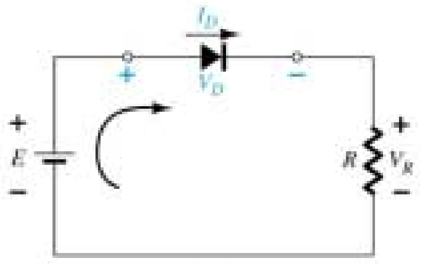
Chapter 2
Diode Applications

- In general, approximate model of diode is used in applications because of non-ideal real life conditions (tolerance, temperature effect, etc) never allow an ideal case to be applied

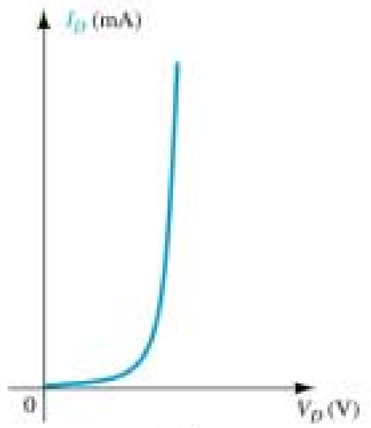
Load Line Analysis

- The load of a circuit determines the point or the region of operation of a diode (or device)
- The method: A line is drawn on the characteristic of the device
- The intersection point gives the point of operation



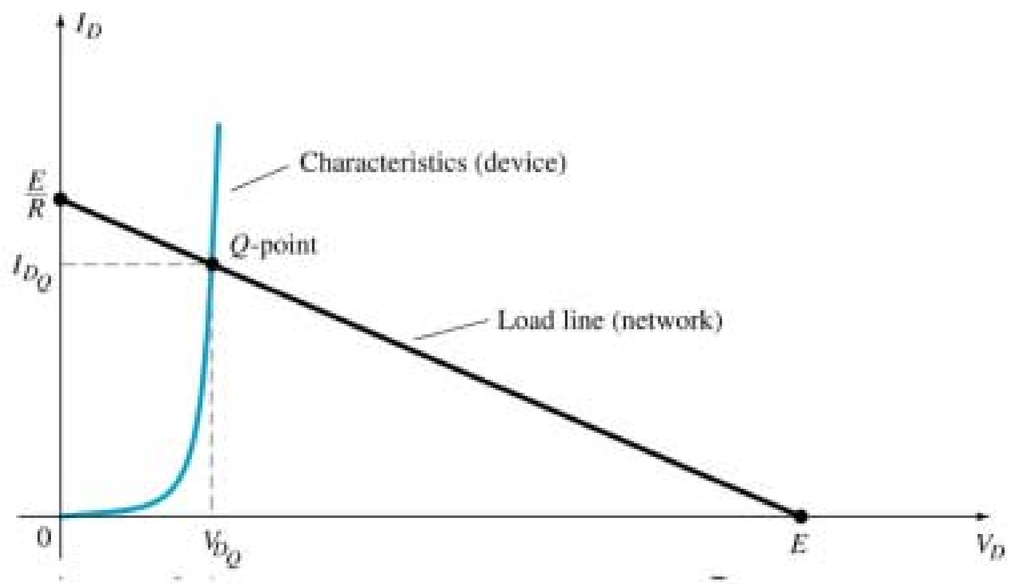
I_D
+
V_D
−
+
E
−
R
+
V_R
−

(a)



I_D (mA)
0
V_D (V)

(b)



I_D
Characteristics (device)
$\frac{E}{R}$
Q-point
I_{D_Q}
Load line (network)
0
V_{D_Q}
E
V_D

Load Line Analysis

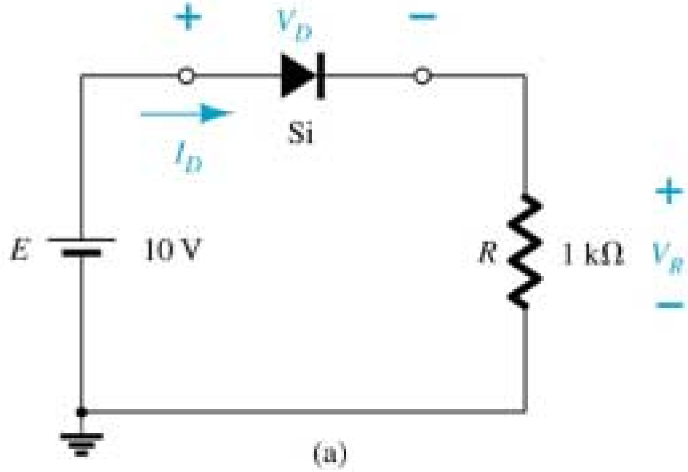
- In the above figure, E has to be in the forward bias direction and $> V_T$ of the diode, in order for the current to flow. Using KVL:
- $-E + V_D + V_R = 0$
- $E = V_D + V_R = V_D + I_D R$
- Notice: Variables V_D , I_D are same in the above equation
- For V_D=0: $I_D = E/R$
- For I_D=0: $E = V_D + I_D R$

Load Line Analysis

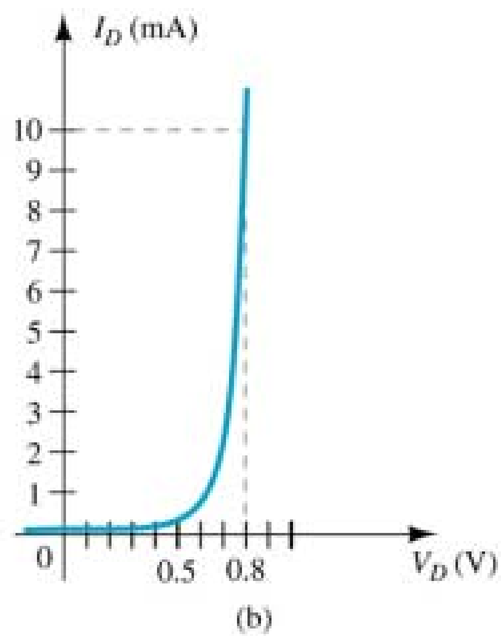
- The intersection point is called Q point
- Same solution can be found by using nonlinear diode equation
- We can avoid heavy math using load line analysis.
- Exp from notes 1
- Exp from notes 2
- Exp from notes 3

Example 1

- For below figure, determine V_{DQ}, I_{DQ} and V_R



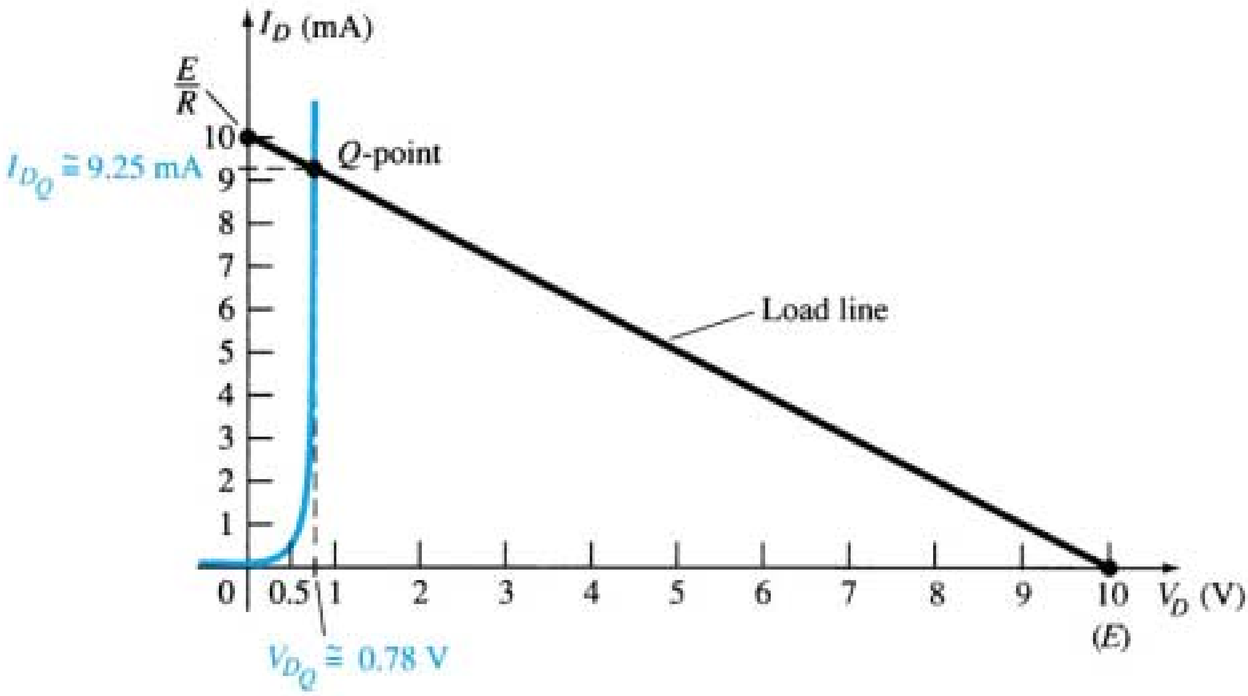
(a)



(b)

Solution

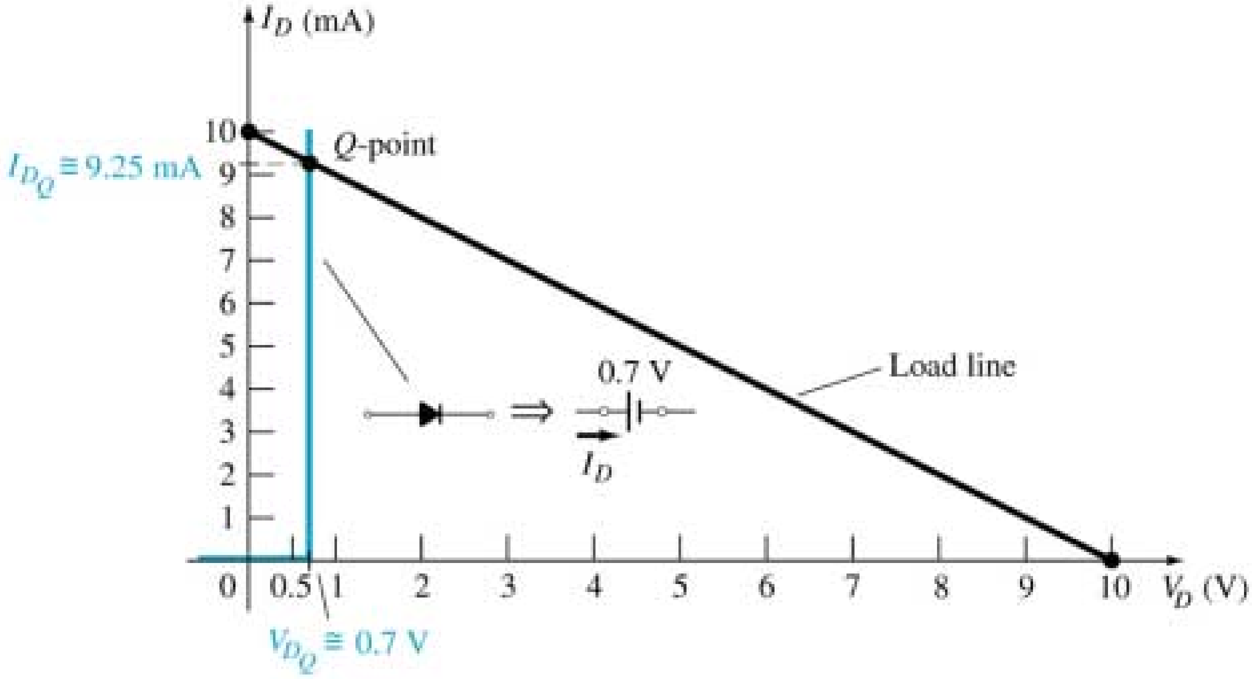
- Refer to notes for the solution



Example 2

- Repeat the previous example using approximate model of the Si diode

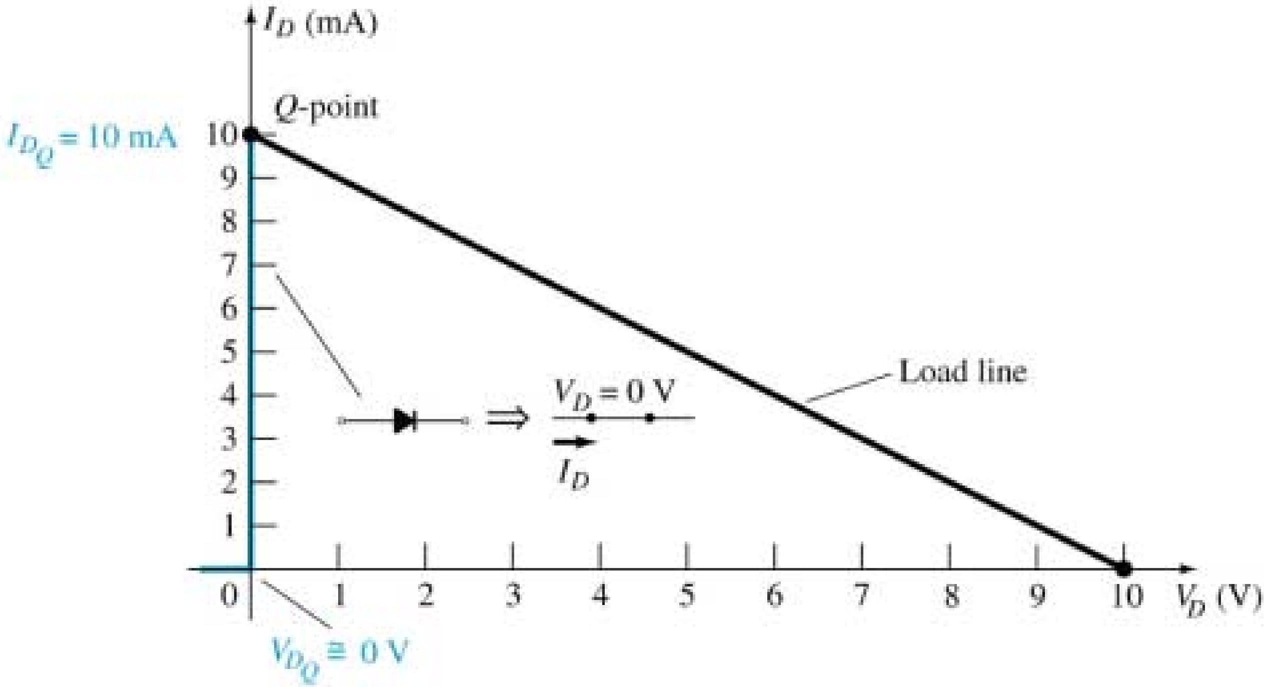
- Solution: Refer to notes and see the next figure



Solution to Example 2.

Example 3

- Repeat the same example using ideal model of the diode
- Solution: Refer to notes and see next figure



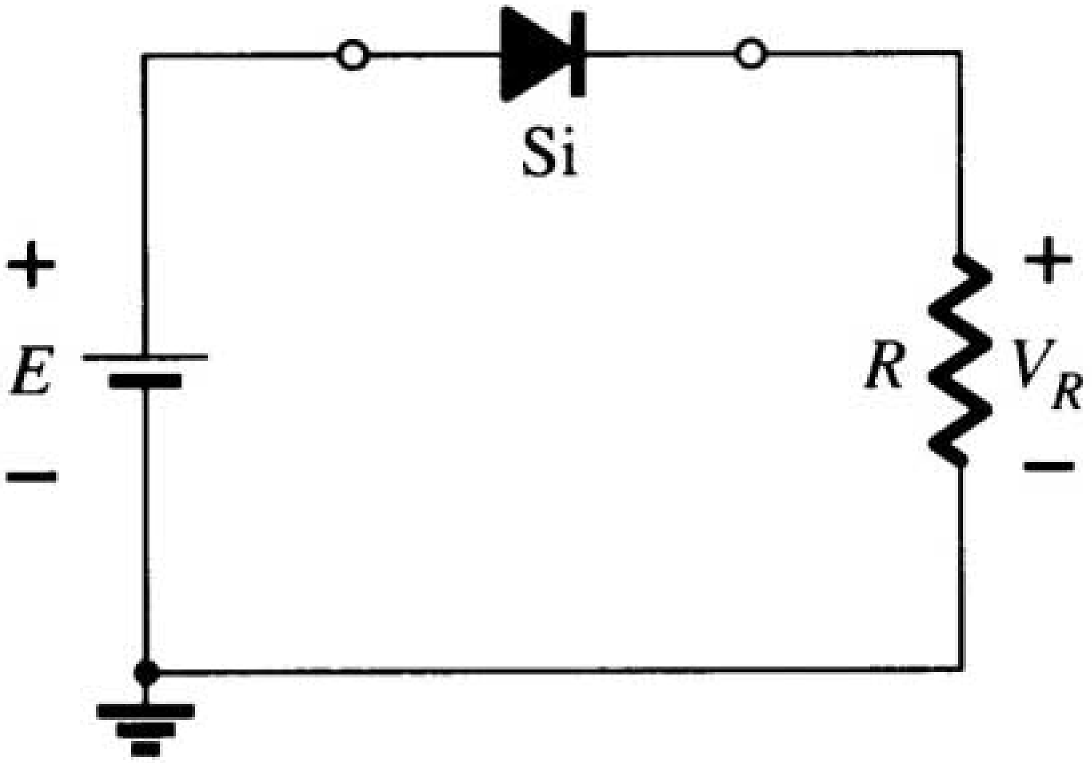
Solution to example 3 using ideal model

Diode Approximations

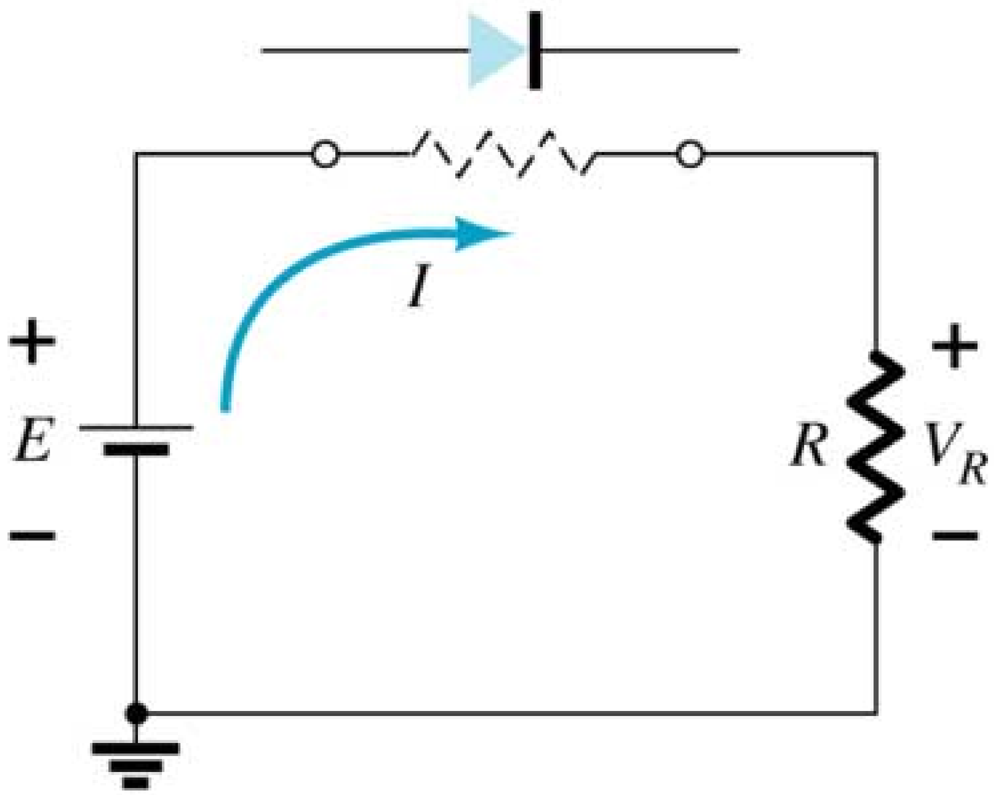
- As an engineer, we will generally use approximate models to avoid extensive mathematical calculations
- This is achieved by using approximate model of a device whenever it is possible
- Approximate model of diodes are given in Table 2.1
- Also see Figure 2.11

Series Diode Config. with DC Inputs

- When connected to voltage sources in series, the diode is on if the applied voltage is in the direction of forward-bias and it is greater than the V_T of the diode
- When a diode is on, we can use the approximate model for the on state
- See next two figures

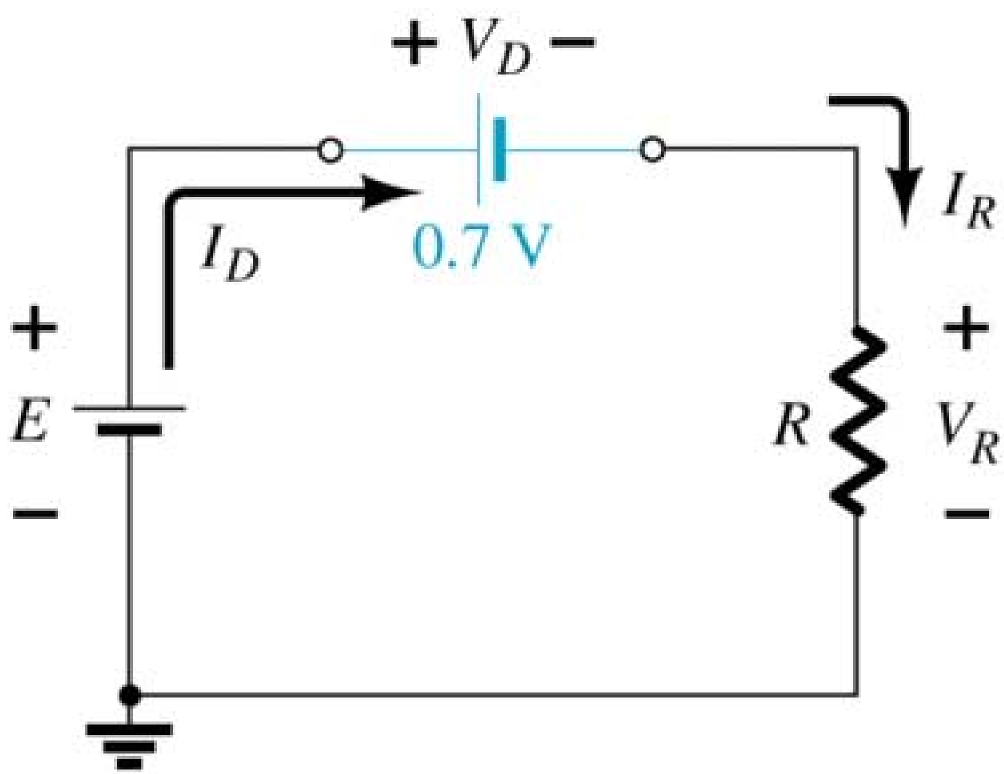


Si
+
E
−
+
R
V_R
−



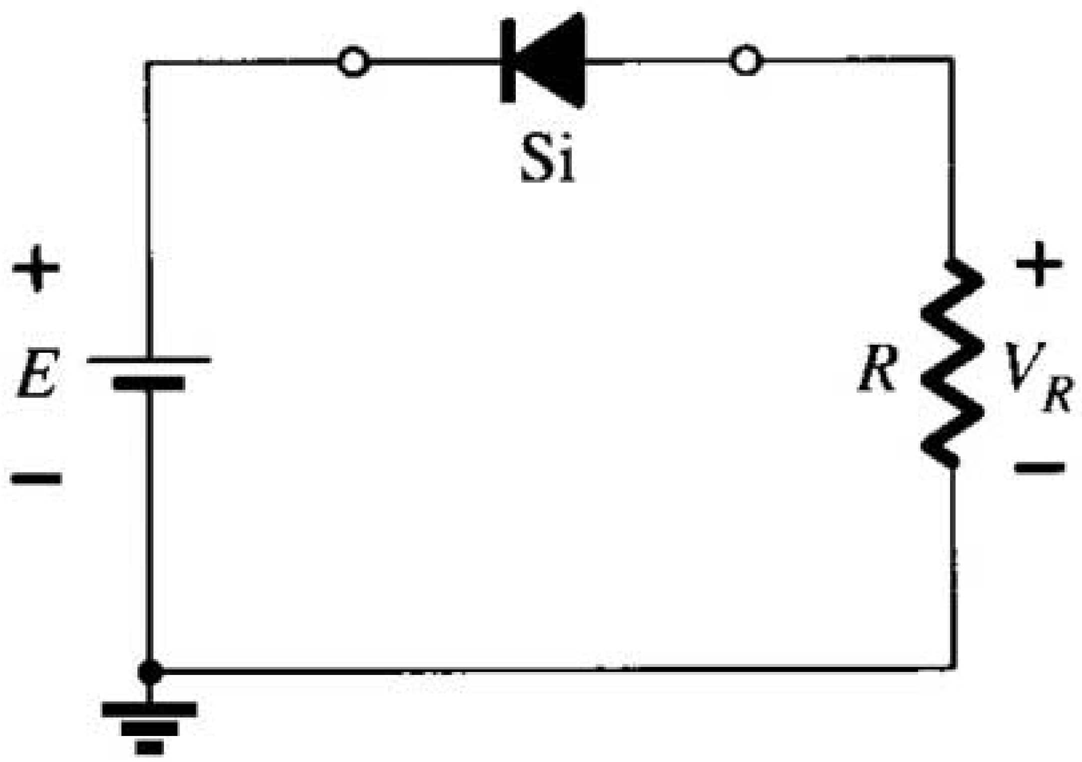
I
+
E
−
+
R
V_R
−

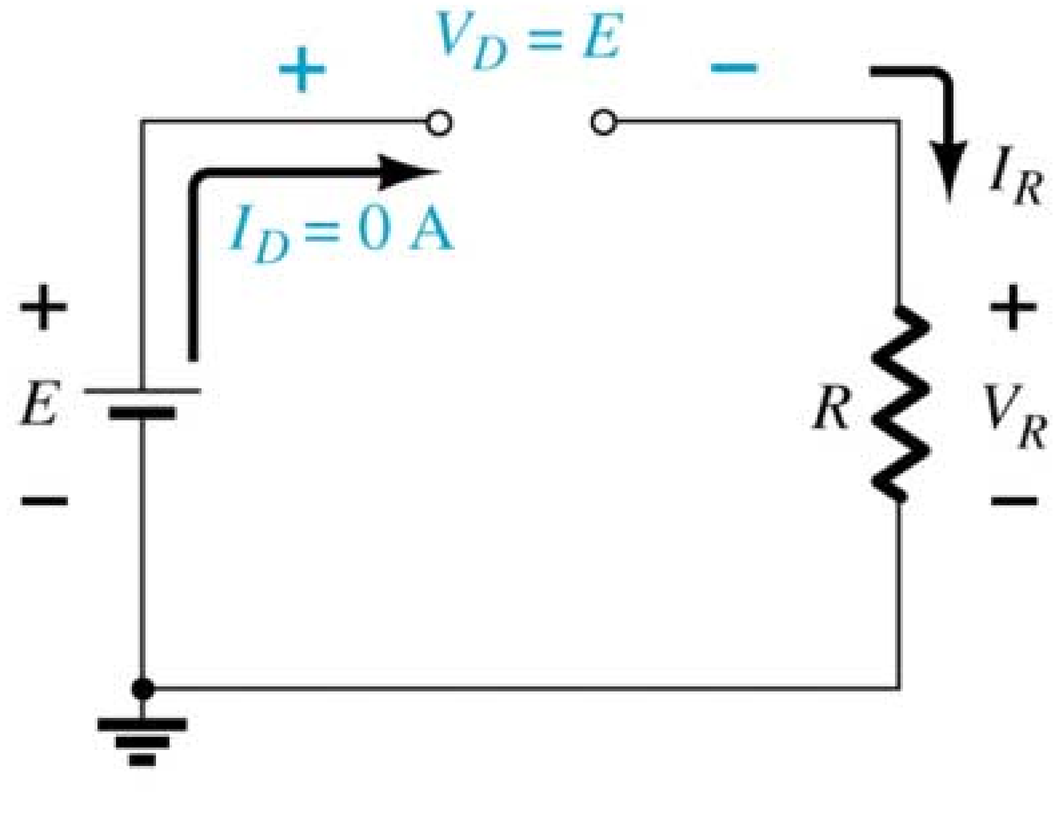
Using equivalent model of the diode in the forward-bias region



Series Diode Config. with DC Inputs

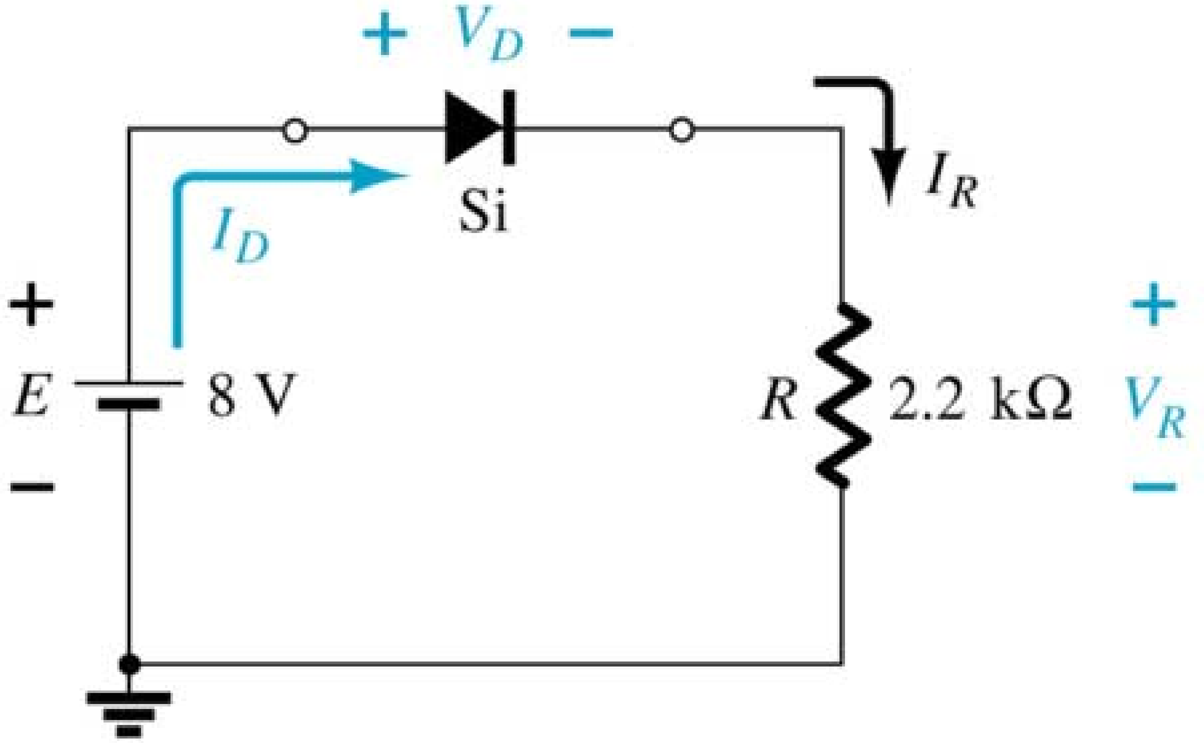
- Here, $V_D = V_T$, $V_R = E - V_T$
- $I_D = I_R = V_R / R$
- When the diode is in the off state, the model for the off state is used
- See two figures
- Here, $V_D = E$, $V_R = 0$, $I_D = 0$
- Keep in mind that KVL has to be satisfied under all conditions
- Exp from notes 1,2,3,4,5


Si
+
E
−
R
+
V_R
−


+
$V_D = E$
−
$I_D = 0$ A
I_R
+
E
−
R
+
V_R
−

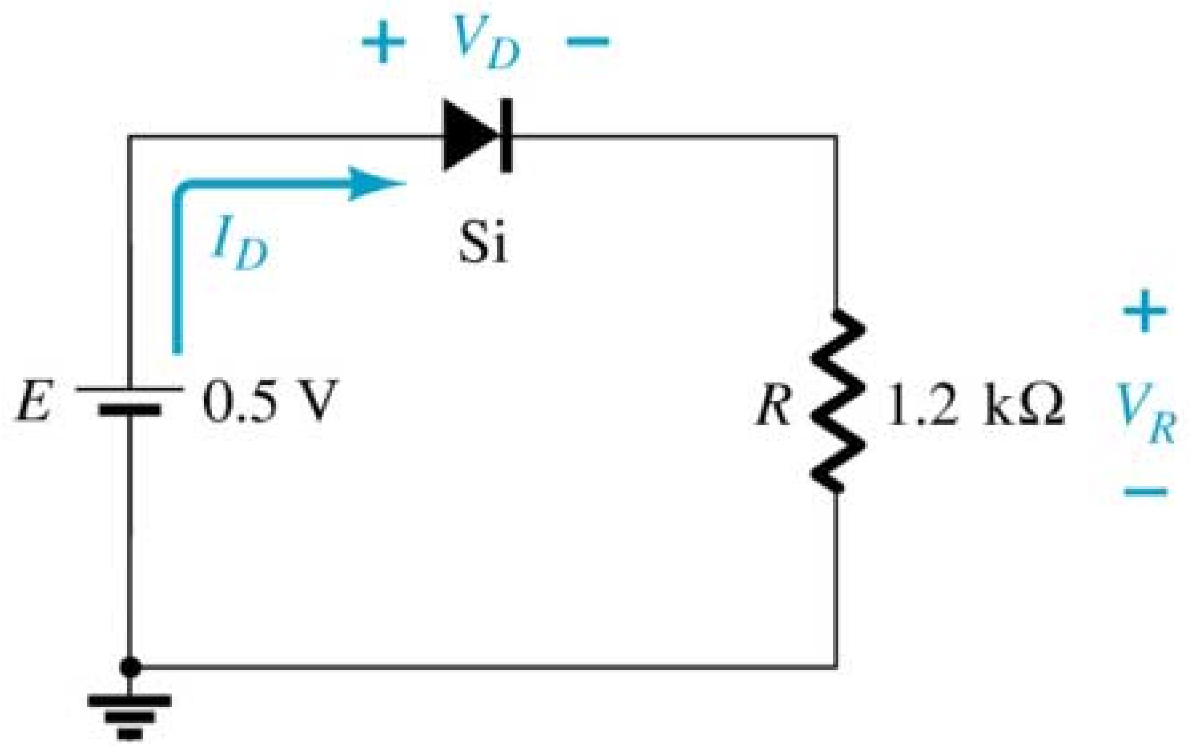
Example 4

- For the figure below, determine V_D, I_D, and V_R
- Refer to notes for the solution



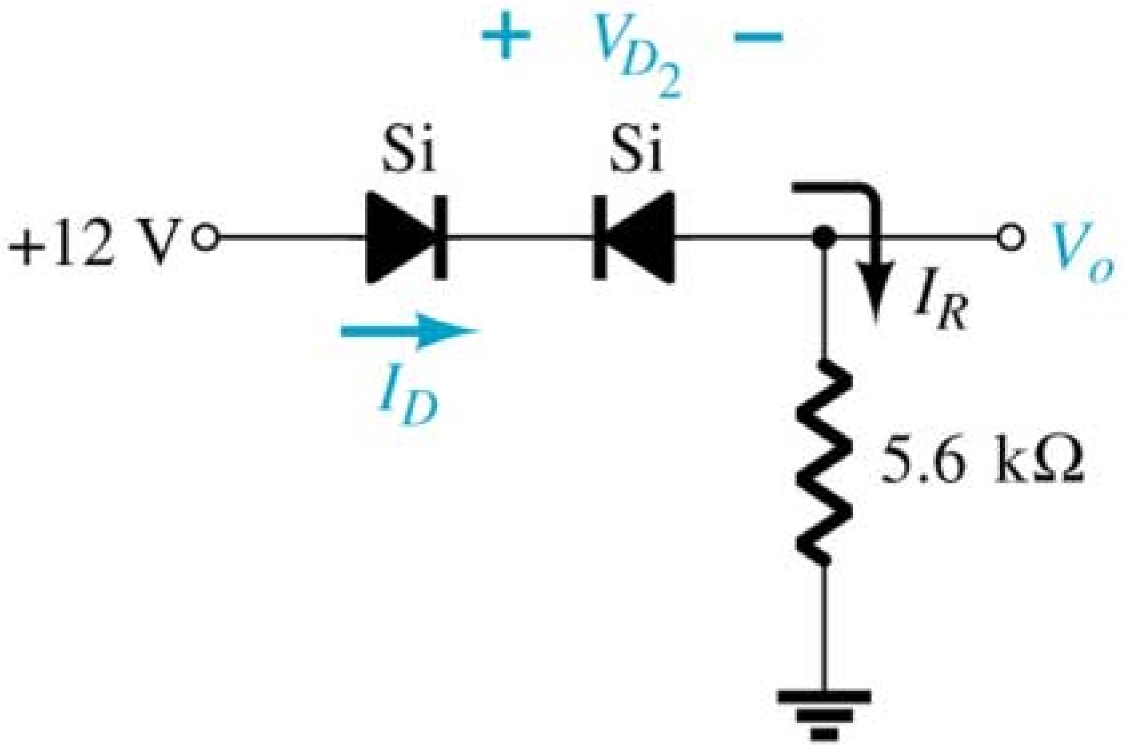
Example 5

- For the figure below, determine V_D, I_D, and V_R
- Refer to notes for the solution



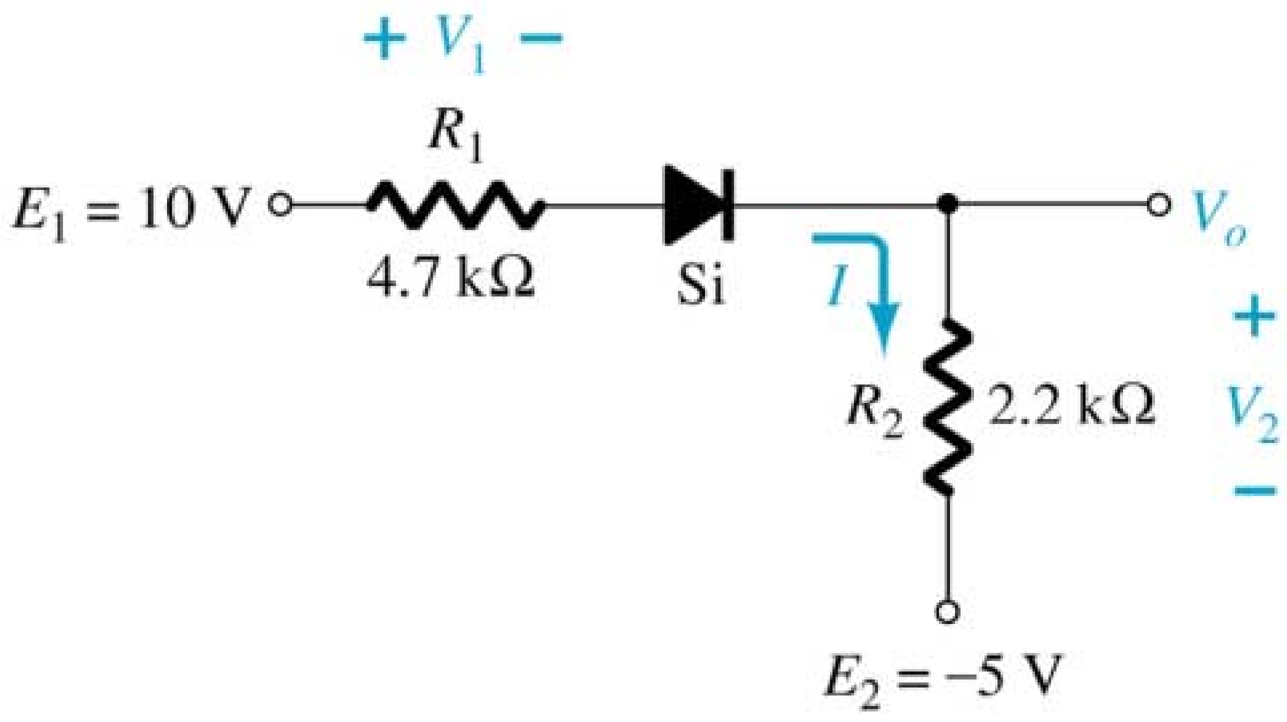
Example 6

- Determine V_{D2} , I_D and V_0 for the figure below
- Refer notes for the solution



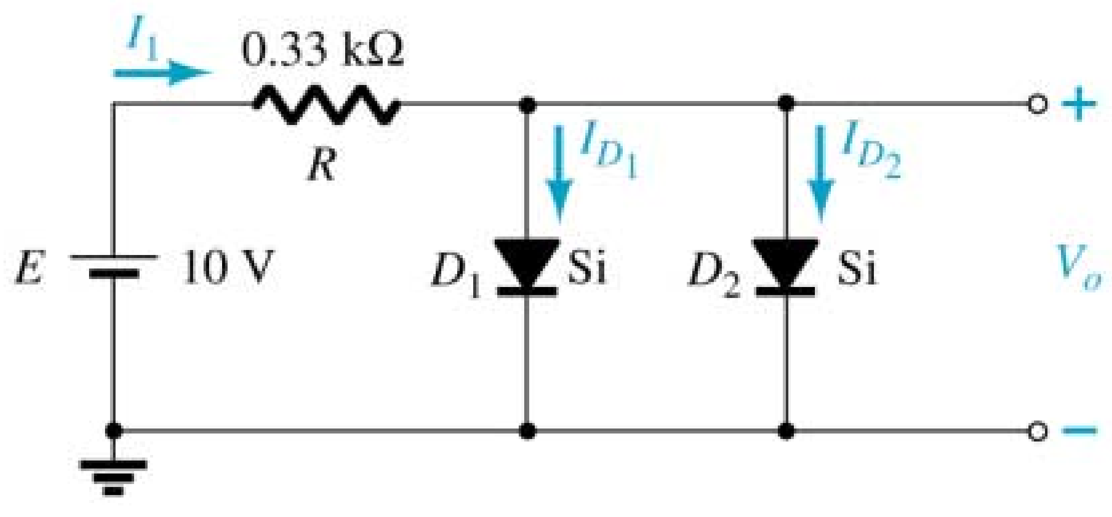
Example 7

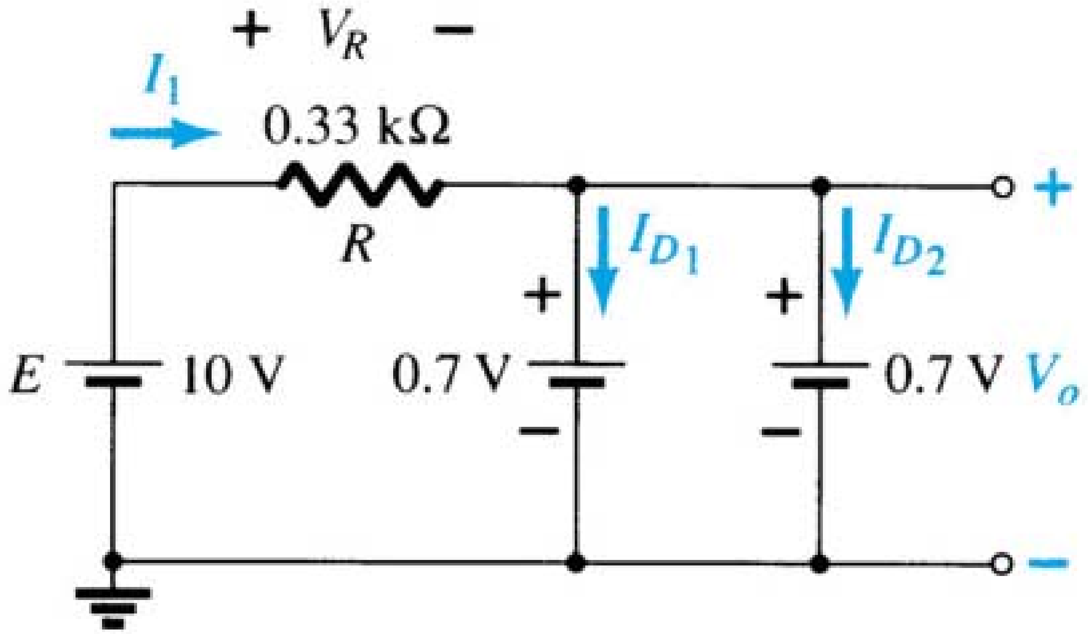
- Determine I_1 , V_1 , V_2 and V_0 for the figure below
- Refer to notes for the solution



Parallel Diode Configurations

- Determine I_1 , V_{D1} , V_{D2} and V_0 for the paralel doide circuit in below figure
- Refer to notes for the solution

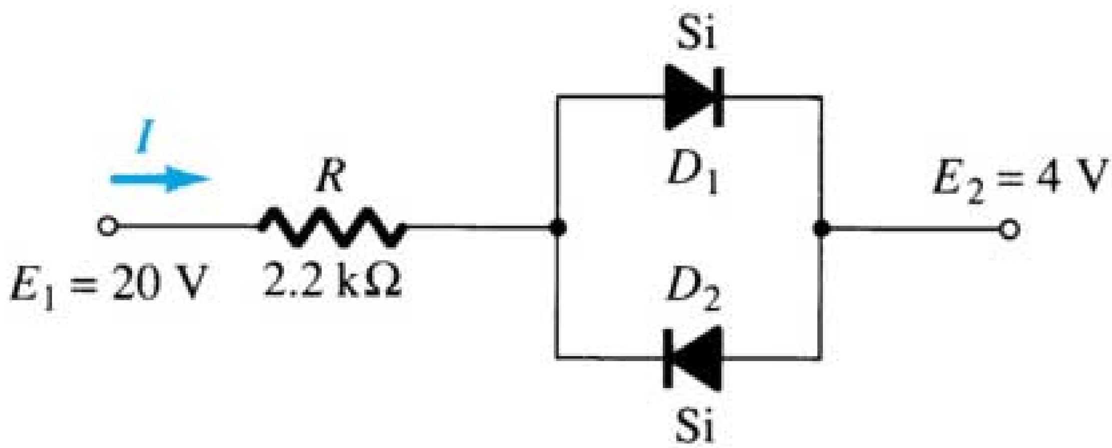




Determining unknown quantities

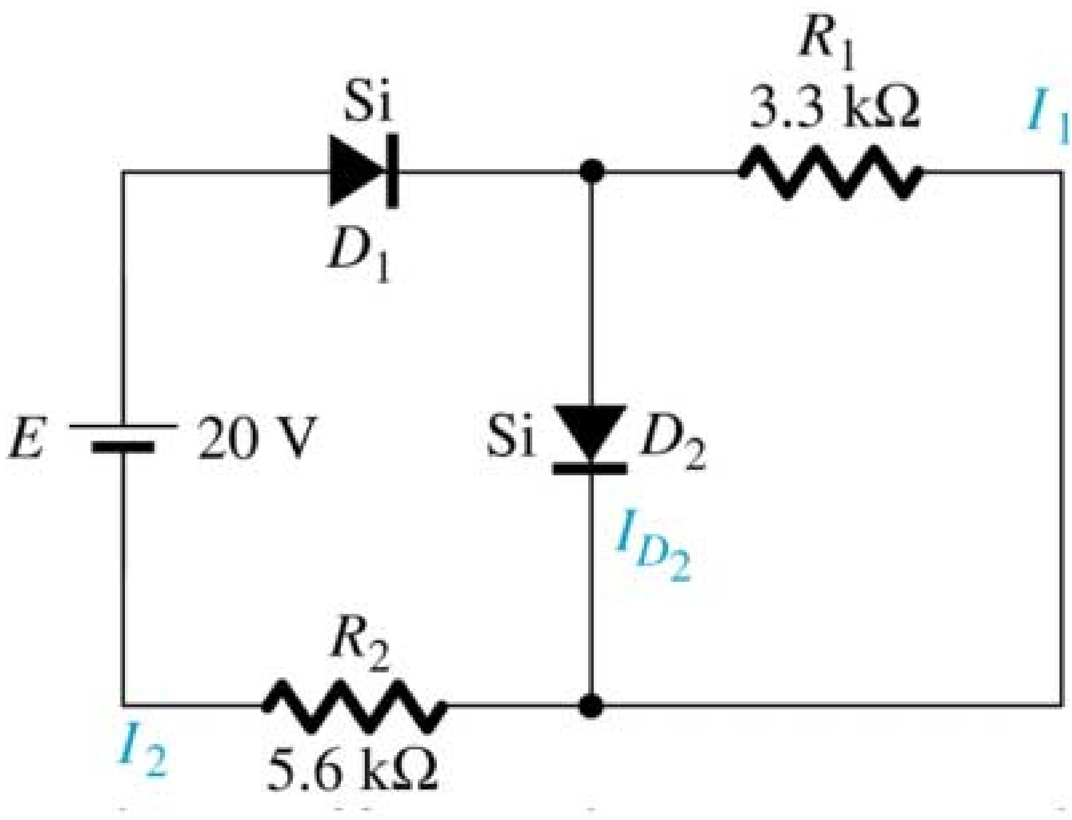
Example 9

- Determine the current I for the circuit below
- Refer to notes for the solution

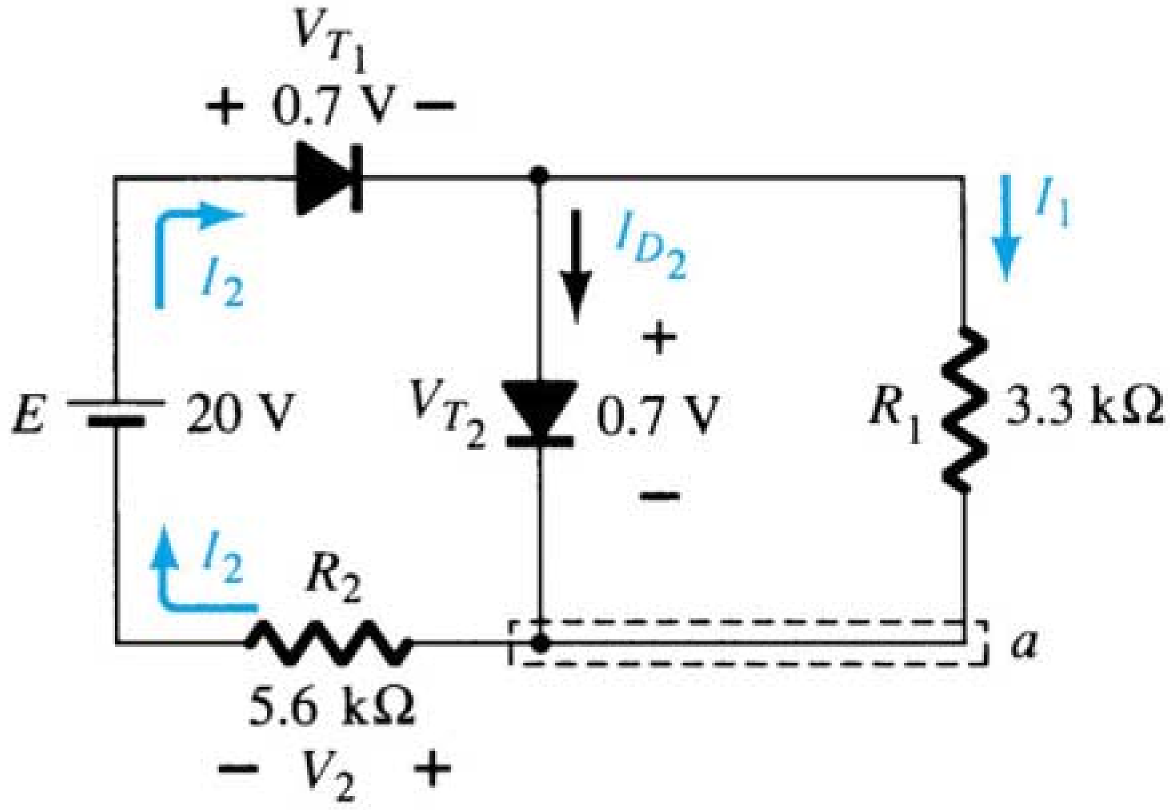


Example 10

- Determine I_1, I_2, and I_D for the figure below
- Refer to notes for the solution



Example 10

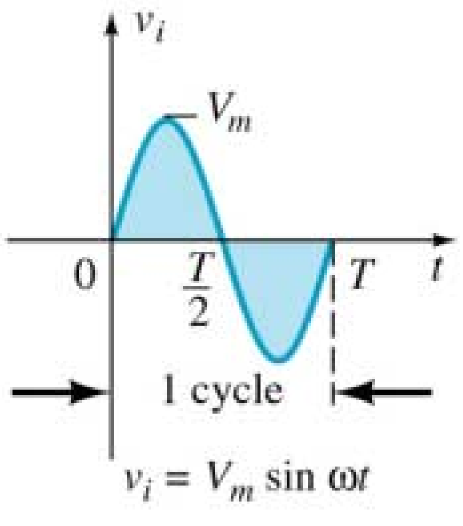


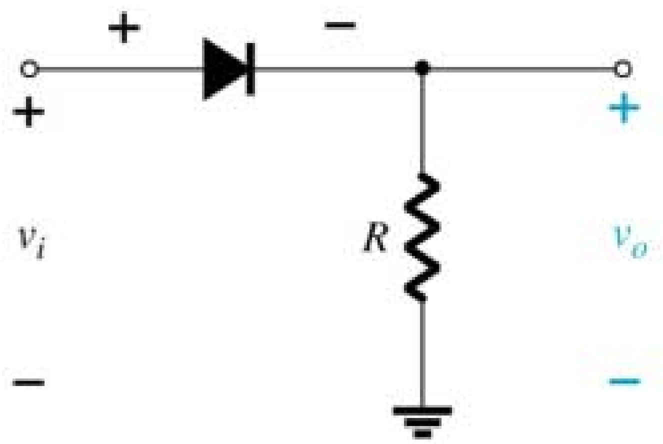
Determining the unknown quantities for the above example

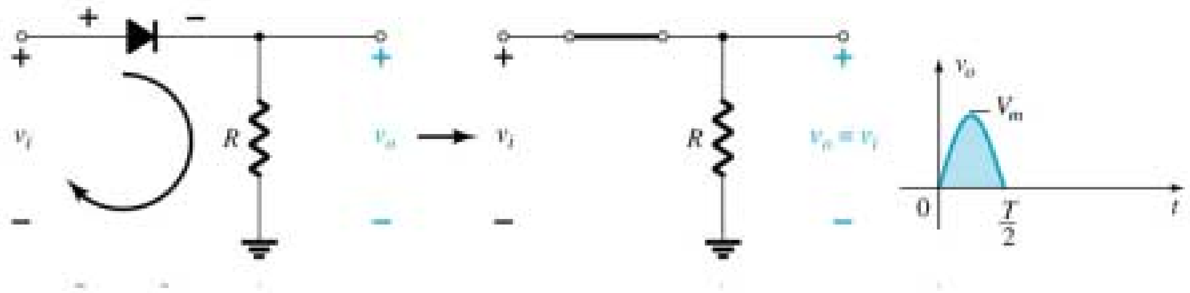
Sinusoidal Inputs: Half-wave Rectifier

- We expand our analysis to include time varying signals
- Such a network is shown as in the next figure
- This circuit is called half-wave rectifier
- For the positive and negative cycles, the circuit is approximated as in below
- See following 2 figures

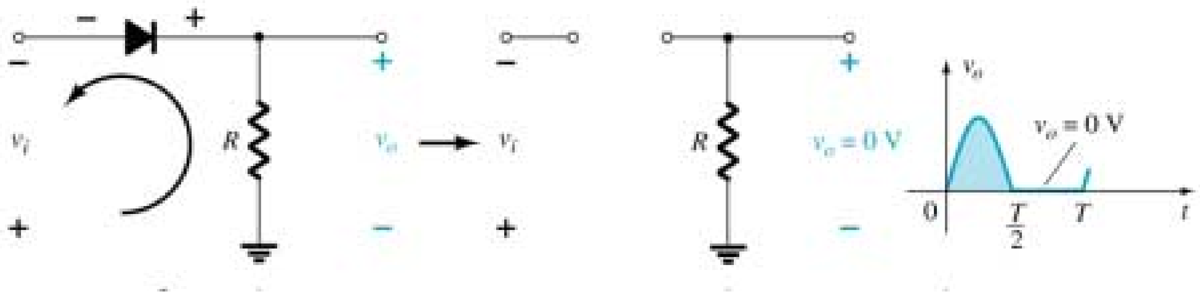
Half-wave Rectifier







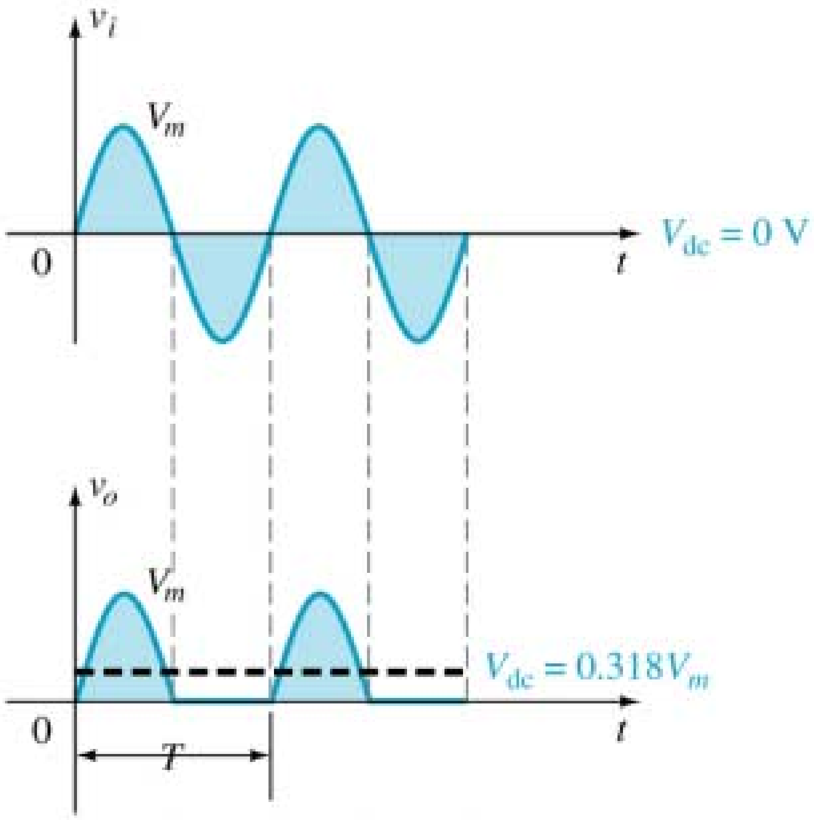
v_i
R
v_o
$v_o = v_i$
v_o
V_m
0
$\frac{T}{2}$
t



v_i
R
v_o
$v_o = 0$ V
v_o
$v_o = 0$ V
0
$\frac{T}{2}$
T
t

Half-wave Rectifier

- The total effect of diode on the output signal is given in below



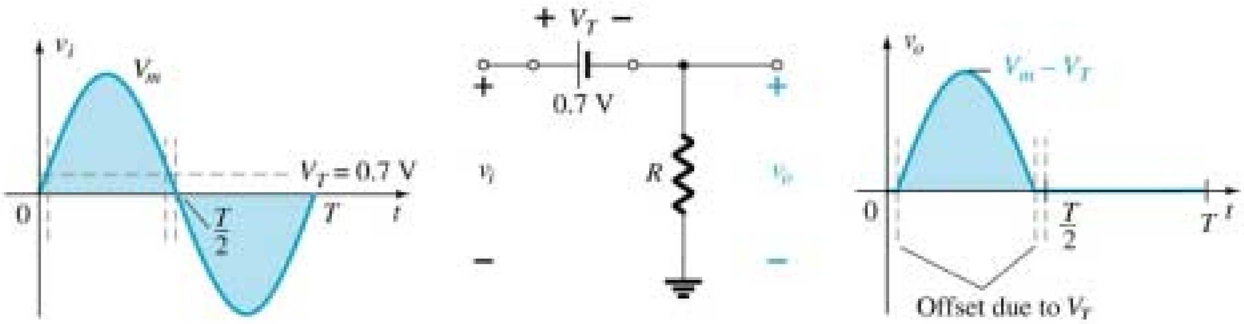
Half-wave Rectifier

- For the half-wave rectified signal:

$$V_{dc} = 0.318\ V_m$$

- If the effect of V_T is also considered, the output of the system will as below
- $V_{dc} = 0.318\ (V_m - V_T)$
- See next Figure

Effect of V_T on half-wave rectified signal



PIV rating of Half-wave Rectifiers

- PIV rating is very important consideration for rectifier circuits
- For the half-wave rectifier:
- $PIV \geq V_m$

Full-wave Rectifiers Bridge Networks

- The dc level obtained from a sinusoidal input to the half-wave rectifier can be improved to 100% using full wave rectifiers
- Bridge networks are used for this purpose
- See Figure 2.54
- For positive and negative cycles, network acts as below
- See Figures 2.55 – 2.58