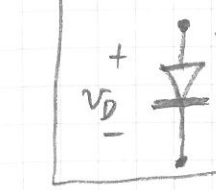
✡ Nonlinear Elements and Circuits

Silicon Diode



$$i_D = I_S\left(e^{v_D/v_{THE}} - 1\right)$$

I_S : saturation current $\approx 10^{-12}$ A

v_{THE} : thermal voltage

$$v_{THE} = \frac{kT}{q}$$

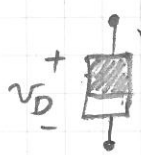
T: temperature in kelvins

$^\circ K = {}^\circ C + 273.15$

k: Boltzmann's constant $= 1.38 \times 10^{-23}$ J/°K

q: charge of an electron $= 1.602 \times 10^{-19}$ C

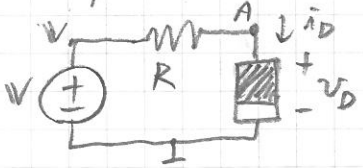
Ideal Nonlinear Device



$$i_D = \begin{cases} 1K \cdot v_D^2 & \text{for } v_D > 0 \\ 0 & \text{otherwise} \end{cases}$$

where $1K$ is a positive constant

Example: find v_D and i_D:



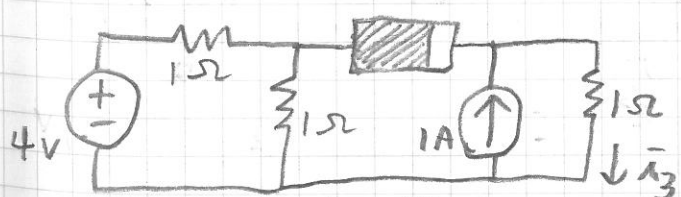
KCL at A: $\frac{1V - v_D}{R} + (-i_D) = 0$

Plug in the i-v relation, we have

$$\begin{cases} \frac{1V - v_D}{R} - 1K\, v_D^2 = 0 & \text{for } v_D > 0 \\ \frac{1V - v_D}{R} = 0 & \text{otherwise} \end{cases}$$

$$\Rightarrow v_D = \frac{-1 + \sqrt{1 + 4R1K1V}}{2R1K} \quad \text{and} \quad i_D = 1K\left(\frac{-1 + \sqrt{1 + 4R1K1V}}{2R1K}\right)^2 \text{ for } v_D > 0$$ ✱

Exercise: find $i_3 = ?$ (hint: Page 29 and the above example)



You can do it!

Ans: $i_3 = \left(\frac{\sqrt{7}-1}{3}\right)^2 + 1$ ✱