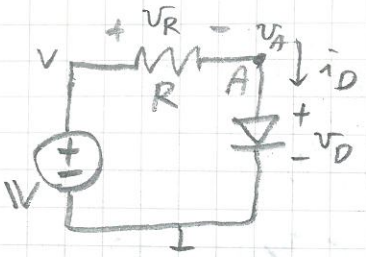
Motivation for graphical analyses:

Consider the following example



KCL at node A:

$$\frac{v_A - V}{R} + I_S\left(e^{v_D/V_{THE}} - 1\right) = 0$$

$$\Rightarrow \frac{v_D - V}{R} + I_S\left(e^{v_D/V_{THE}} - 1\right) = 0$$

Solving for v_D is like solving for

x for $ax + be^x + c = 0$ for some constants a, b, and c.

→ May be solved by trail-and-error

→ little insight, however.

What if we want to know the impact of increasing/decreasing V to the value of v_D? And, how would v_D change with the change of R? These are critical questions to ask when designing an electronic circuit.

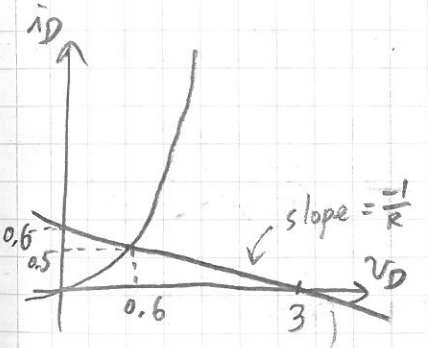
Now, graphical analyses can be very helpful in this aspect!

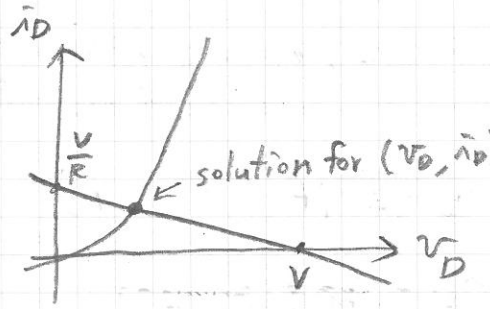
For concreteness, suppose $\begin{cases} V = 3\,V \\ R = 500\,\Omega \\ V_{THE} = 0.025\,V \text{ in room temperature} \end{cases}$ in the example on P38.

We can leverage KCL and KVL to state two equations for i_D:

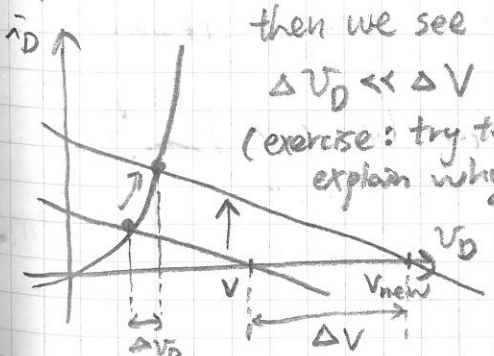
$$\begin{cases} i_D = I_S\left(e^{v_D/V_{THE}} - 1\right) = 10^{-12}\left(e^{v_D/0.025} - 1\right) \\ i_D = \dfrac{V_R}{R} = \dfrac{V - v_D}{R} = -\dfrac{1}{R}v_D + 0.006 \quad (\text{unit: A}) \end{cases}$$

then graphically speaking, the solution of i_D and v_D lies at the intersection point of the two curves on the $i_D - v_D$ plane:

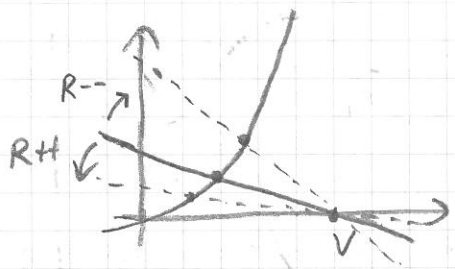




if V increases



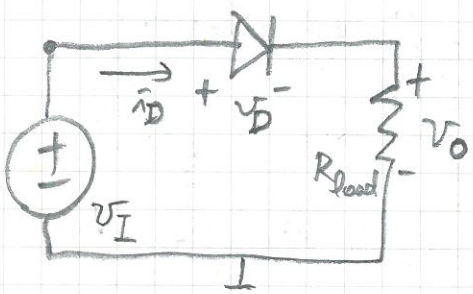
if R changes

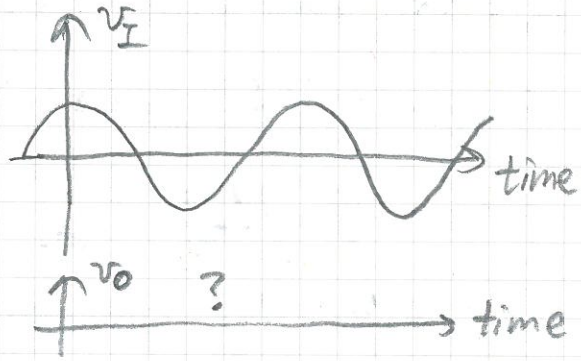


which give much insight in how the circuit would behave!

P40 Another example (half-wave voltage rectifier)

In the following circuit, given a time-varying voltage source v_I, what will be the output voltage v_O across a resistor?



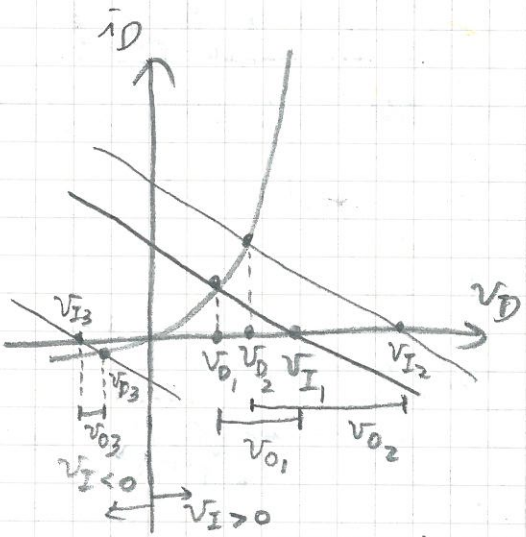


From KVL, $v_I - v_D - v_O = 0$

$\Rightarrow v_O = v_I - v_D$

From KCL, element law, and the i-v characteristic of the diode:

$$\begin{cases} i_D = I_S\left(e^{v_D/V_{THE}} - 1\right) \\ i_D = \dfrac{v_O}{R} = \dfrac{v_I - v_D}{R} \end{cases}$$



We see $v_{O_3} \approx 0$ when $v_D < 0$ because the curve is very close to the X axis