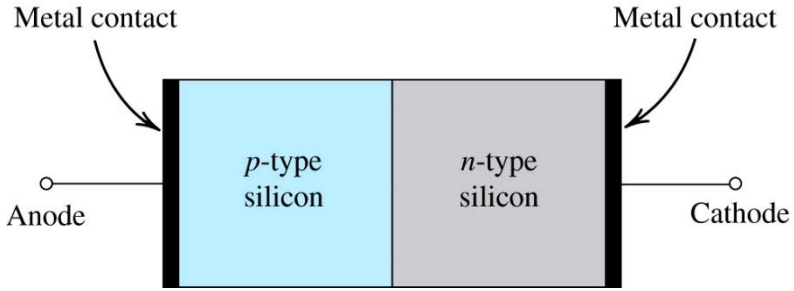
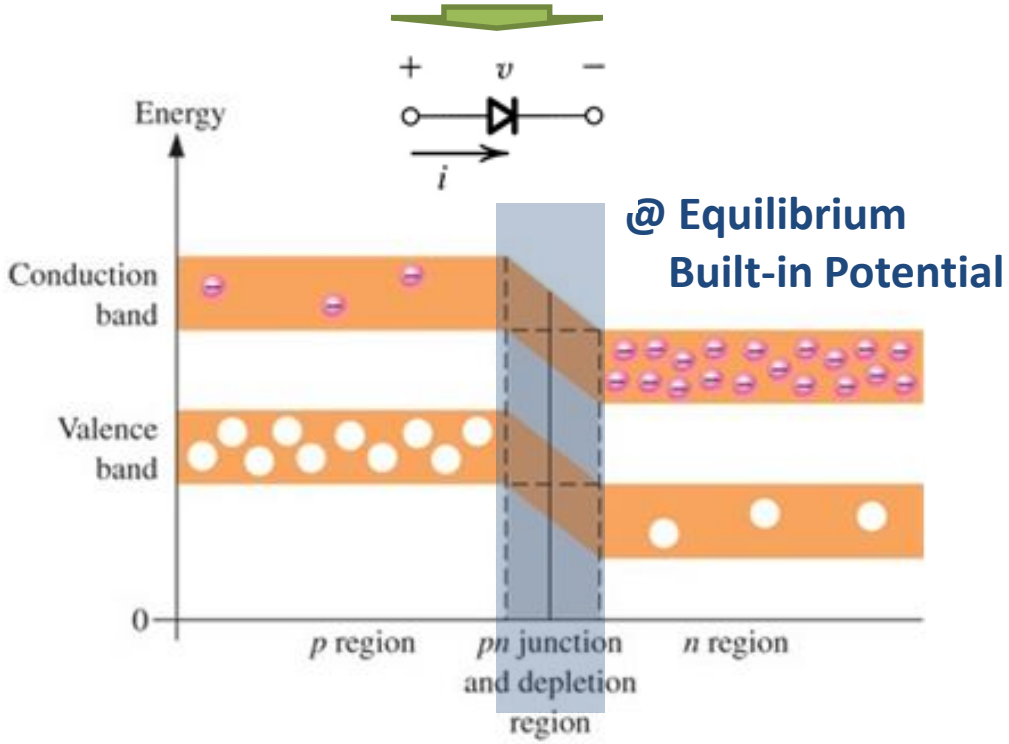
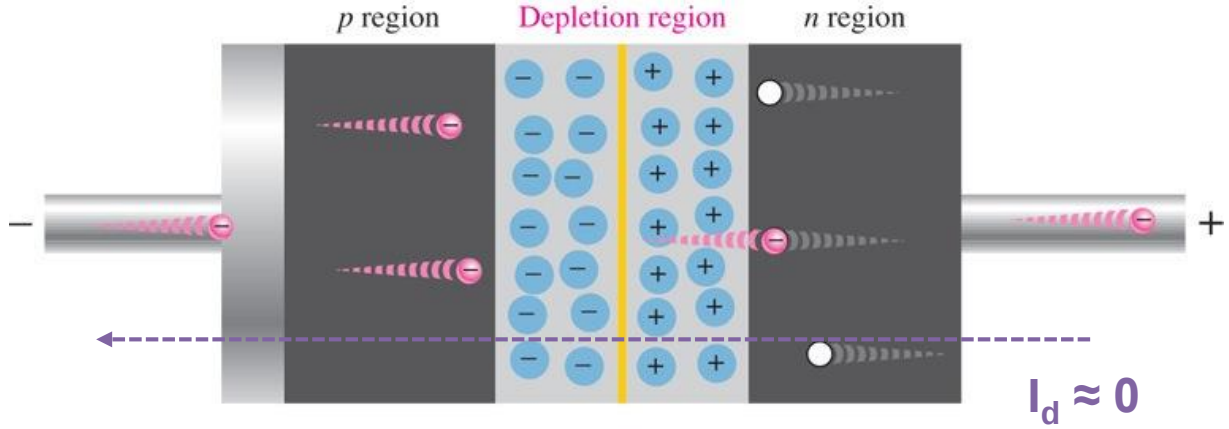
Last Lecture → PN Junction





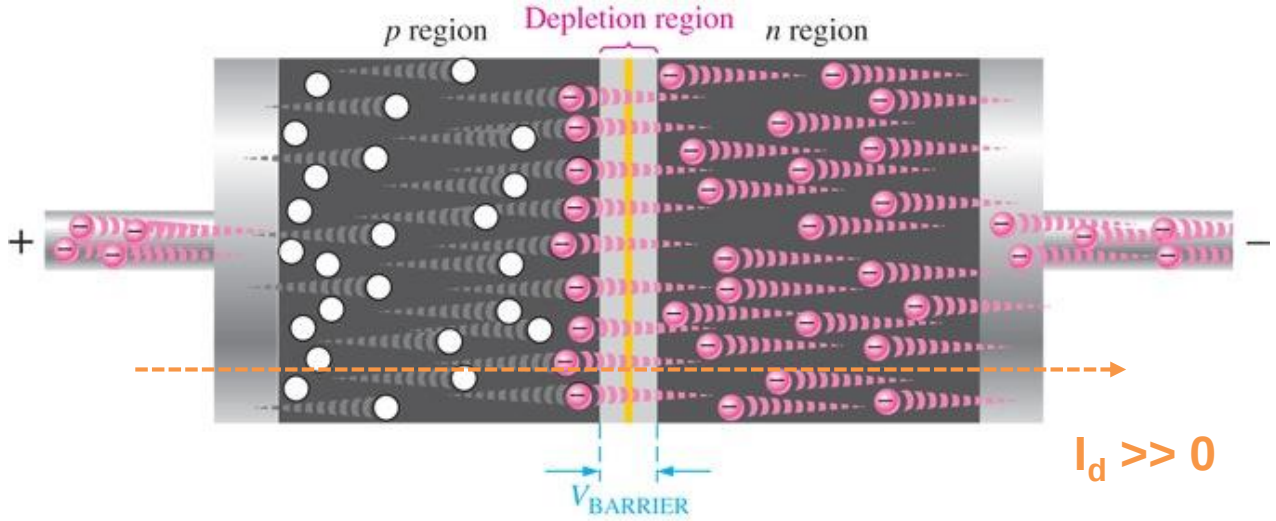
@ Equilibrium
Built-in Potential

- ***Reversed Biased → $v_d < 0$***



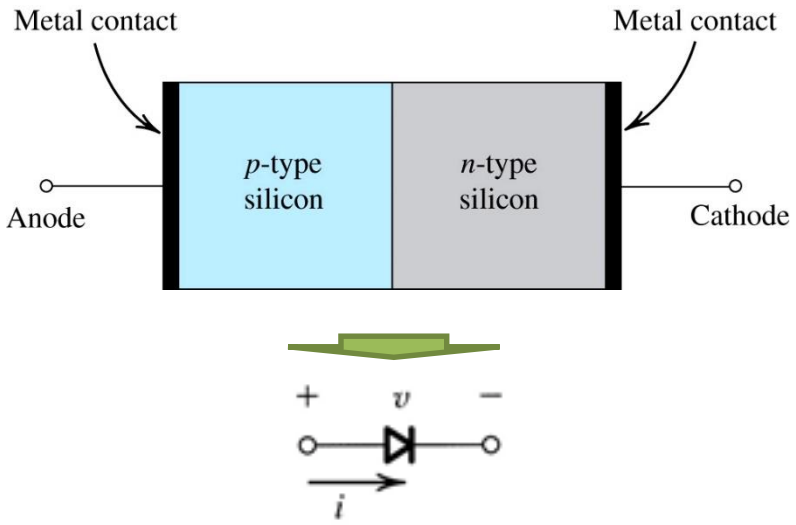
$I_d \approx 0$

- ***Forward Biased → $v_d > v_0$***



$I_d >> 0$

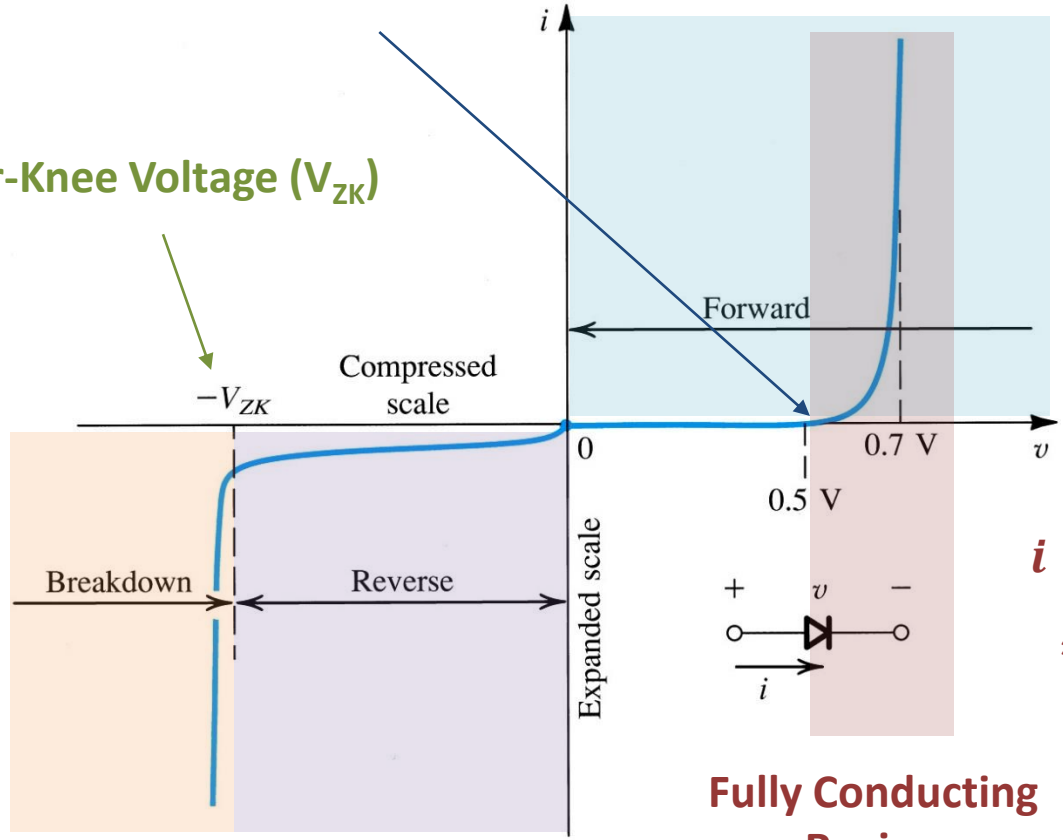
Terminal Characteristics of Diodes



- I_S → saturation current
- V_T → thermal voltage

Cut-in Voltage ≈ 0.5V

Zener-Knee Voltage (V_{ZK})



$$i = I_S\left(e^{v/V_T} - 1\right)$$

$$\approx I_S e^{v/V_T}$$

Fully Conducting Region
0.6V < v < 0.8V

Characteristic Regions

- **Forward Bias:** v > 0
- **Reverse Bias:** v < 0
- **Breakdown:** v << 0

$$i = -I_S e^{-|v|/V_T}$$

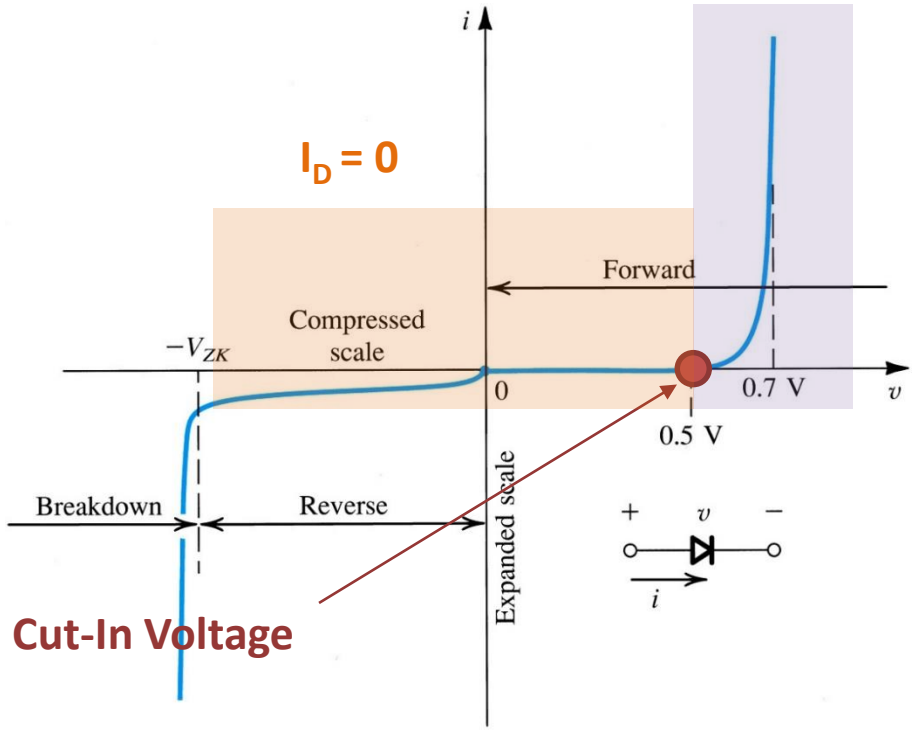
$$i \approx -I_S$$

Diode Models

DC Analysis
- Ideal Model
- Constant-Voltage-Drop Model
- Exponential Model
  - Graphical Analysis
  - Numerical Analysis

AC Analysis
- Small Signal Model

Your simulation results are as good as your model!!!!



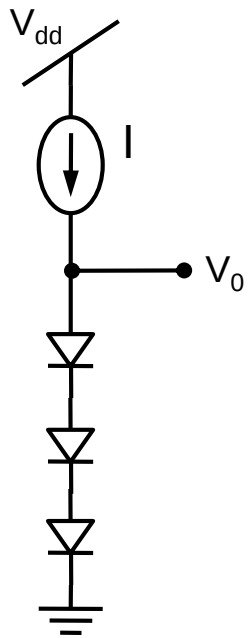
Exponential Model

$$for\ v < 0.5 \rightarrow I_D \approx 0$$

$$for\ v > 0.5 \rightarrow I_D \approx I_S e^{v_D/V_T}$$

Problem 4.23

The circuit provided below utilizes three identical diodes having $I_s = 10^{-16}$A. Find the value of the current I required to obtain an output voltage $V_0 = 2.4$V. If a current of 1mA is drawn away from the output terminal by a load, what is the change in the output voltage.

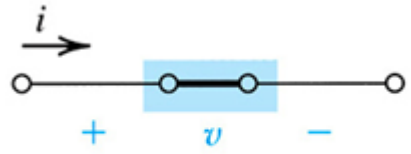


Diode Models

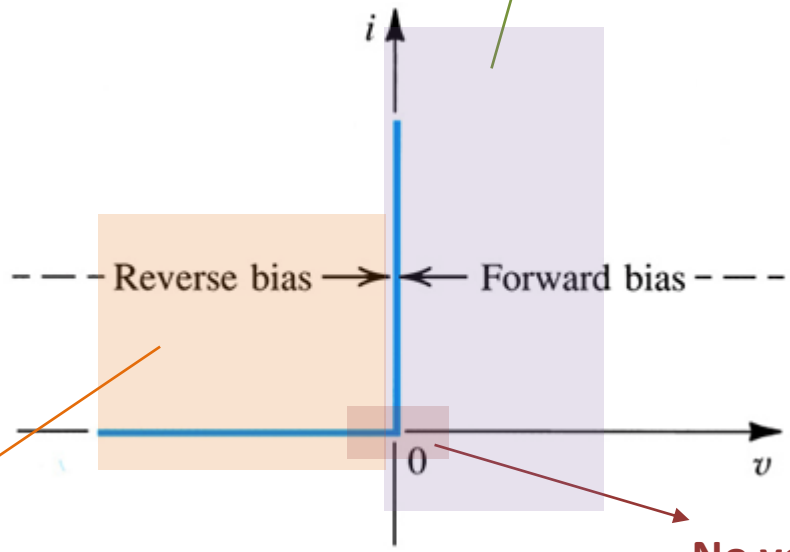
DC Analysis
- Ideal Model
- Constant-Voltage-Drop Model
- Exponential Model
  - Graphical Analysis
  - Numerical Analysis

AC Analysis
- Small Signal Model

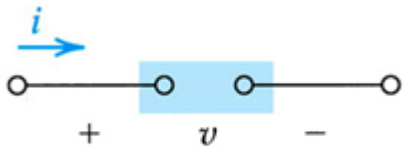
I_D is not a function of V_D



$i > 0 \Rightarrow v = 0$



No reverse current



$v < 0 \Rightarrow i = 0$

No voltage drop when conducting current

Ideal Model

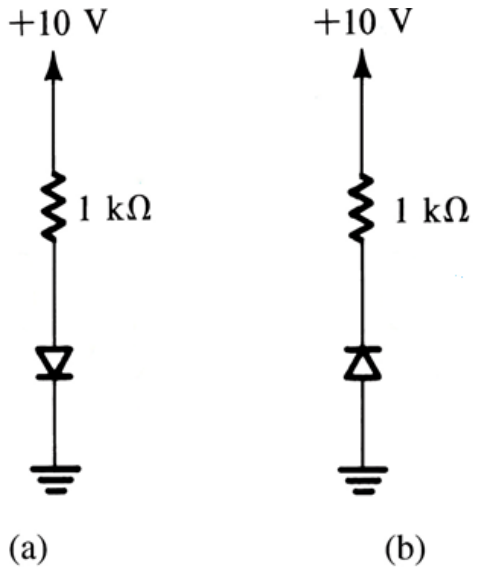
$for\ v < 0 \rightarrow I_D = 0$

$for\ I_D > 0 \rightarrow v = 0$

Solving Circuits with Diodes

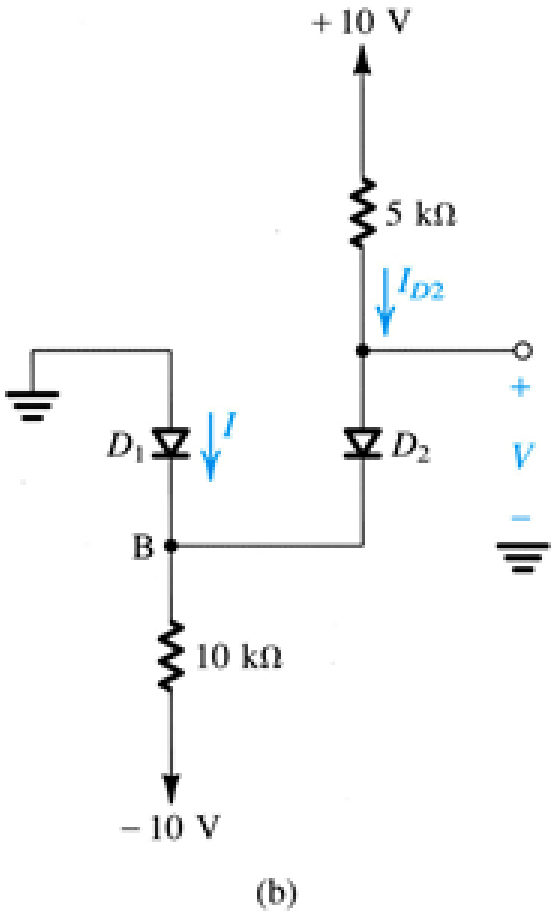
1. **Choose a model for the diode**
2. **Make an educated guess of the region of operation of the diode**
3. **Solve the circuit via mesh / nodal analysis**
4. **Verify if the condition of the region of operation are satisfied!**

For the given circuits, determine the current flowing through the resistor.



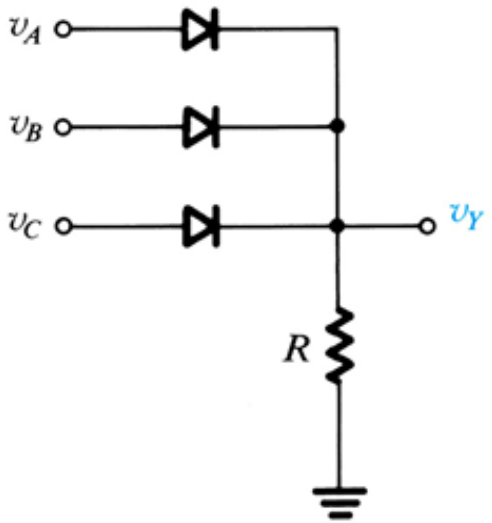
Example 4.2

Assuming the diodes to be ideal, find the values of I and V in the given circuits …

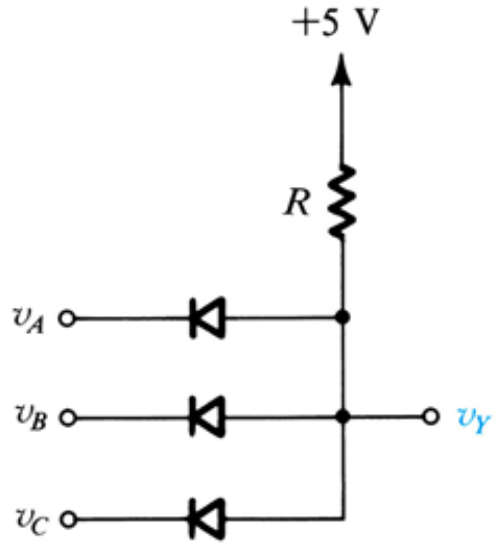


Diode Logic Gates

Diodes together with resistors can be used to implement logic functions…



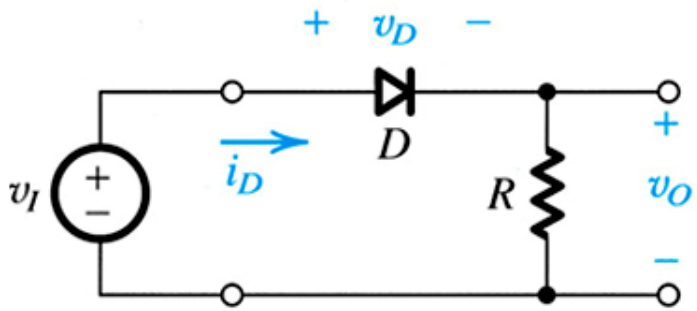
(a)

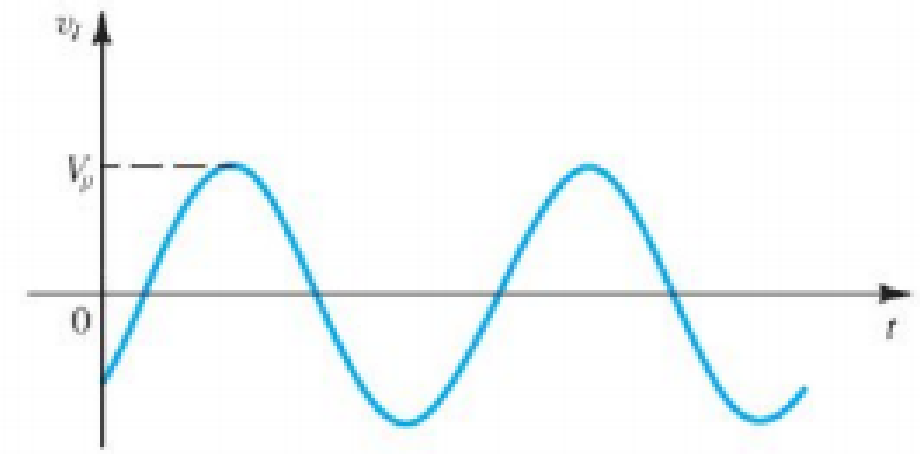


(b)

A Simple Application

→ The Rectifier





Example 4.1

For the following circuit, assuming v_s is a sinusoid with 24-V peak amplitude find

a) **the fraction of each cycle during which the diode conducts**
b) **the peak value of the diode current**
c) **The maximum reverse-bias voltage that appears across the diode**