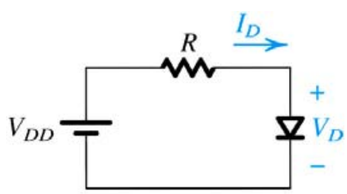
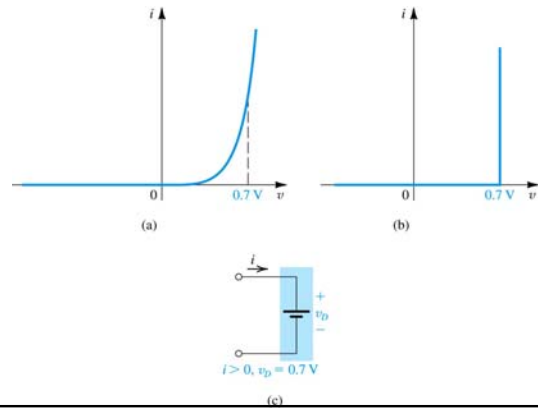
# Constant Voltage Drop Model

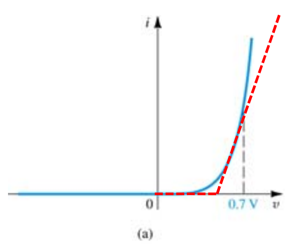
- Assume that if the diode is ON, it has a constant voltage drop (0.7V)



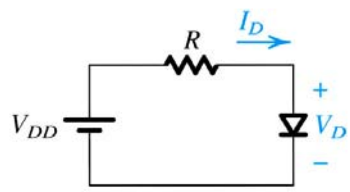

# Piecewise Linear Model

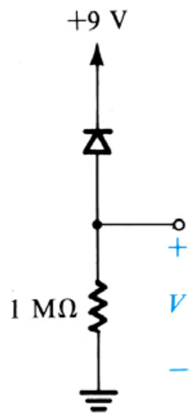
- Constant voltage up to ~0.5V then resistor



# Ideal Diode Model

- Similar to constant voltage drop, but the voltage drop is 0 V




Find ID and VD for VDD = 5V, R=10KΩ
Assume 0.7 V at 1-mA Use iteration

Design a circuit to provide output voltage of 2.4V
(0.7 V at 1 mA)

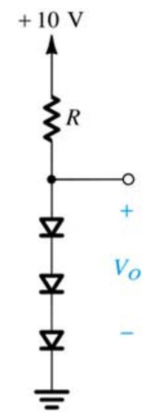
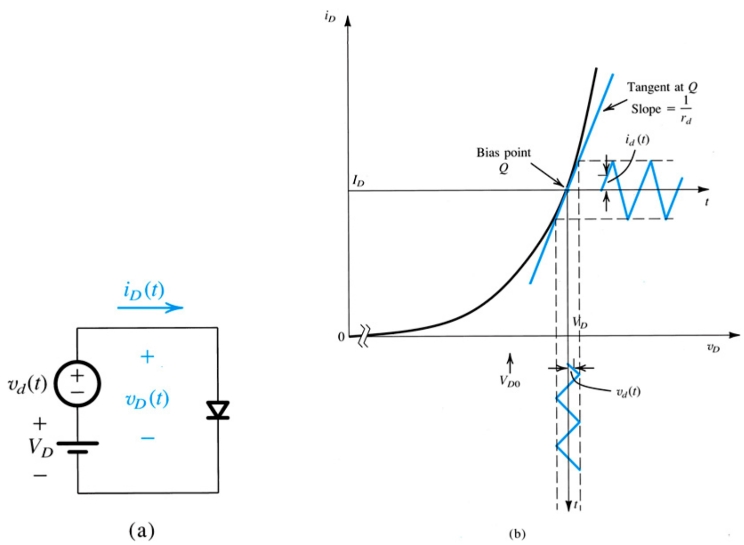



Figure E4.11



# Small Signal Model



Solve

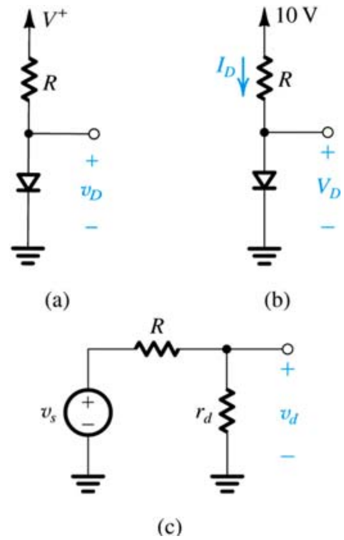



Figure 4.14 (a) Circuit for Example 4.5. (b) Circuit for calculating the dc operating point. (c) Small-signal equivalent circuit.



# Voltage Regulator (forward bias)

- A voltage regulator is a circuit that provides a constant DC voltage even with the changes of the load resistance or the source resistance.
- Since the diode in the forward bias region have a constant voltage with relatively large changes in current, it could be used as a voltage regulator

Solve

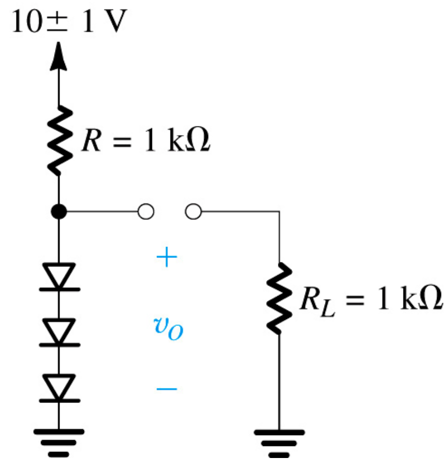



Figure 4.15 Circuit for Example 4.6.

Solve

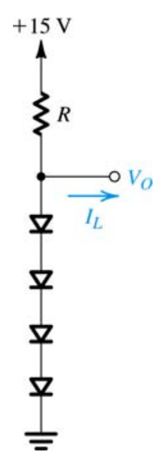
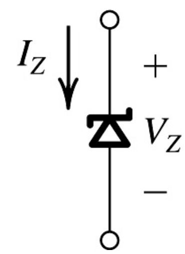



Figure E4.15

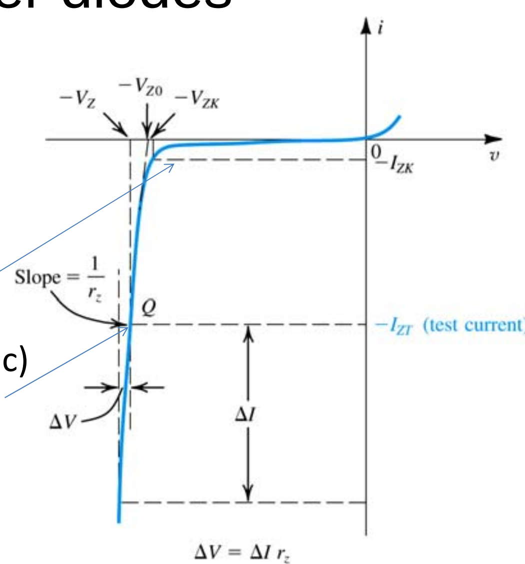
# Zener Diode

- Diodes that are designed to operate in the reverse breakdown region.
- Used for low current regulators (although regulators chips are widely used now).



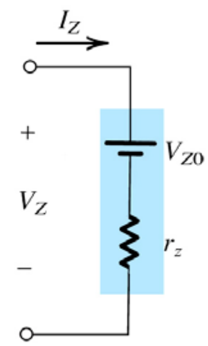

# Zener diodes

- Characterized by
  - $V_z$ at a specified test current $I_{ZT}$
  - Maximum power
  - Knee current $I_{KZ}$
  - Incremental (dynamic) resistance $r_z=\Delta V/\Delta I$



# Zener Diodes

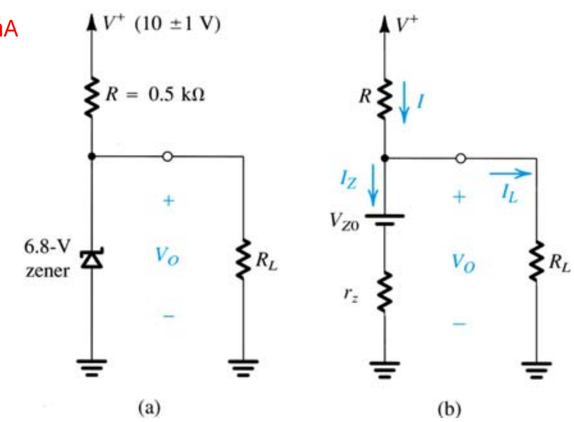
- Equivalent circuit
- VZ0 in practice is the same as the knee voltage



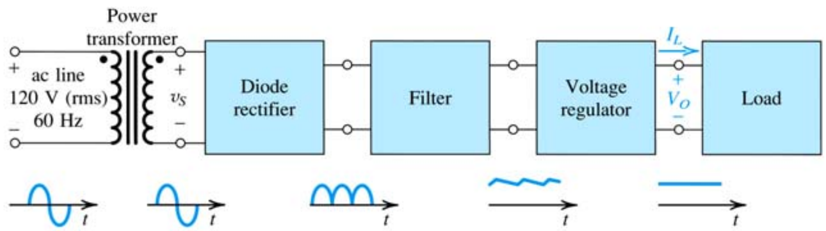
Assume a 6.8-V Zener diode with $V_Z$=6.8 at $I_z$=5mA, $r_z$=20 Ω, $I_{ZK}$ = 0.2 mA, $V^+$ =10V± 1V

- Find VO and the line regulation at no load
- Find the load regulation when the load current is 1mA
- Find VO for R=2 KΩ, 0.5KΩ
- Find the minimum load for the diode to operate in the breakdown region



Changing amplitude and ***Electrical isolation***



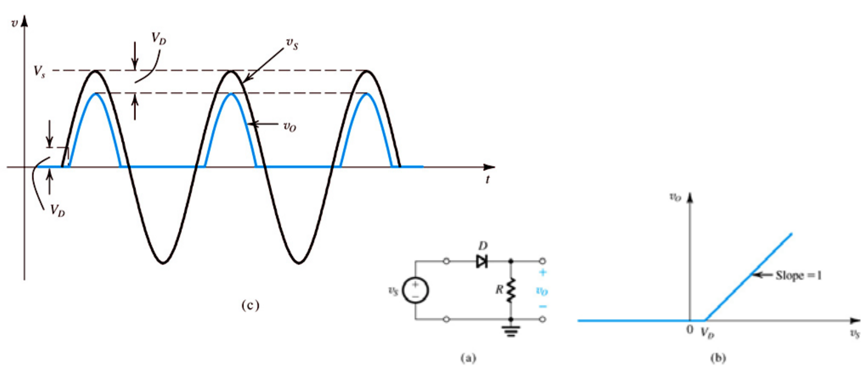

ripples

Figure 4.20 Block diagram of a dc power supply.




# Half-Wave Rectifier

- Removes the negative voltage half cycle
- Peak inverse voltage < breakdown voltage

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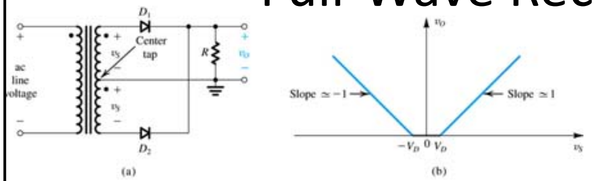
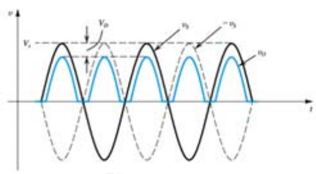
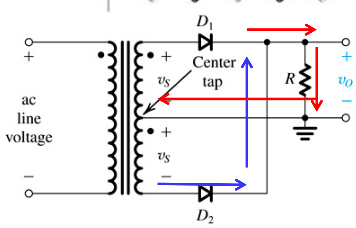
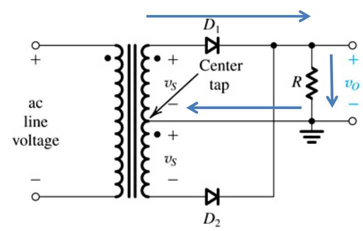
# Full-Wave Rectifier

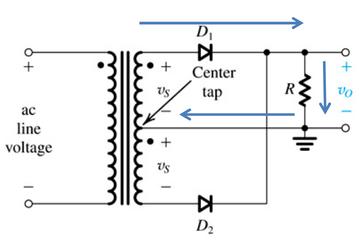


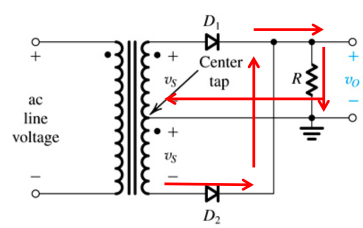





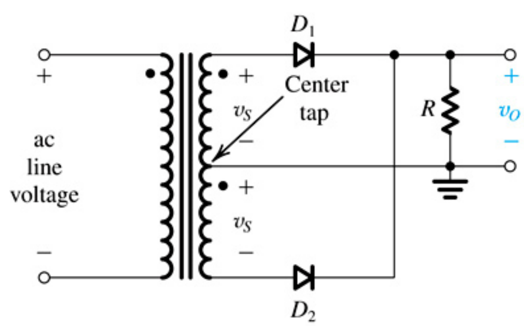






**PIV ?**



# Bridge Rectifier

**PIV ?**

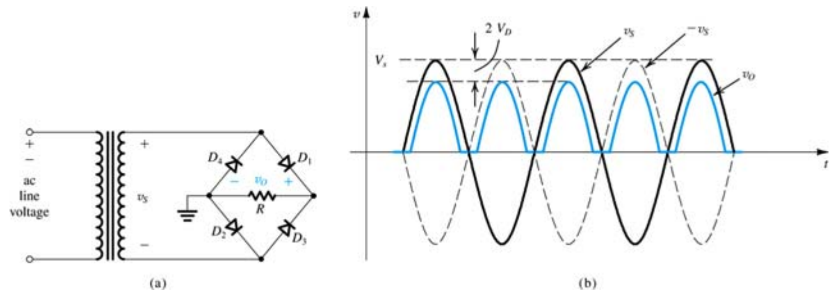



Figure 4.23 The bridge rectifier: (a) circuit; (b) input and output waveforms.

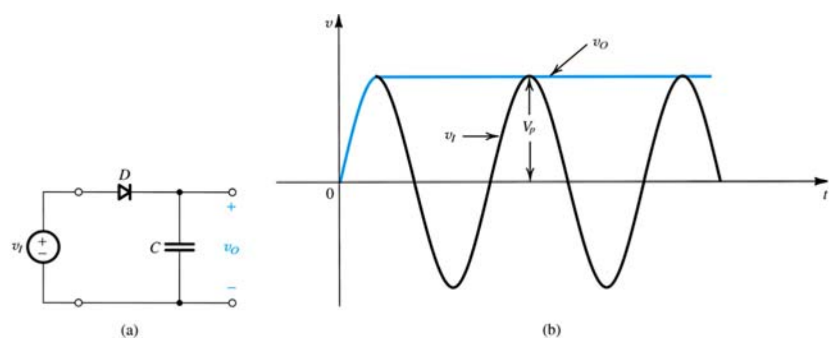



Figure 4.24 (a) A simple circuit used to illustrate the effect of a filter capacitor. (b) Input and output waveforms assuming an ideal diode. Note that the circuit provides a dc voltage equal to the peak of the input sine wave. The circuit is therefore known as a *peak rectifier* or a *peak detector*.

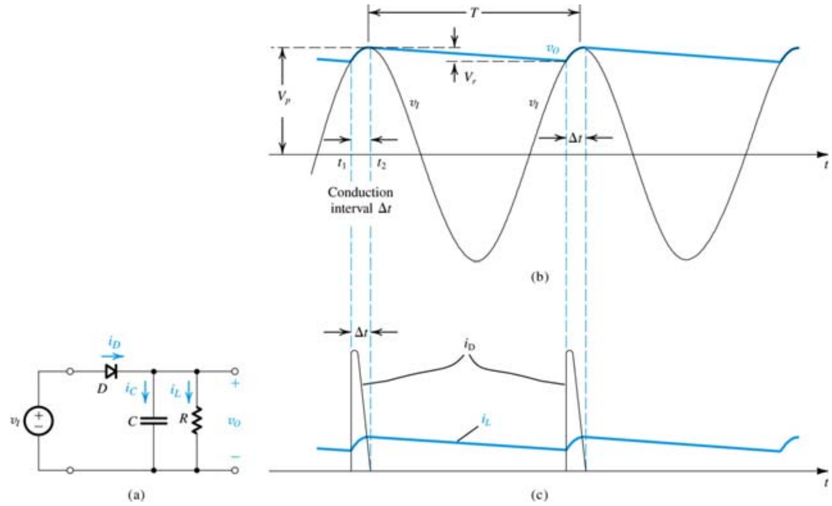



**Figure 4.25** Voltage and current waveforms in the peak rectifier circuit with $CR \gg T$. The diode is assumed ideal.

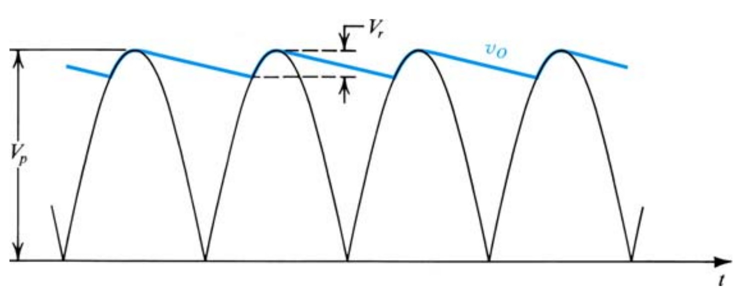



Figure 4.26 Waveforms in the full-wave peak rectifier.

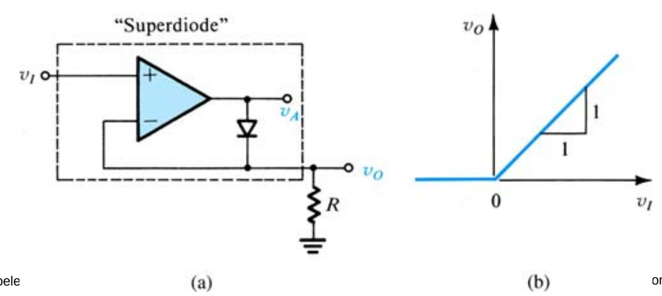
 

# Superdiode

- There is one or 2 diode voltage drops in the rectifier circuits we studied.
- That is O.K. when we are designing a DC power supply.
- Can not be used to rectify a small voltage signal (100 mV).

# Superdiode

- When $v_I$ is positive, $v_A$ is positive, the diode conducts providing the –ve feed back and $v_O=v_I$
- When $v_I$ is –ve $v_A$ is negative diode is reverse biased, no current in R no drop on R, $v_o=0$

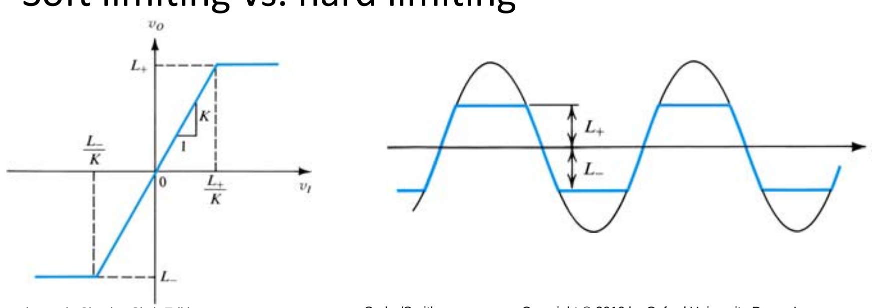


# Diode Circuits

- Limiter circuits
- Clamped capacitor or DC restorer
- Voltage doubler

# Limiter Circuits

- K could be > 1, but we concentrate of k<=1 (passive limiter)
- Also known as clippers
- Soft limiting vs. hard limiting



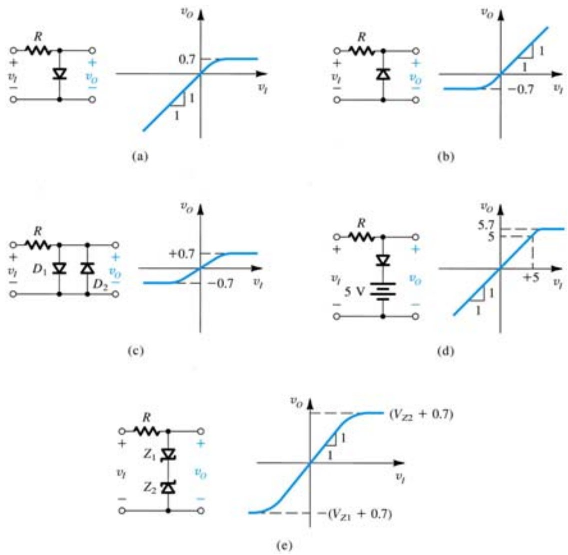



Figure 4.31 A variety of basic limiting circuits.

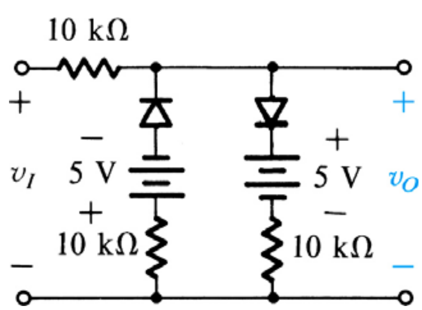
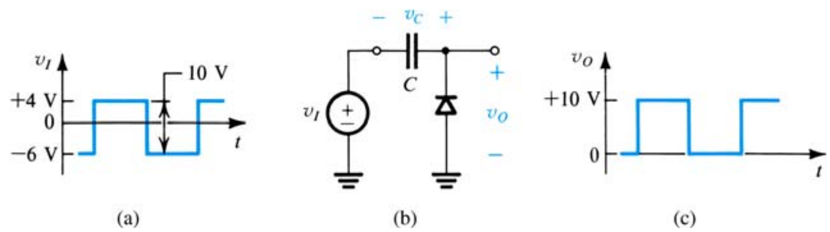



Figure E4.26

# Clamped Capacitor (DC restorer)

- Shifts the input signal by a specific amount
- When $v_I$ is -6, $v_C$ = 6 V as shown
- When $v_I$ is +4, diode is off and capacitor does not discharge
- $v_O = v_I + v_C$



# Clamped Capacitor with a Load

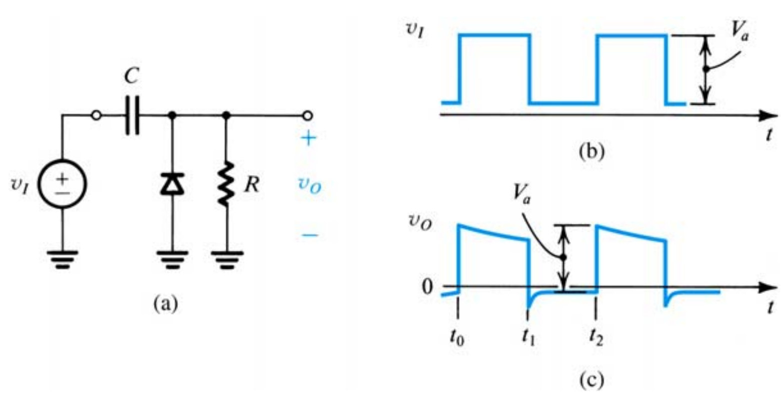



Figure 4.33 The clamped capacitor with a load resistance *R*.

# Voltage Doubler

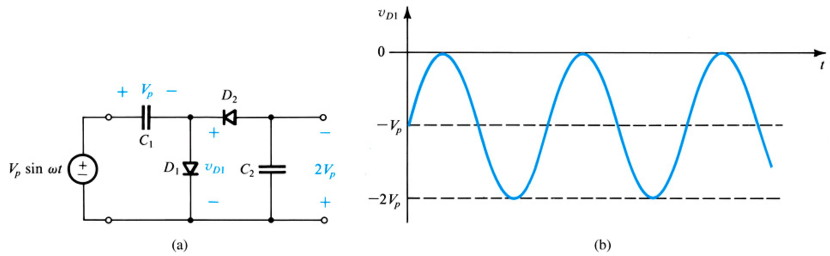



Figure 4.34 Voltage doubler: (a) circuit; (b) waveform of the voltage across $D_1$.

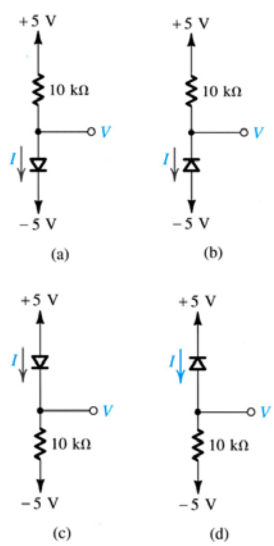



Figure P4.2

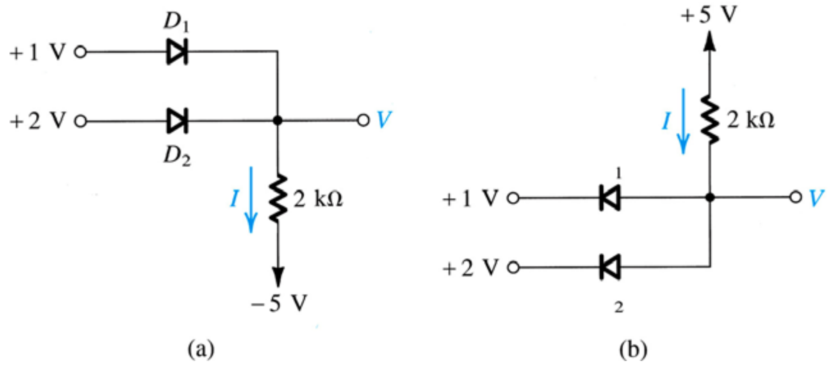



Figure P4.3



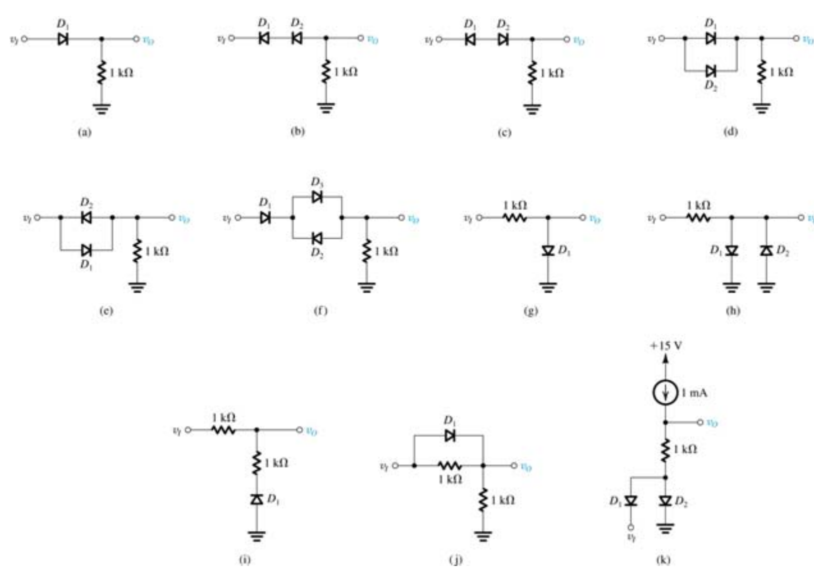



Figure P4.4

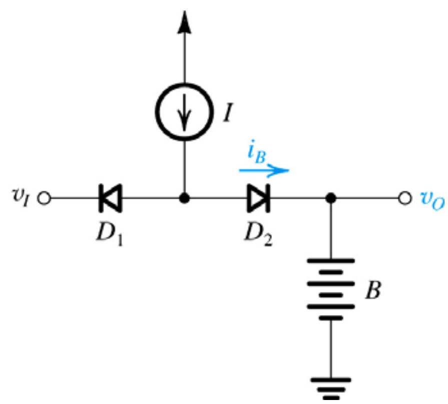



Figure P4.5

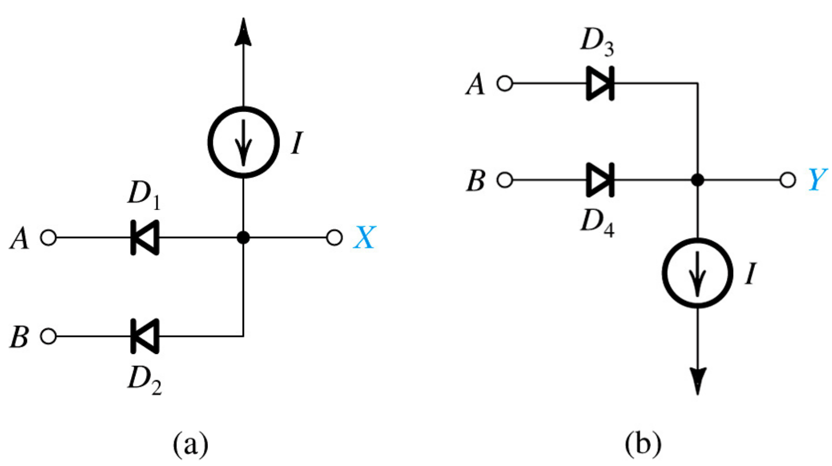



Figure P4.6

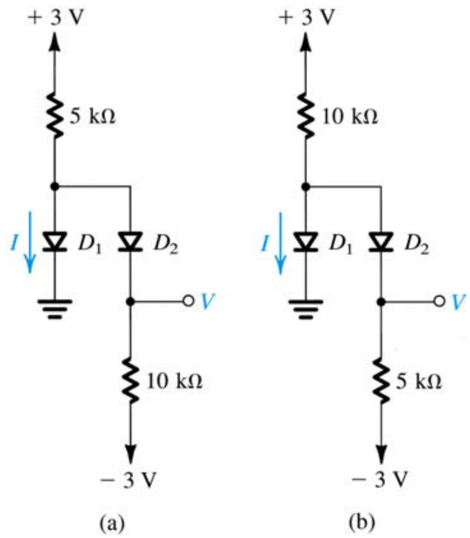



Figure P4.9