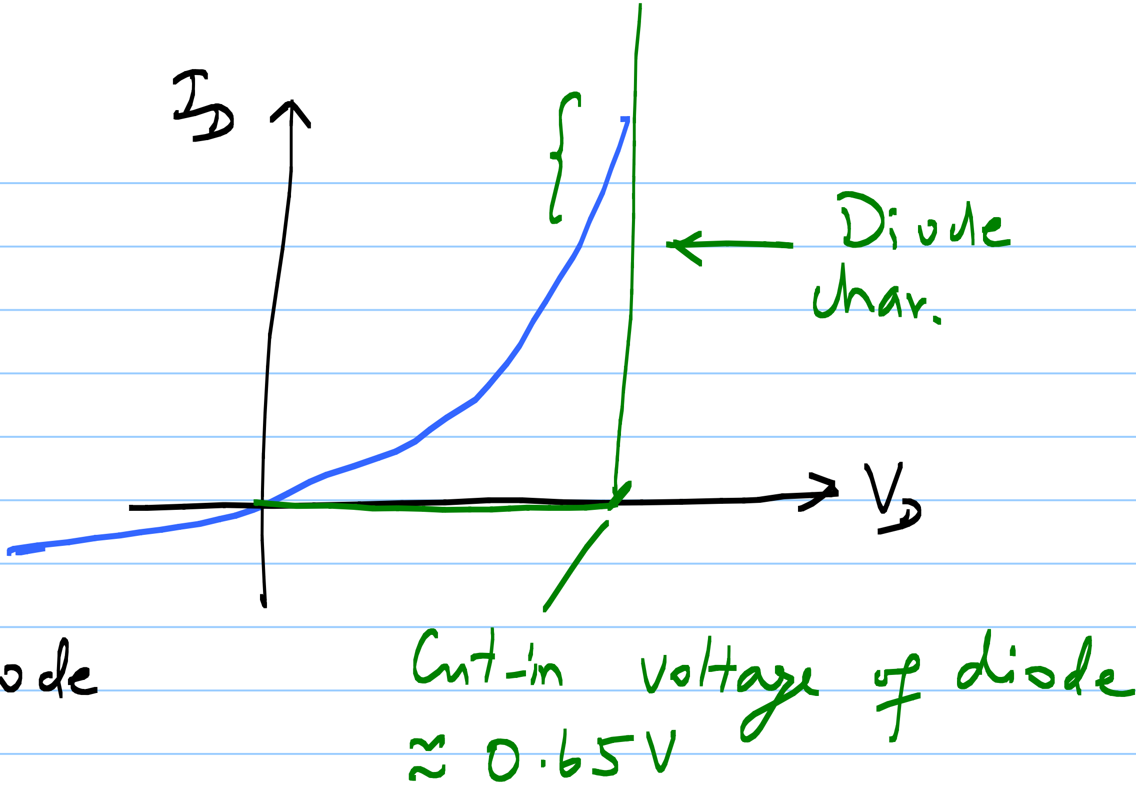
$$V_s = V_{R_s} + V_D$$

$$V_s = I_D R_s + V_D = I_D R_s + V_t \ln\left(1 + \frac{I_D}{I_s}\right)$$

Solution

1) Zeroth order:

Assume that the voltage drop across a forward biased diode $\approx 0.65V$



$$I_D \approx \frac{V_s - 0.65}{R_s}$$

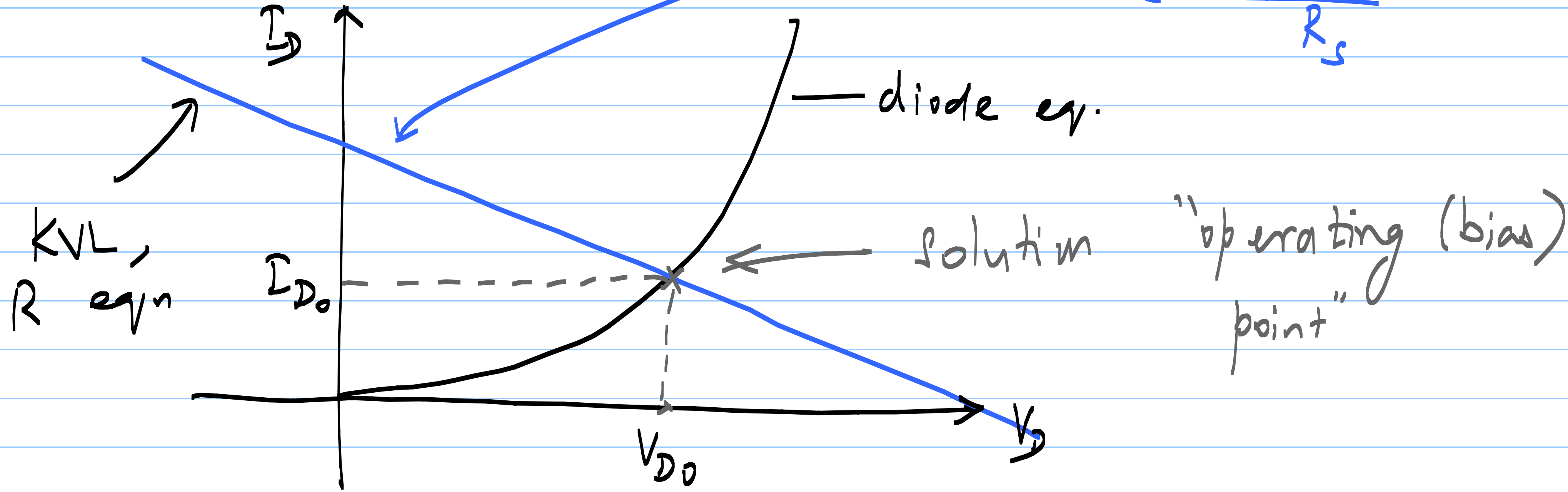
2) Exact solution : Iteration (actual characteristic) NL

Numerical Solution

3) Graphical solution on $I_D - V_D$ plot

$I_{R_s} = I_D$ (KCL)

$I_{R_s} = \frac{V_s - V_D}{R_s}$



If $V_s \to V_s' = V_s + \Delta V_s$

new op. pt.?