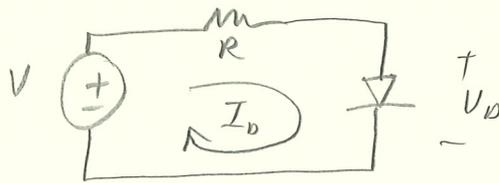


Diode Circuit Analysis

1) Quiescent Operating Point: Q-point

→ the DC current and voltage that define the point of operation

→ of the diode here

Basic Circuit

let  $V = 10V$ ,  $R = 10k\Omega$

$$\therefore V = I_D R + V_D$$

Methods for solving this equation

① Load-Line Analysis

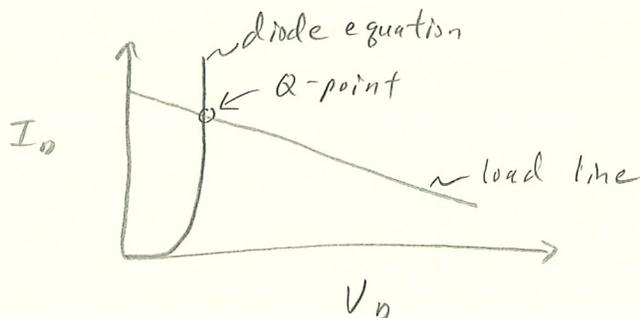
→ a graphical method

plot (1) diode equation

(2)  $V = I_D R + V_D$  → called the Load Line

→ the intersection of these two plots is the Q-point

→ not very precise: useful before wide access to computers



## ② Analysis use diode mathematical model

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

$$(2) V = I_D R + V_D$$

ex:  $V = 10V$ ,  $R = 10k\Omega$ ,  $I_S = 10^{-13}A$ ,  $V_T = 0.025V$

$$\therefore 10 = 10^4 (10^{-13}) \left[ e^{\left(\frac{40V_D}{0.025}\right)} - 1 \right] + V_D$$

→ solve for  $V_D$

→ No closed form solution

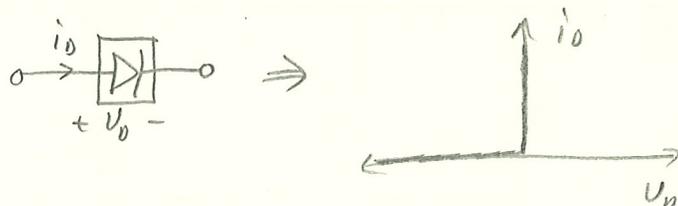
→ solve use numerical techniques → use a computer

↳ such as Newton's method → iterative approach

→ yields an accurate solution

## ③ Ideal Diode Model

→ using a simplified diode circuit model



Diode is On  $\rightarrow V_D = 0 : i_D > 0 \rightarrow$   short circuit  $\rightarrow$  forward biased

Diode is Off  $\rightarrow V_D \leq 0 : i_D = 0$   open circuit  $\rightarrow$  reverse biased

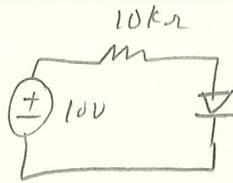
↑  
2 states

### Analysis Procedure

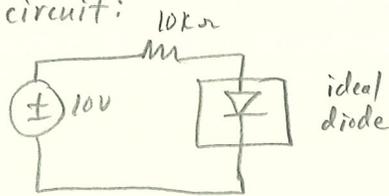
- ① select a diode model
- ② identify anode and cathode, and label diode voltage,  $V_D$ , and current,  $i_D$
- ③ make an "educated" guess as to the diode state
- ④ analyze the circuit using the appropriate diode model, from ③
- ⑤ check the results to see if they are consistent with the assumptions

ex1:

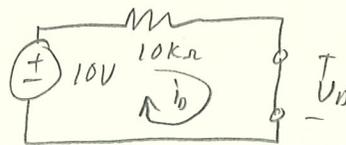
original circuit:



ideal diode mode in circuit:



since 10V source appears to be trying to force positive current through the diode: our first guess will be that the diode is on:

Solve for  $i_D$ :

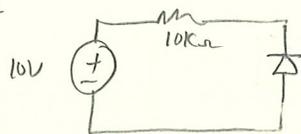
$$i_D = \frac{10}{10k} = 1mA$$

$i_D > 0 \rightarrow$  consistent with our assumption that the diode is on.

$\therefore$  the Q-point is: 1mA, 0V

ex2:

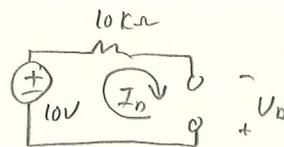
original circuit:



ideal diode circuit:



guess: off state:



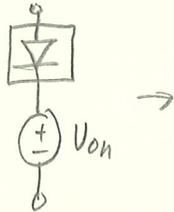
$$\text{Loop Eq: } 10 + V_D - 10^4 I_D = 0 \rightarrow I_D = 0, V_D = 10V$$

$\rightarrow V_D < 0$ : diode is off

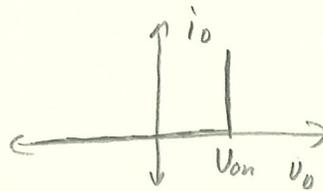
#### ④ Constant Voltage Drop Model

→ this model adds a constant voltage source,  $V_{on}$  is series with the ideal diode

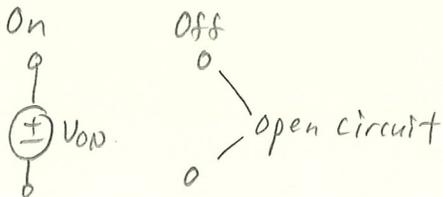
schematic diagram:



I-V characteristic



2 states

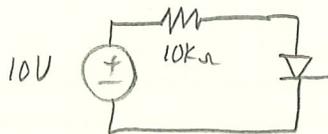


∴  $V_D = V_{on}$  for  $i_D > 0$  → on state

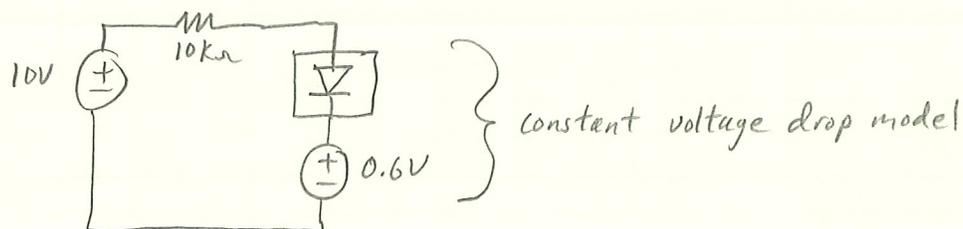
$i_D = 0$  for  $V_D \leq V_{on}$  → off state

reasonable value for  $V_{on}$ :  $0.6V \leq V_{on} \leq 0.7V$

ex: original circuit:



circuit with the constant voltage drop model: assume diode is on:



$$I_D = \frac{10 - V_{on}}{10k} = \frac{10 - 0.6}{10,000} = 0.940 \text{ mA} \rightarrow \text{diode is on}$$

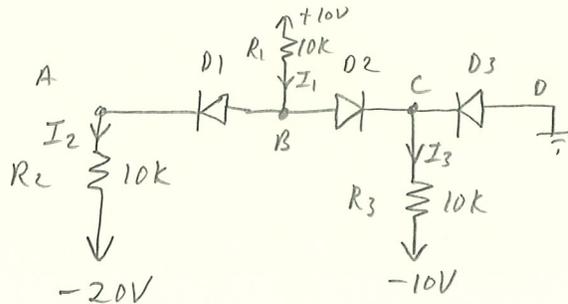
## 2) Multiple Diode Circuits

For analysis by hand  $\rightarrow$  use simplified diode models

$\rightarrow$  PSPICE uses numerical solving techniques

Ex 3.8, p. 105

$\rightarrow$  use the CVD model to solve the circuit



Possible Diode States : "1" = on, "0" = off

$D_1$	$D_2$	$D_3$
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

$2^n = 2^3 = 8$  possible solutions

solution

$\rightarrow$  1<sup>st</sup> assume all diodes are off and solve for  $(I_{D1}, V_{D1})$ ,  $(I_{D2}, V_{D2})$  and  $(I_{D3}, V_{D3})$