

DIODE APPROXIMATIONS

SEMICONDUCTOR DIODE

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TOPIC OUTLINE

Diode Approximations

- Ideal Diode
- 2nd Approximation
- 3rd Approximation

Shockley's Equation

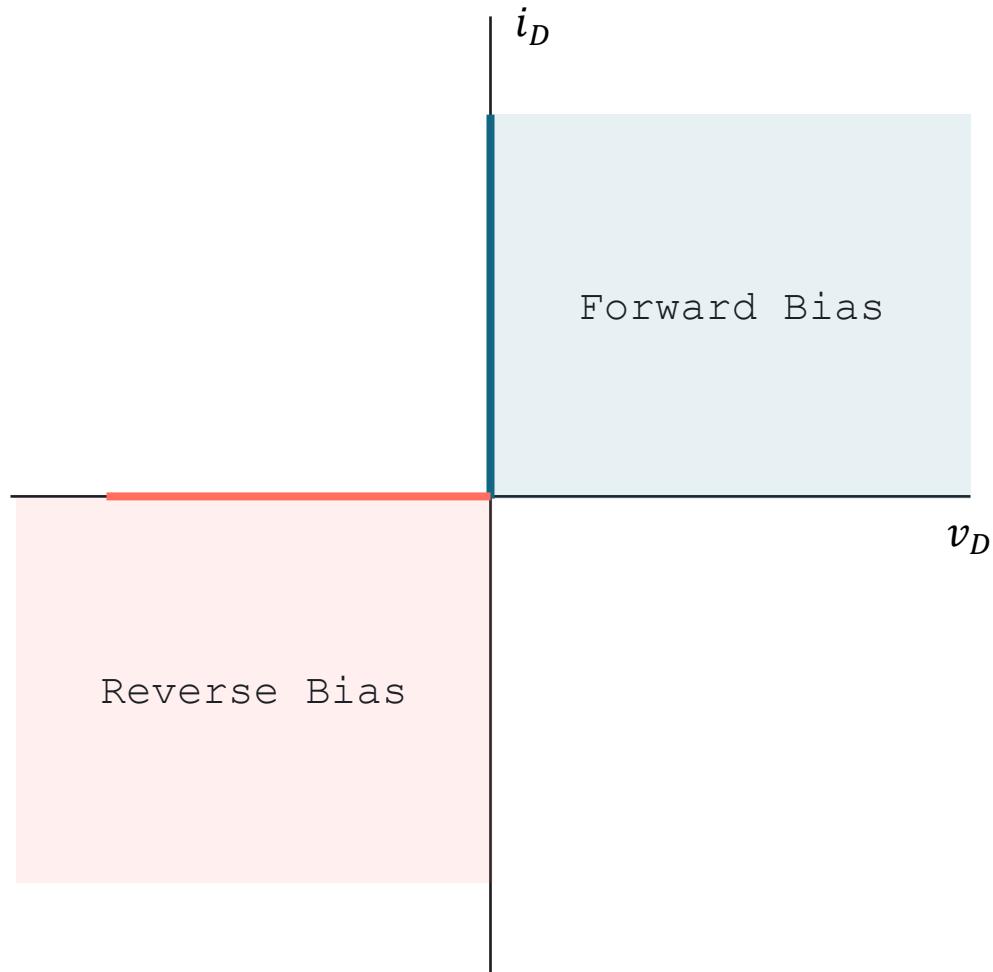
Reading Datasheet



DIODE APPROXIMATIONS

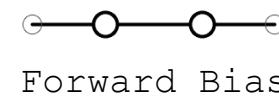
IDEAL DIODE

Characteristic Curve

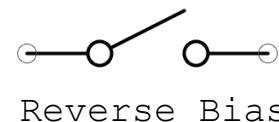


The diode is modeled as an ideal switch.

Circuit Equivalent



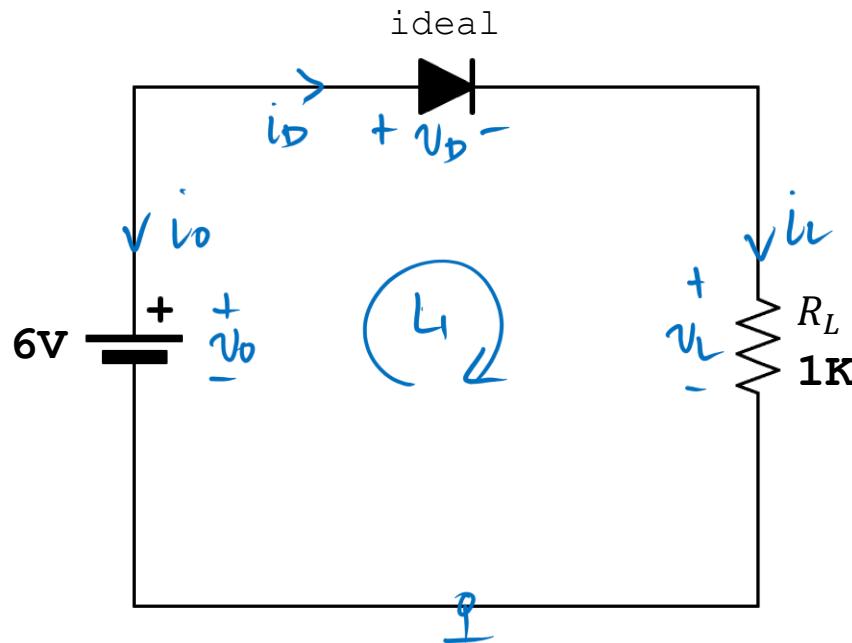
Acts like a closed switch.
(zero (0) resistance)



Acts like an open switch.
(infinite (∞) resistance)

EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

$$\frac{1}{kV L @ L_1}$$
$$-V_0 + \cancel{V_D} + V_L = 0$$

$$V_L = V_0$$

$$V_L = 6V$$

ans

$$i_L = \frac{V_L}{R_L}$$

$$i_L = \frac{6}{1k}$$

$$i_L = 6mA$$

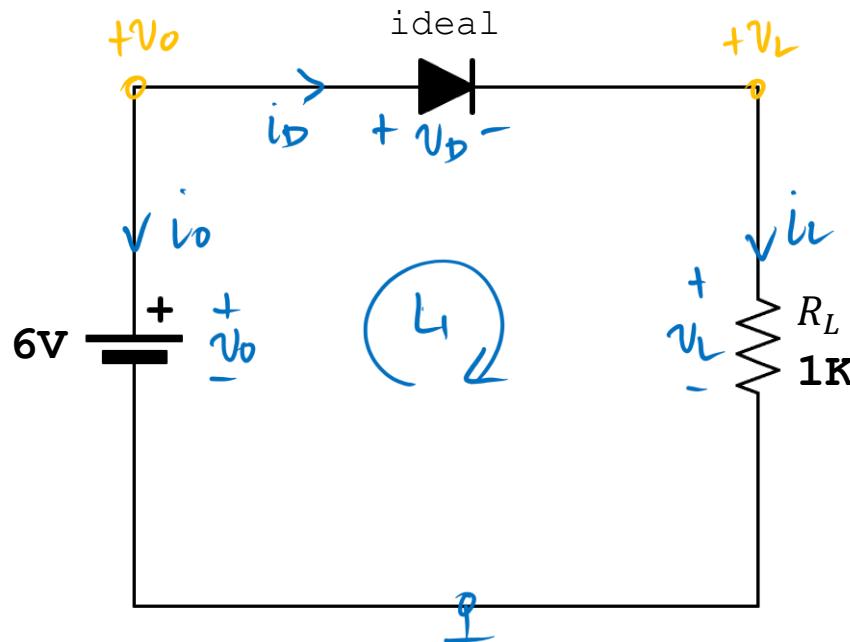
ans

$$P_D = i_D V_D$$

ans

EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

Node Analysis Method

$$v_D^0 = v_o - v_L$$

$$v_L = v_o$$

$$v_L = 6\text{V}$$

ans

$$i_L = \frac{v_L}{R_L}$$

$$i_L = \frac{6}{1\text{K}}$$

$$i_L = 6\text{mA}$$

ans

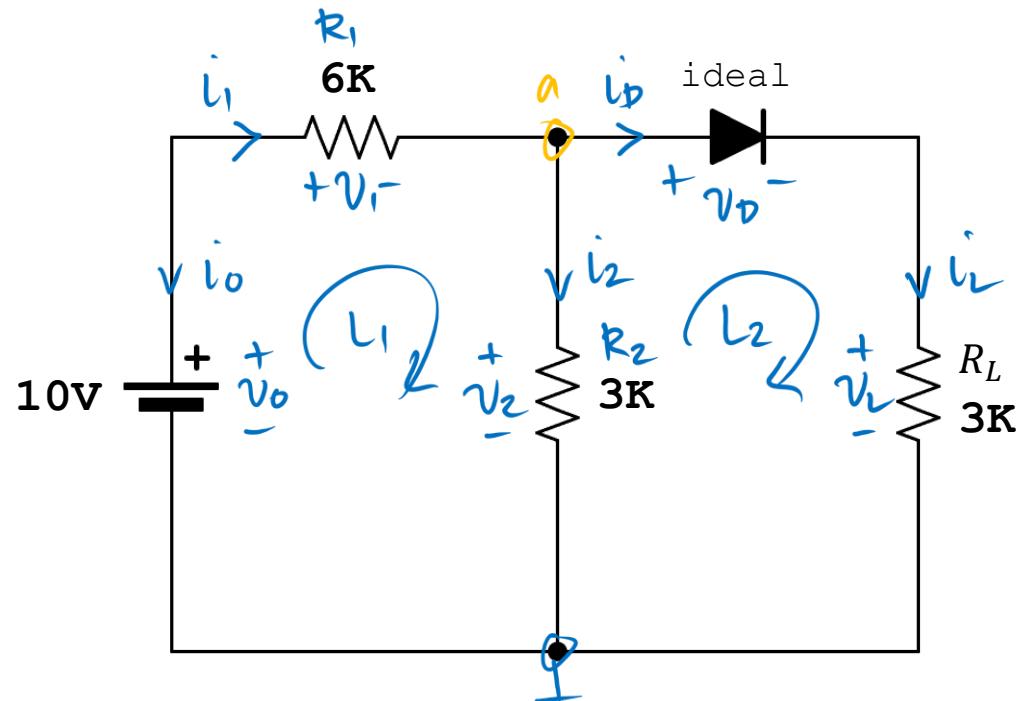
$$P_D = i_D v_D^0$$

$$P_D = 0$$

ans

EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

KVL @ L1

$$-V_0 + V_1 + V_2 = 0$$

$$\underline{V_1 + V_2 = V_0} \quad (\text{eq. 1})$$

KCL @ a

$$-i_1 + i_2 + i_D = 0$$

$$-\frac{V_1}{R_1} + \frac{V_2}{R_2} + i_D = 0$$

$$\underline{-V_1 G_1 + V_2 G_2 + V_0 G_2 = 0} \quad (\text{eq. 2})$$

KVL @ L2

$$-V_2 + V_D + V_L = 0$$

$$\underline{-V_2 + V_L = 0} \quad (\text{eq. 3})$$

EXERCISE

Gaussian Elimination Method

v_1	v_2	v_L		
r_1			0	
			10	r_2
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$		
1	1	0		
0	-1	1		r_3

$r_2 \leftarrow 6r_1 + r_2$

System of Linear Equations

$$\underline{v_1 + v_2 = v_0} \quad (\text{eq. 1})$$

$$\underline{-v_1x_1 + v_2x_2 + v_Lx_L = 0} \quad (\text{eq. 2})$$

$$\underline{-v_2 + v_L = 0} \quad (\text{eq. 3})$$

v_1	v_2	v_L		
r_1			0	
			10	r_2
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$		
0	3	2		
0	-1	1		r_3

EXERCISE

Gaussian Elimination Method

v_1	v_2	v_L	
r_1			
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	0
0	3	2	10
0	0	5	10

v_1	v_2	v_L	
r_1			
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	0
0	3	2	10
0	-1	1	0

System of Linear Equations

$$v_1 + v_2 = v_0 \quad (\text{eq. 1})$$

$$-v_1 r_1 + v_2 r_2 + v_L r_L = 0 \quad (\text{eq. 2})$$

$$-v_2 + v_L = 0 \quad (\text{eq. 3})$$

from r_3

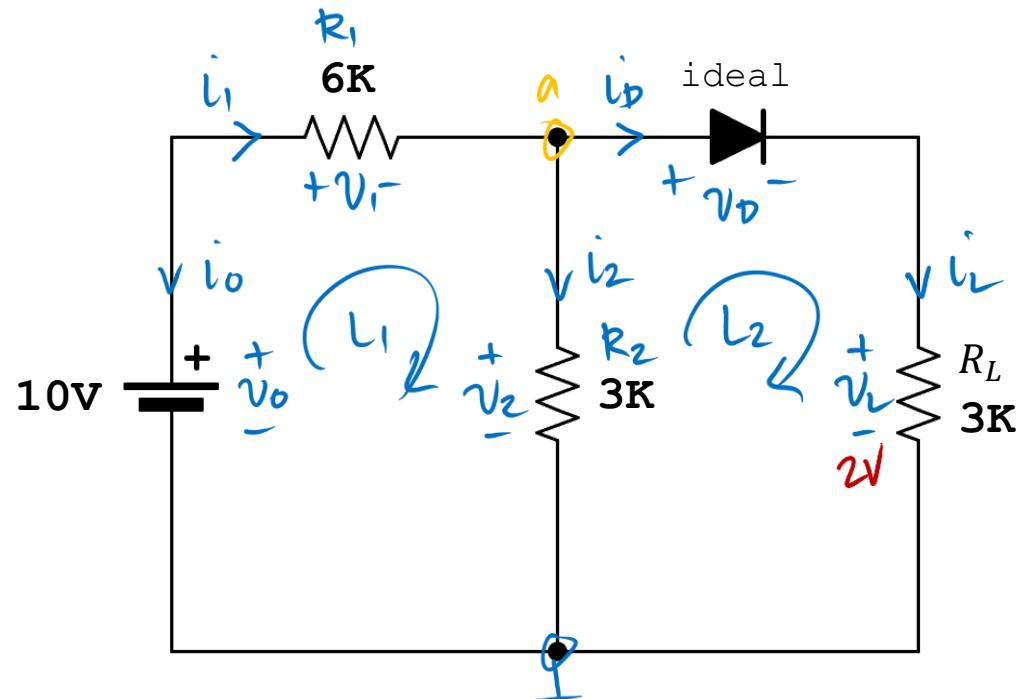
$$\frac{5v_L}{5} = \frac{10}{5}$$

$$\boxed{v_L = 2V}$$

ans

EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

$$i_L = \frac{v_L}{R_L}$$

$$i_L = \frac{2}{3k}$$

$$i_L = 666.67 \text{ mA}$$

ans

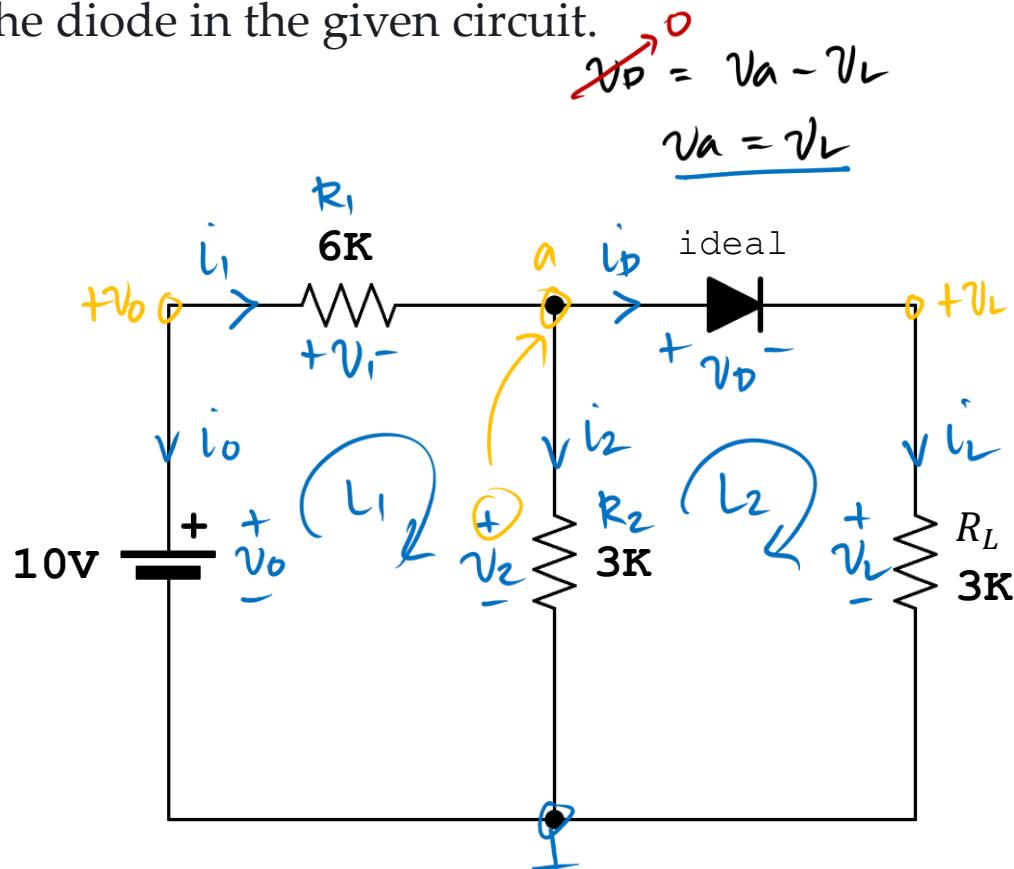
$$P_D = i_D v_D$$

$$P_D = 0$$



EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit. 20



Solution

Node Analysis Method

KCL @ a

$$-i_1 + i_2 + \cancel{i_3} = 0$$

$$-\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_L}{R_L} = 0$$

$$-\frac{V_0 - V_L}{R_1} + \frac{V_L}{R_2} + \frac{V_L}{R_L} = 0$$

$$-\underline{V_0 G_1} + \underline{V_L G_1} + \underline{V_L G_2} + \underline{V_L G_L} = 0$$

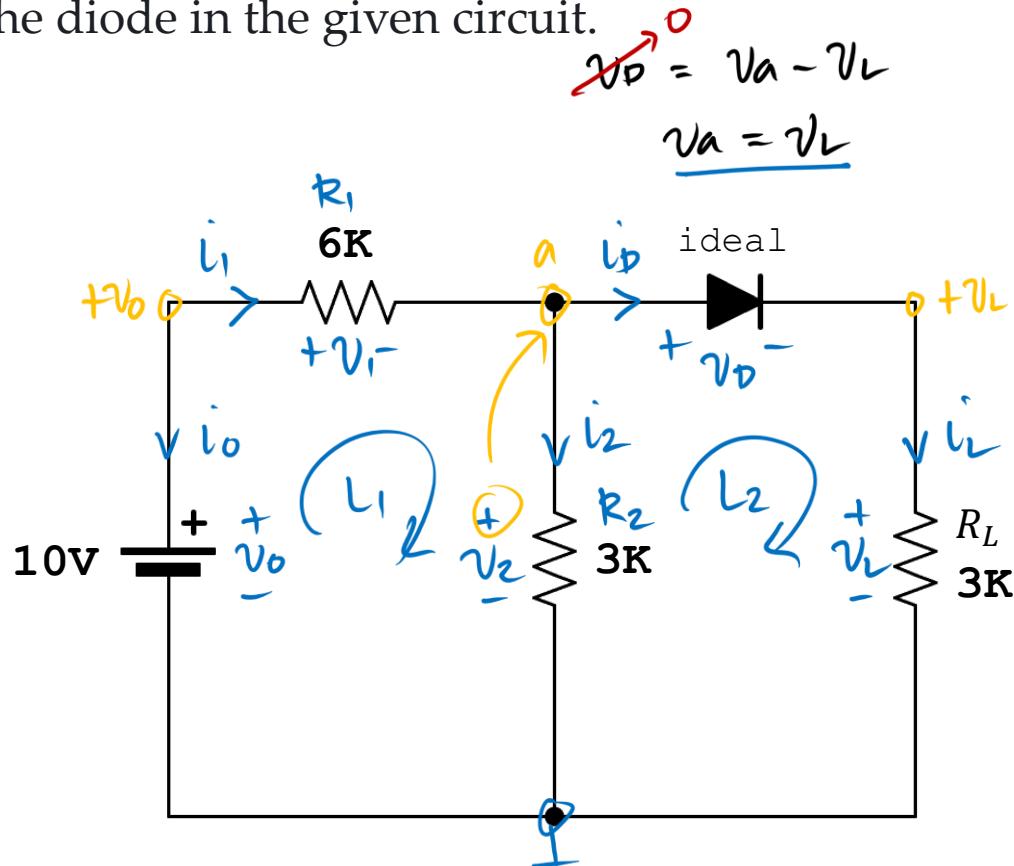
$$v_L(\theta_1 + \theta_2 + \theta_L) = v_0 \theta_1$$

$$V_L = \frac{V_0 G_1}{G_1 + G_2 + G_3}$$



EXERCISE

Using the ideal diode model, determine the load voltage, load current, and the power dissipated by the diode in the given circuit. 20



Solution

$$V_L = \frac{V_0 G_1}{G_1 + G_2 + G_3}$$

$$V_L = \frac{10(\%k)}{\%k + \%k + \%k}$$

$$V_L = 2V$$

$$i_L = \frac{v_L}{R_L}$$

$$i_L = \frac{2}{3k}$$

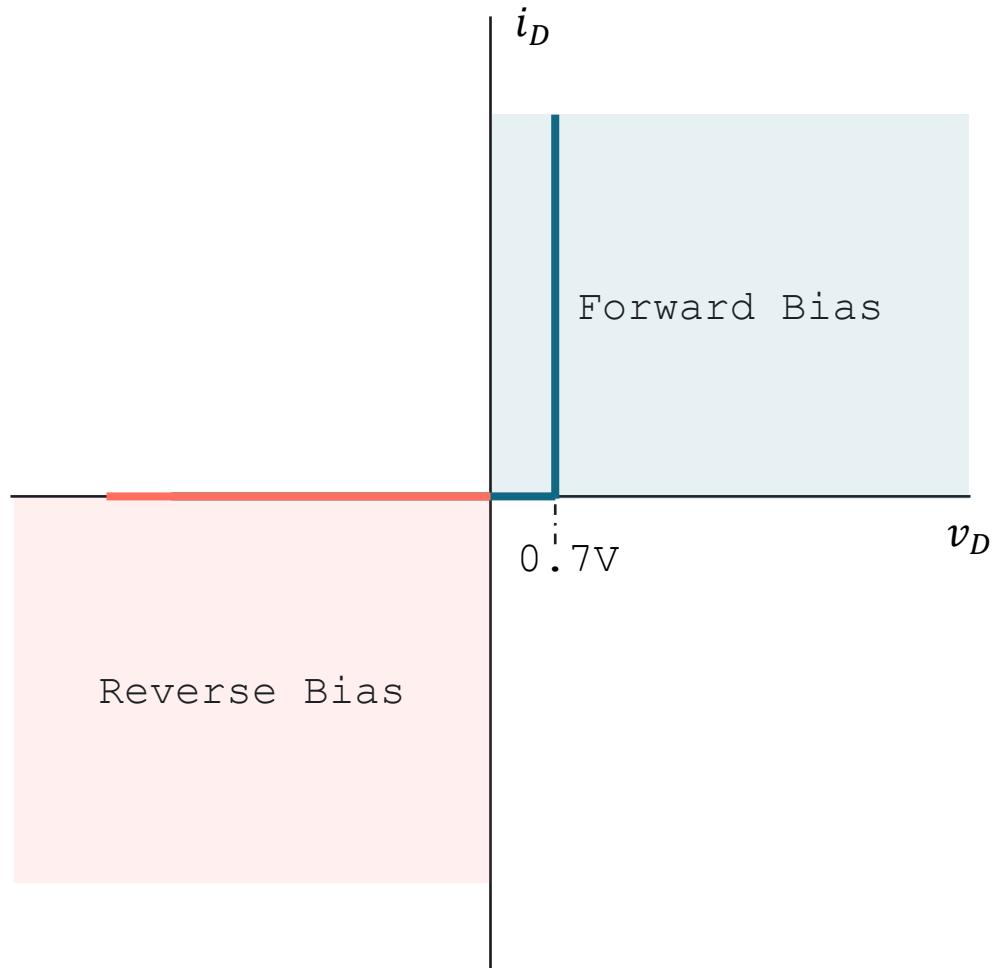
$$li = 666.67 \text{ ms}$$

$$P_D = \cancel{i_D V_D}^0$$



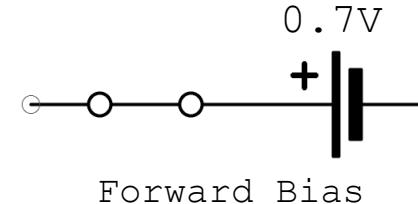
2ND APPROXIMATION

Characteristic Curve

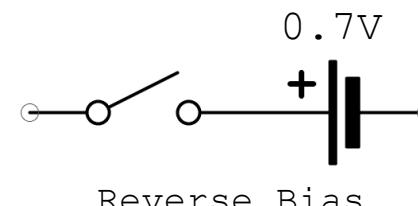


The diode is modeled as an ideal switch in series with a barrier potential.

Circuit Equivalent



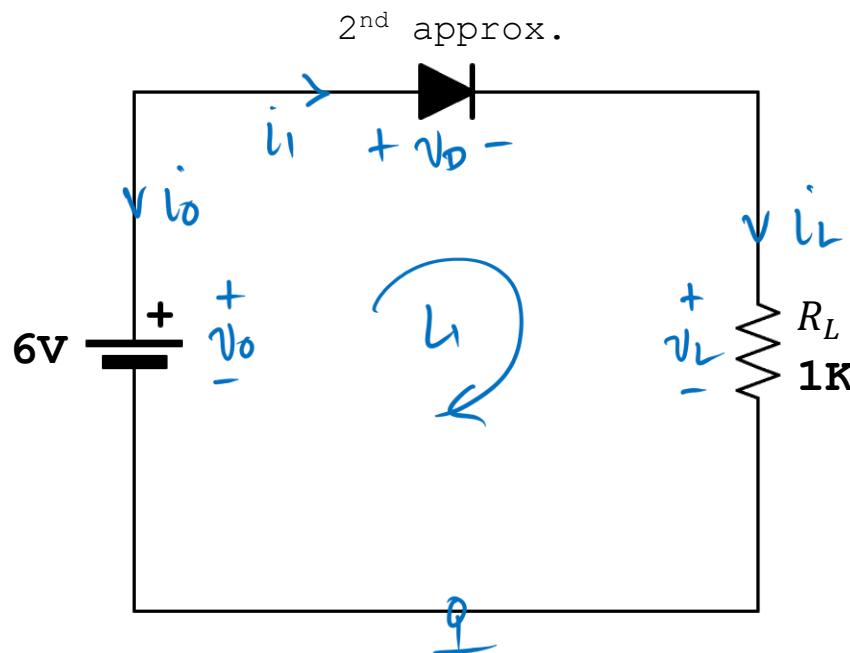
If $v_D \geq 0.7$ V, the switch is closed, and the diode conducts.



If $v_D < 0.7$ V, the switch is open, and the diode does not conduct.

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

KVL @ L1

$$-V_0 + V_D + V_L = 0$$

$$V_L = V_0 - V_D$$

$$V_L = 6 - 0.7$$

$$V_L = 5.3\text{V}$$

ans

$$i_L = \frac{V_L}{R_L}$$

$$i_L = \frac{5.3}{1\text{K}}$$

$$i_L = 5.3\text{mA}$$

ans

$$P_D = i_D V_D$$

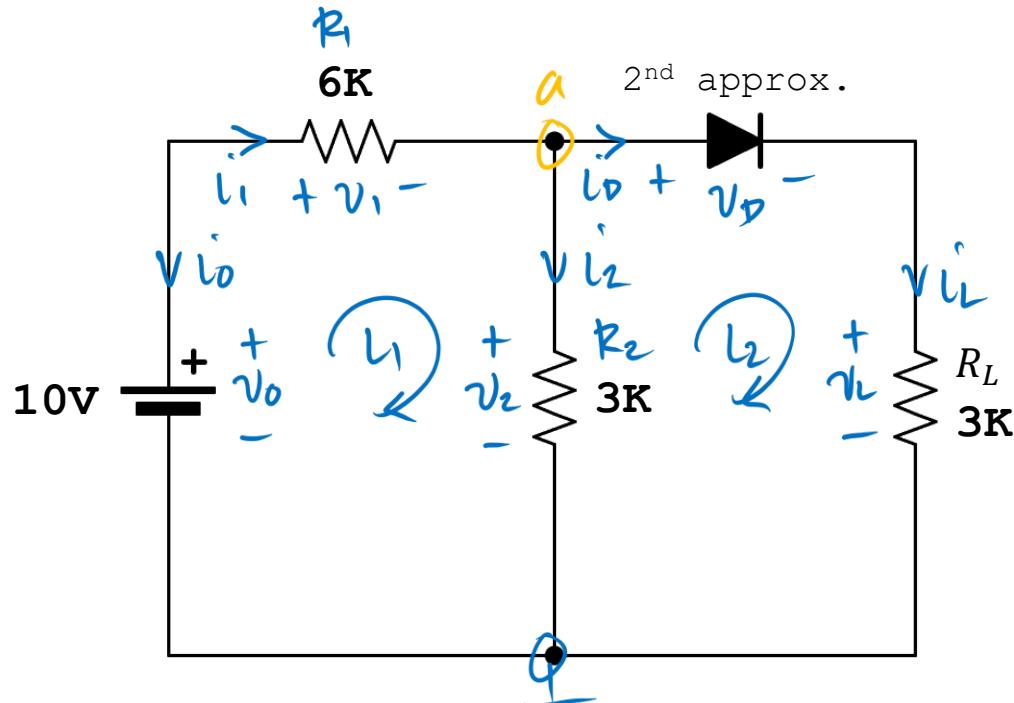
$$P_D = 5.3 \text{mA} (0.7)$$

$$P_D = 3.71 \text{mW}$$

ans

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

$$\frac{KCL @ a}{-i_1 + i_2 + \cancel{i_D} = 0}$$

$$-\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_L}{R_L} = 0$$

$$-V_1 \mathcal{G}_1 + V_2 \mathcal{G}_2 + V_L \mathcal{G}_2 = 0 \quad (\text{eq.1})$$

$$\frac{KVL @ L_1}{-V_0 + V_1 + V_2 = 0}$$

$$V_1 + V_2 = V_0$$

$$V_1 + V_2 = V_0 \quad (\text{eq.2})$$

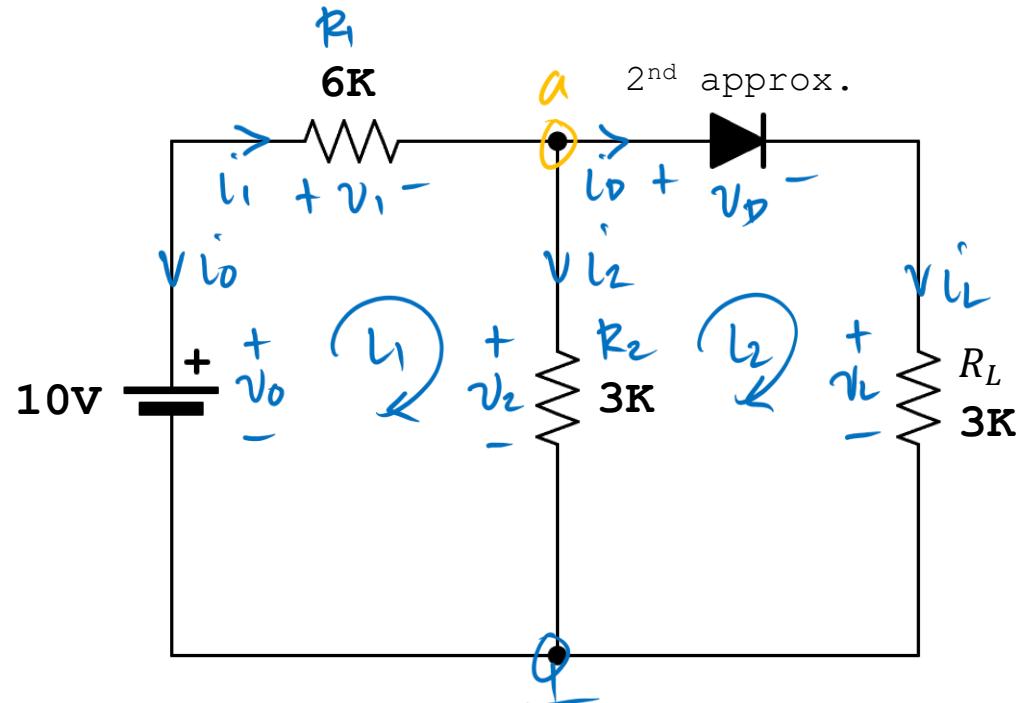
$$\frac{KVL @ L_2}{-V_2 + V_D + V_L = 0}$$

$$-V_2 + V_L = -V_D$$

$$-V_2 + V_L = -V_D \quad (\text{eq.3})$$

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

$$-V_1G_1 + V_2G_2 + V_3G_3 = 0 \quad (\text{eq.1})$$

$$V_1 + V_2 = V_0 \quad (\text{eq.2})$$

$$-V_2 + V_L = -V_D \quad (\text{eq.3})$$

EXERCISE

Gaussian Elimination Method

v_1	v_2	v_L		
r_1				
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	0	
1	1	0	10	$r_2 \leftarrow 6r_1 + r_2$
0	-1	1	-0.7	r_3

v_1	v_2	v_L		
r_1				
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	0	
0	3	2	10	r_2
0	-1	1	-0.7	r_3

System of Linear Equations

$$-\frac{1}{6}v_1 + \frac{1}{3}v_2 + \frac{1}{3}v_L = 0 \quad (\text{eq.1})$$

$$v_1 + v_2 = 10 \quad (\text{eq.2})$$

$$-v_2 + v_L = -0.7 \quad (\text{eq.3})$$

EXERCISE

Gaussian Elimination Method

v_1	v_2	v_L	
r_1			
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	0
0	3	2	10
0	0	5	7.9

v_1	v_2	v_L	
r_1			
$-\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{3}$	0
0	3	2	10
0	-1	1	-0.7

System of Linear Equations

$$-\frac{1}{6}v_1 + \frac{1}{3}v_2 + \frac{1}{3}v_L = 0 \quad (\text{eq.1})$$

$$v_1 + v_2 = 10 \quad (\text{eq.2})$$

$$-v_2 + v_L = -0.7 \quad (\text{eq.3})$$

from r_3

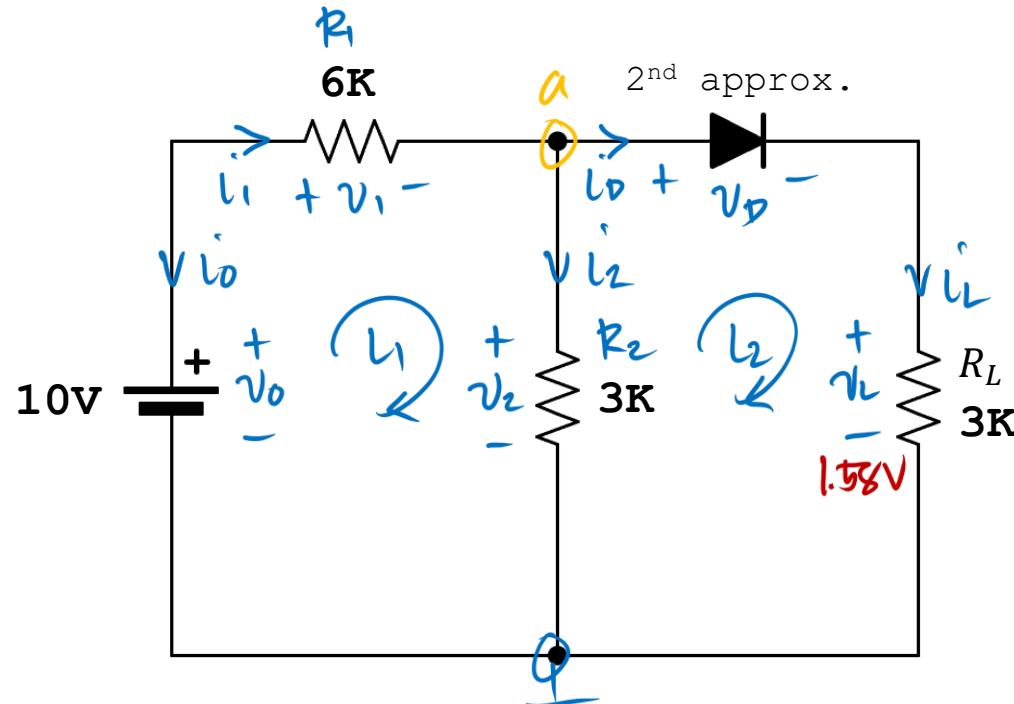
$$\frac{v_L}{5} = \frac{7.9}{5}$$

$$v_L = 1.58 \text{ V}$$

ans

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

$$i_L = \frac{V_L}{R_L}$$

$$i_L = \frac{1.58}{3k}$$

$$i_L = 520.67 \mu A$$

ans

$$P_D = i_D v_D$$

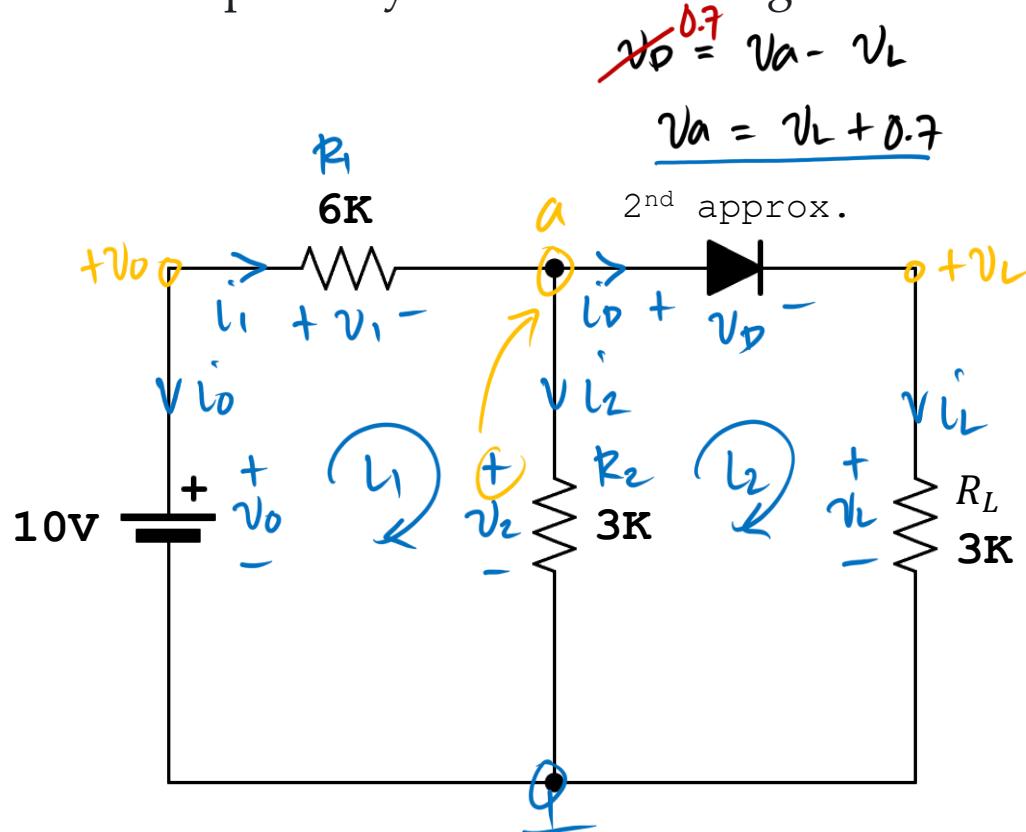
$$P_D = 520.67 \mu A (0.7)$$

$$P_D = 368.67 \mu W$$

ans

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

Node Analysis Method

KCL @ a

$$-i_1 + i_2 + i_D = 0$$

$$-\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_L}{R_L} = 0$$

$$-\frac{v_0 - v_a}{R_1} + \frac{v_L}{R_2} + \frac{v_L}{R_L} = 0$$

$$-v_0 G_1 + v_a G_1 + v_a G_2 + v_L G_L = 0$$

$$-v_0 G_1 + v_a (G_1 + G_2) + v_L G_L = 0$$

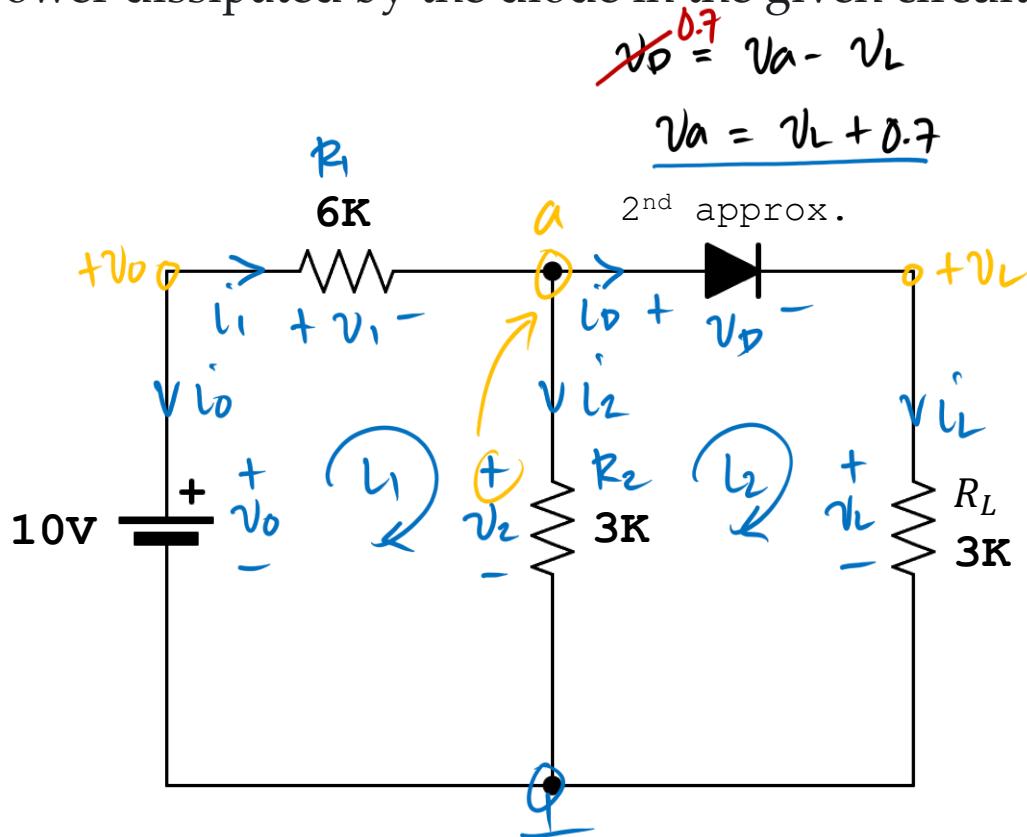
$$-v_0 G_1 + (v_L + 0.7 (G_1 + G_2)) + v_L G_L = 0$$

$$-v_0 G_1 + v_L (G_1 + G_2) + 0.7 (G_1 + G_2) + v_L G_L = 0$$

$$\frac{v_L (G_1 + G_2 + G_L)}{G_1 + G_2 + G_L} = \frac{v_0 G_1 - 0.7 (G_1 + G_2)}{G_1 + G_2 + G_L}$$

EXERCISE

Apply the second approximation of the diode model to determine the load voltage, load current, and the power dissipated by the diode in the given circuit.



Solution

$$V_L = \frac{V_0 G_1 - 0.7 (G_1 + G_2)}{G_1 + G_2 + G_L}$$

$$V_L = \frac{10 (\frac{1}{6k}) - 0.7 (\frac{1}{6k} + \frac{1}{3k})}{\frac{1}{6k} + \frac{1}{3k} + \frac{1}{3k}}$$

$$V_L = 1.58 \text{ V}$$

ans

$$P_D = i_D V_D$$

$$i_L = \frac{V_L}{R_L}$$

$$i_L = \frac{1.58}{3k}$$

$$i_L = 520.67 \text{ mA}$$

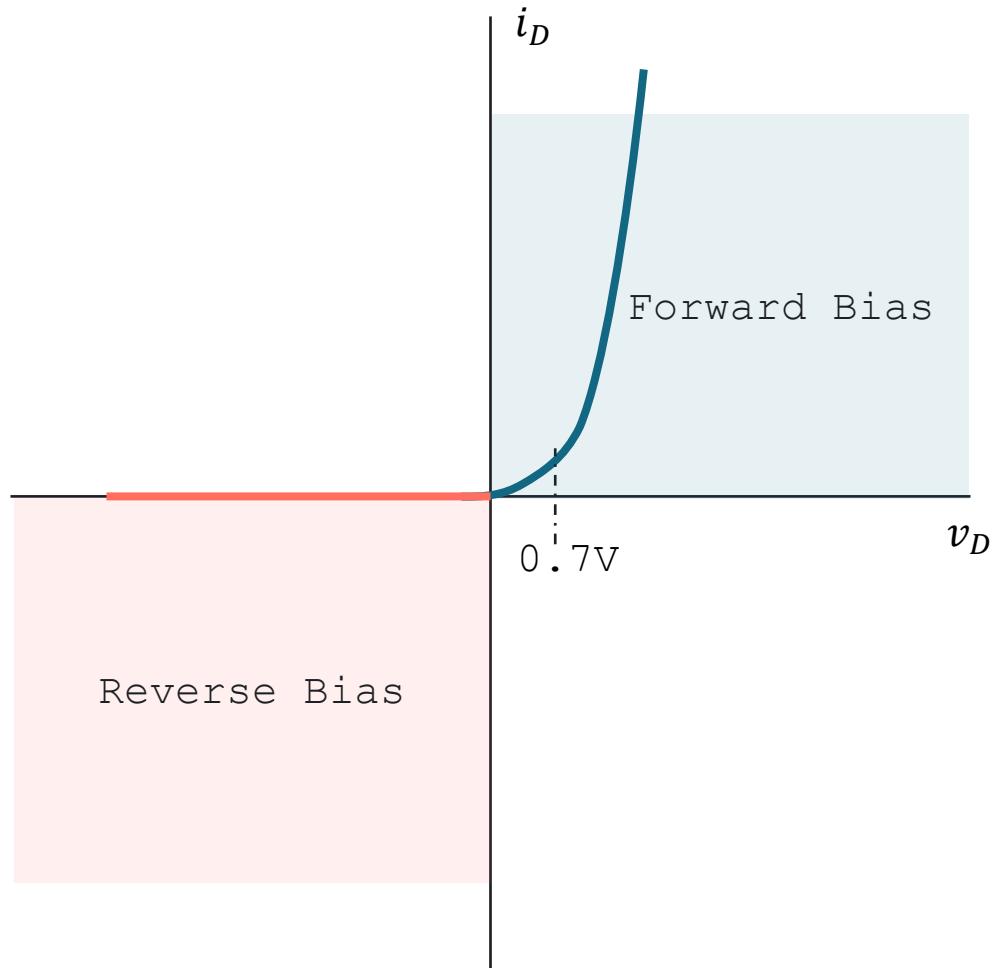
ans

$$P_D = 520.67 \text{ mW}$$

ans

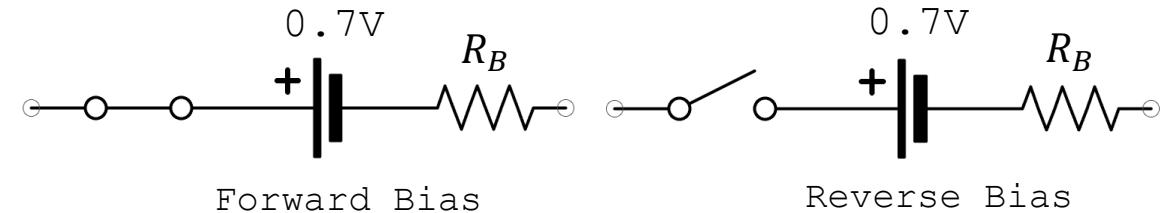
3RD APPROXIMATION

Characteristic Curve



The diode is modeled as an ideal switch in series with a barrier potential and a bulk resistance.

Circuit Equivalent

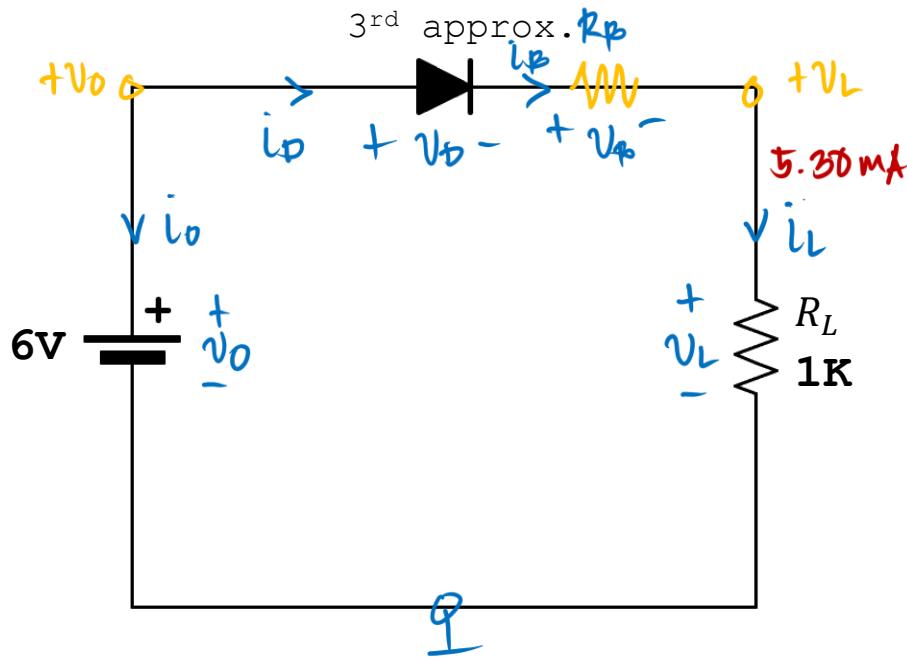


$$v_D = 0.7V + i_D R_B$$

Typical value of $R_B < 1\Omega$,
and often ignored if $R_B < 0.01R_{TH}$

EXERCISE

The 1N4001 of the given network has a bulk resistance of 0.23Ω . What is the load voltage, load i_L, and the power dissipated by the diode?



Solution

Node Analysis Method

$$V_D + V_B = V_0 - V_L$$

$$V_D + i_D R_B = V_0 - i_L R_L$$

$$i_L R_B + i_L R_L = V_0 - V_D$$

$$\frac{i_L (R_B + R_L)}{R_B + R_L} = \frac{V_0 - V_D}{R_B + R_L}$$

$$i_L = \frac{6 - 0.7}{0.23 + 1k}$$

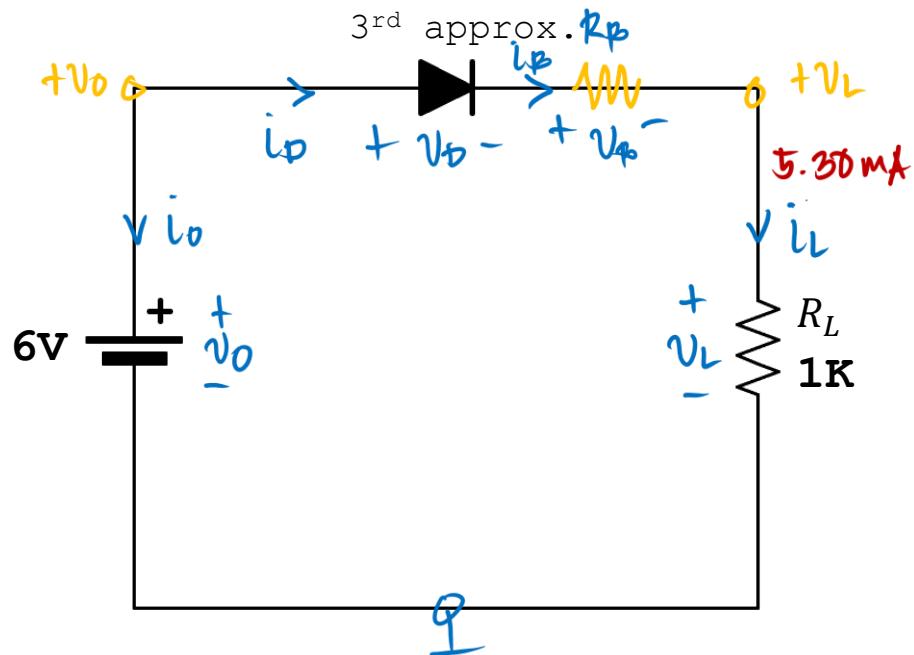
$$i_L = 5.30 \text{ mA}$$

ans



EXERCISE

The 1N4001 of the given network has a bulk resistance of 0.23Ω . What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$V_L = i_L R_L$$

$$V_L = 5.30 \text{ mA} (1\text{K})$$

$$V_L = 5.30 \text{ V}$$

ans

$$P_D = i_D V_D + i_B V_B$$

$$P_D = i_D V_D + i_B^2 R_B$$

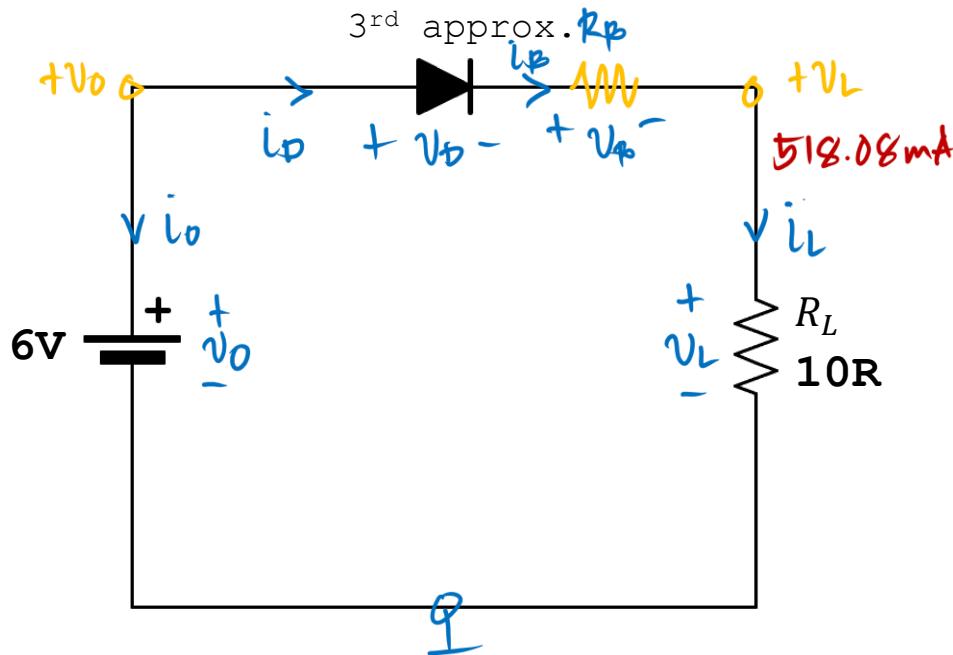
$$P_D = 5.3 \text{ mA} (0.7) + (5.3)^2 (0.23)$$

$$P_D = 3.72 \text{ mW}$$

ans

EXERCISE

The 1N4001 of the given network has a bulk resistance of 0.23Ω . What is the load voltage, load i_L, and the power dissipated by the diode?



Solution

Node Analysis Method

$$V_D + V_B = V_0 - V_L$$

$$V_D + i_D R_D = V_0 - i_L R_L$$

$$i_L R_D + i_L R_L = V_0 - V_D$$

$$\frac{i_L (R_D + R_L)}{R_D + R_L} = \frac{V_0 - V_D}{R_D + R_L}$$

$$i_L = \frac{6 - 0.7}{0.23 + 10}$$

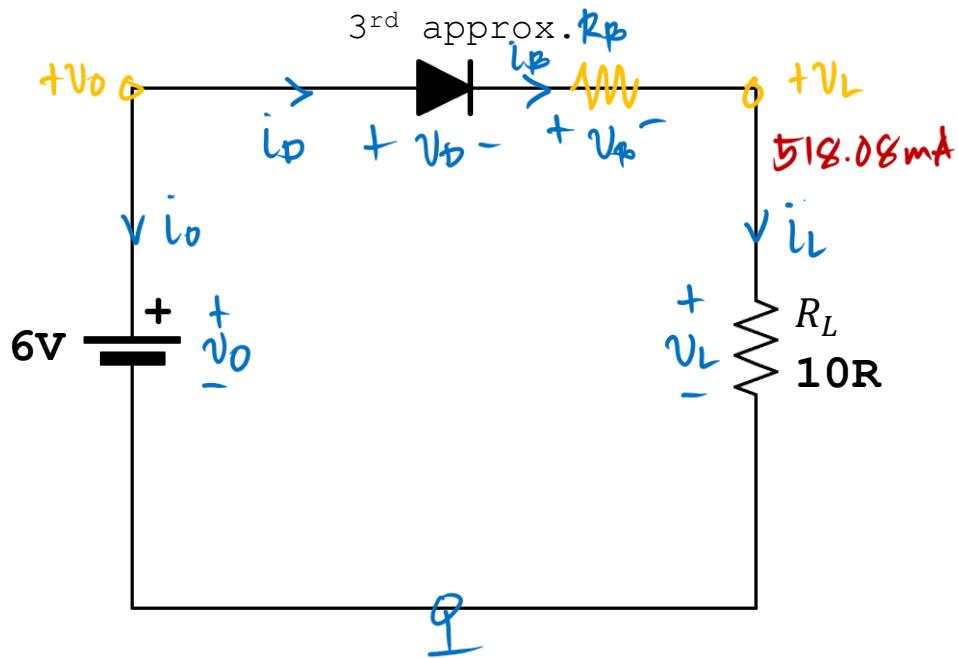
$$i_L = 518.08 \text{ mA}$$

ans



EXERCISE

The 1N4001 of the given network has a bulk resistance of 0.23Ω . What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$V_L = i_L R_L$$

$$V_L = 518.08 \text{ m} (10)$$

$$V_L = 5.18 \text{ V}$$

ans

$$P_D = i_D V_D + i_B V_B$$

$$P_D = i_D V_D + i_B^2 R_B$$

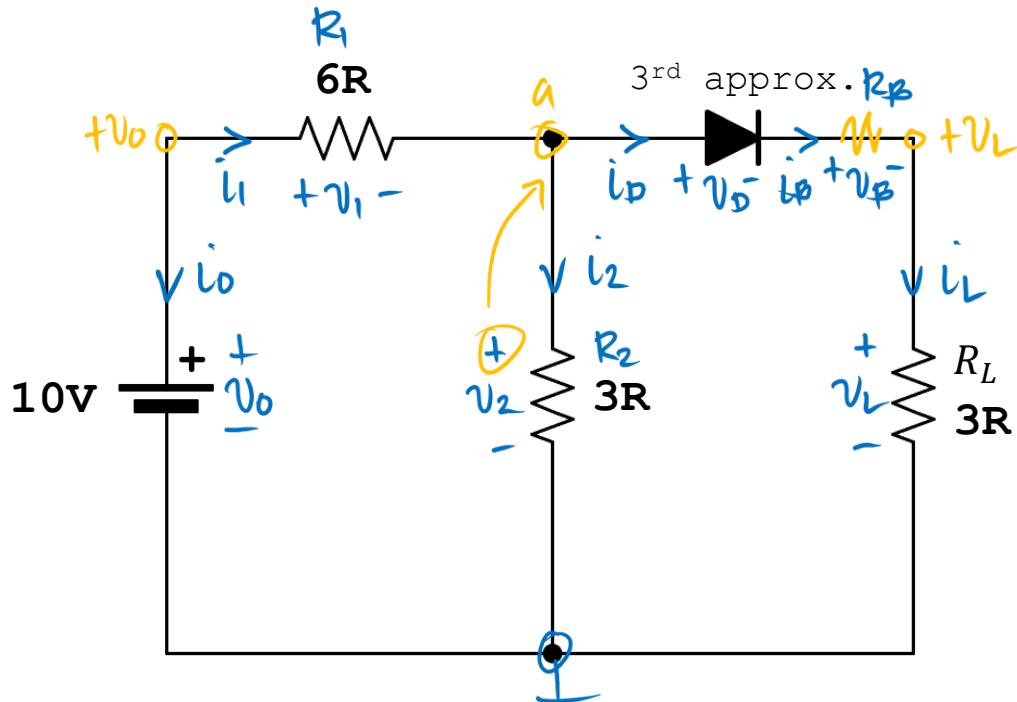
$$P_D = 518.08 \text{ m} (0.7) + (518.08 \text{ m})^2 10$$

$$P_D = 3.04 \text{ W}$$

ans

EXERCISE

The 1N4001 of the given network has a bulk resistance of $0.23\ \Omega$. What is the load voltage, load current, and the power dissipated by the diode?



Solution

Node Analysis Method

KCL @ a

$$-i_1 + i_2 + \cancel{i_D} = 0$$

$$-\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_L}{R_L} = 0$$

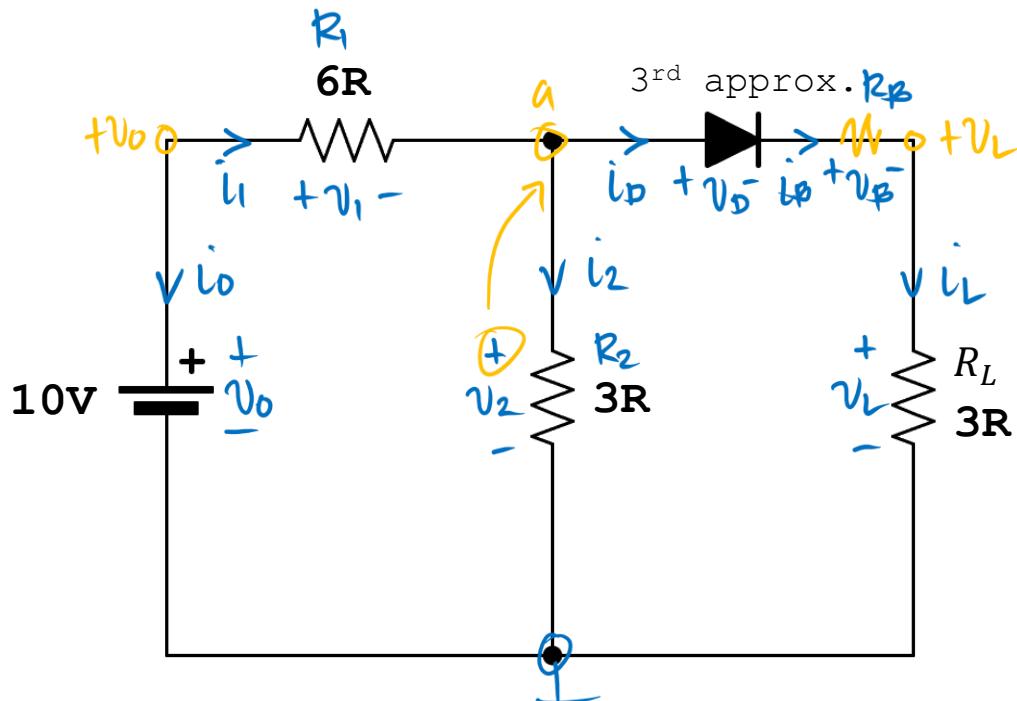
$$-\frac{v_0 - v_2}{R_1} + \frac{v_2}{R_2} + \frac{v_L}{R_L} = 0$$

$$-\cancel{v_0 G_1} + \cancel{v_2 G_1} + \cancel{(v_2 G_2 + v_L G_1)} = 0$$

$$\underline{v_2(G_1 + G_2) + v_L G_1 = v_0 G_1 \text{ (eq. 1)}}$$

EXERCISE

The 1N4001 of the given network has a bulk resistance of $0.23\ \Omega$. What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$V_D + V_B = V_2 - V_L$$

$$V_2 = V_D + V_B + V_L$$

$$V_2 = V_D + i_L R_B + i_L R_L$$

$$\underline{V_2 = V_D + i_L (R_B + R_L)}$$

$$\underline{V_2 (G_1 + G_2) + V_L G_L = V_0 G_1 \text{ (eq.1)}}$$

$$\underline{[V_D + i_L (R_B + R_L)] (G_1 + G_2) + V_L G_L = V_0 G_1}$$

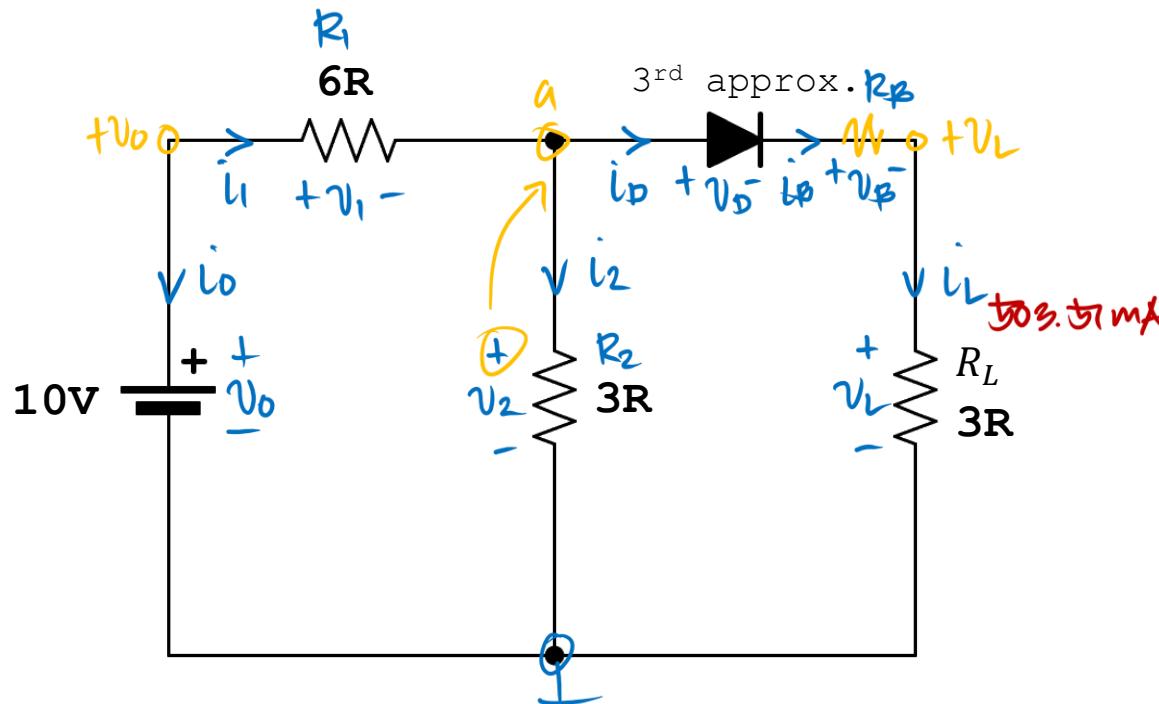
$$\underline{V_D (G_1 + G_2) + i_L (R_B + R_L) (G_1 + G_2) + i_L = V_0 G_1}$$

$$\underline{i_L [(R_B + R_L) (G_1 + G_2) + 1] = V_0 G_1 - V_D (G_1 + G_2)}$$

$$\underline{i_L = \frac{V_0 G_1 - V_D (G_1 + G_2)}{(R_B + R_L) (G_1 + G_2) + 1}}$$

EXERCISE

The 1N4001 of the given network has a bulk resistance of $0.23\ \Omega$. What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$i_L = \frac{V_0 G_1 - V_D (G_1 + G_2)}{(R_P + R_L)(G_1 + G_2) + 1}$$

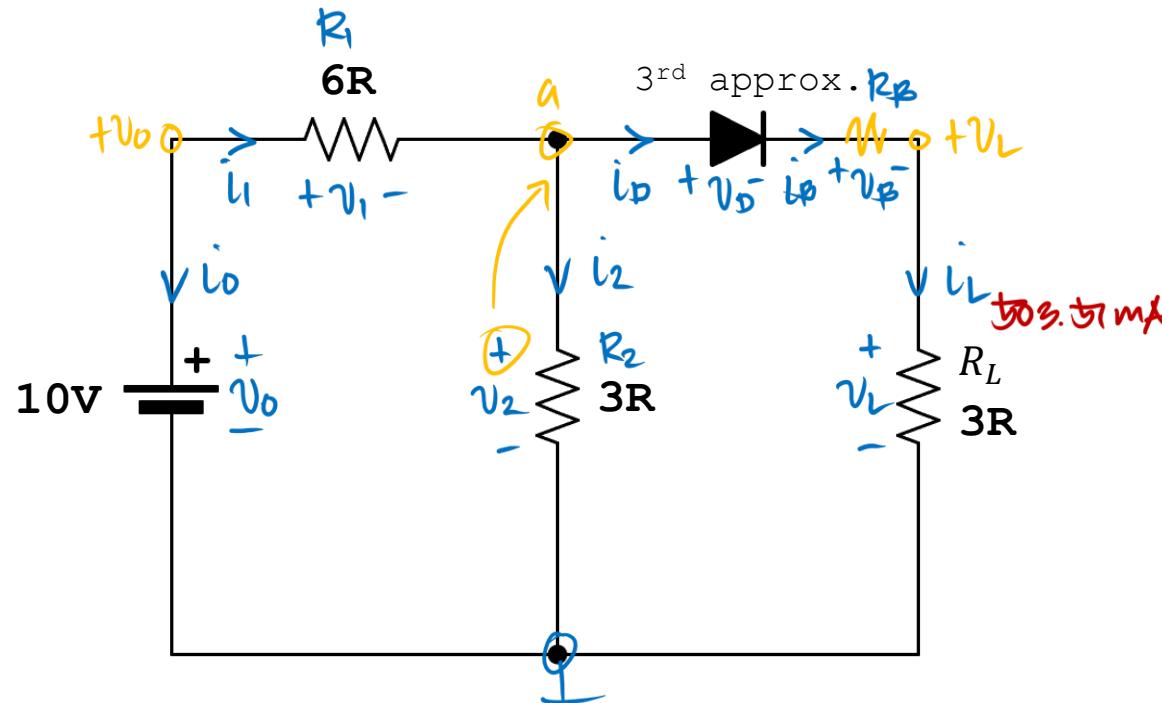
$$i_L = \frac{10(\gamma_6) - 0.7(\gamma_6 + \gamma_3)}{(0.23 + 3)(\gamma_6 + \gamma_3) + 1}$$

$$i_L = 503.51 \text{ mA}$$



EXERCISE

The 1N4001 of the given network has a bulk resistance of 0.23Ω . What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$v_L = i_L R_L$$

$$v_L = 503.51 \text{ mV (3)}$$

$$v_L = 1.51 \text{ V}$$

ans

$$P_D = i_D V_D + i_D^2 R_B$$

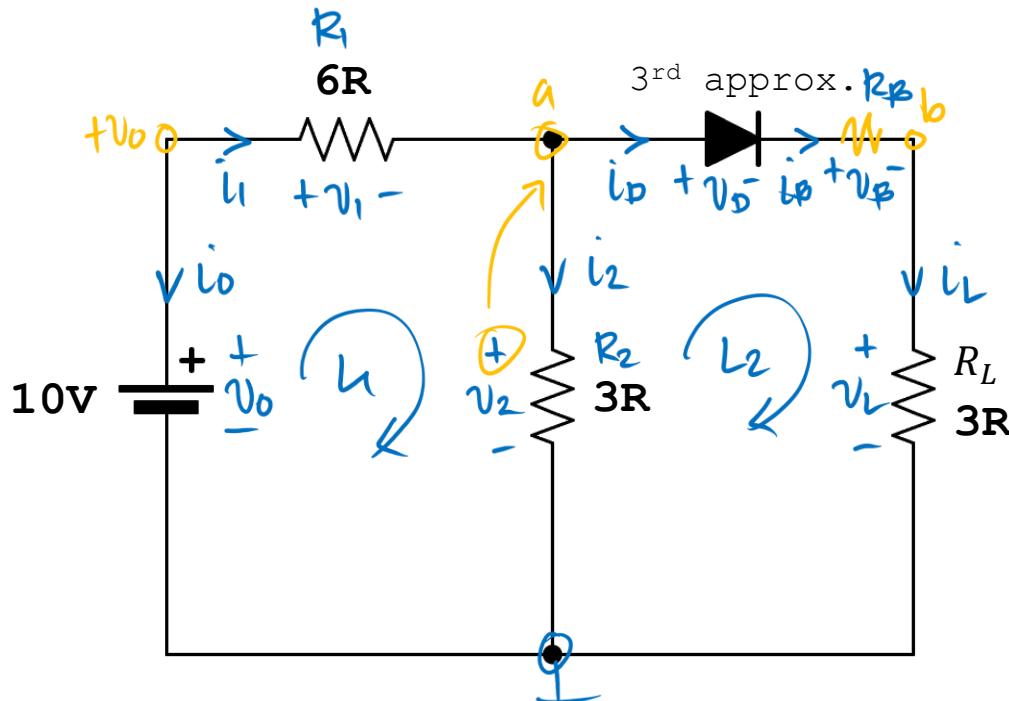
$$P_D = 503.51 \text{ mV (0.7)} + (503.51 \text{ mV})^2 (0.23)$$

$$P_D = 410.77 \text{ mW}$$

ans

EXERCISE

The 1N4001 of the given network has a bulk resistance of $0.23\ \Omega$. What is the load voltage, load current, and the power dissipated by the diode?



Solution

KCL @ a

$$-i_1 + i_2 + i_D = 0$$

$$-\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_L}{R_L} = 0$$

$$-v_1 g_1 + v_2 g_2 + v_L g_L = 0 \quad (\text{eq.1})$$

KCL @ b

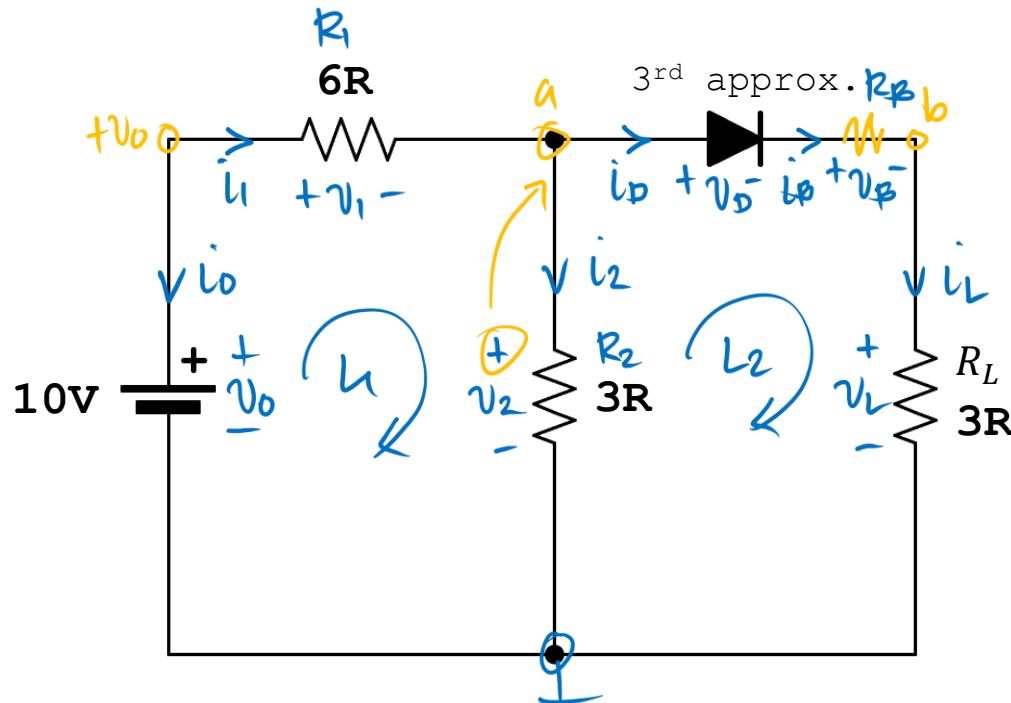
$$-i_D + i_L = 0$$

$$-\frac{v_D}{R_D} + \frac{v_L}{R_L} = 0$$

$$-v_D g_D + v_L g_L = 0 \quad (\text{eq.2})$$

EXERCISE

The 1N4001 of the given network has a bulk resistance of $0.23\ \Omega$. What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$\frac{KVL @ h}{-V_0 + V_1 + V_2 = 0}$$

$$\underline{v_1 + v_2 = v_0} \quad (\text{eq.3})$$

ICVL@12

$$-V_2 + \underline{V_D} + V_B + V_L = 0$$

$$-V_2 + V_B + V_L = -V_D \quad (\text{eq. 4})$$



EXERCISE

Gaussian Elimination Method

v_1	v_2	v_B	v_L		r_1
$-\frac{1}{6}$	$\frac{1}{3}$	0	$\frac{1}{3}$	0	r_1
0	-1	1	1	-0.7	r_2
0	0	$-\frac{1}{0.23}$	$\frac{1}{3}$	0	r_3
1	1	0	0	10	$r_4 \leftarrow 6r_1 + r_4$

v_1	v_2	v_B	v_L		r_1
$-\frac{1}{6}$	$\frac{1}{3}$	0	$\frac{1}{3}$	0	r_1
0	-1	1	1	-0.7	r_2
0	0	$-\frac{1}{0.23}$	$\frac{1}{3}$	0	r_3
0	3	0	2	10	r_4

System of Linear Equations

$$\frac{-v_1 f_1 + v_2 f_2 + v_L f_L = 0 \text{ (eq.1)}}{Y_1 f_1 + Y_2 f_2 + Y_L f_L = 0 \text{ (eq.2)}} \rightarrow r_1$$

$$\frac{-v_B f_B + v_L f_L = 0 \text{ (eq.2)}}{Y_B f_B + Y_L f_L = 0 \text{ (eq.3)}} \rightarrow r_3$$

$$\frac{v_1 + v_2 = v_0 \text{ (eq.3)}}{v_1 + v_2 = v_0 \text{ (eq.3)}} \rightarrow r_4$$

$$\frac{-v_2 + v_B + v_L = -v_0 \text{ (eq.4)}}{-v_2 + v_B + v_L = -v_0 \text{ (eq.4)}} \rightarrow r_2$$

EXERCISE

Gaussian Elimination Method

v_1	v_2	v_B	v_L	
$-\frac{1}{6}$	$\frac{1}{3}$	0	$\frac{1}{3}$	0
0	-1	1	1	-0.7
0	0	$-\frac{1}{0.23}$	$\frac{1}{3}$	0
0	0	3	5	7.9

v_1	v_2	v_B	v_L	
$-\frac{1}{6}$	$\frac{1}{3}$	0	$\frac{1}{3}$	0
0	-1	1	1	-0.7
0	0	$-\frac{1}{0.23}$	$\frac{1}{3}$	0
0	3	0	2	10

System of Linear Equations

$$-\frac{1}{6}v_1 + \frac{1}{3}v_2 + \frac{1}{3}v_L = 0 \quad (\text{eq.1}) \rightarrow r_1$$

$$-\frac{1}{0.23}v_B + \frac{1}{3}v_L = 0 \quad (\text{eq.2}) \rightarrow r_3$$

$$v_1 + v_2 = 10 \quad (\text{eq.3}) \rightarrow r_4$$

$$-v_2 + v_B + v_L = -10 \quad (\text{eq.4}) \rightarrow r_2$$

EXERCISE

Gaussian Elimination Method

v_1	v_2	v_3	v_L		v_1
$-\frac{1}{6}$	$\frac{1}{3}$	0	$\frac{1}{3}$	0	v_1
0	-1	1	1	-0.7	v_2
0	0	$-\frac{1}{0.23}$	$\frac{1}{3}$	0	v_3
0	0	3	5	7.9	$v_4 \leftarrow 3v_3 + \frac{1}{0.23}v_4$

v_1	v_2	v_3	v_L		v_1
$-\frac{1}{6}$	$\frac{1}{3}$	0	$\frac{1}{3}$	0	v_1
0	-1	1	1	-0.7	v_2
0	0	$-\frac{1}{0.23}$	$\frac{1}{3}$	0	v_3
0	0	0	$\frac{523}{23}$	$\frac{790}{23}$	v_4

System of Linear Equations

from v_4

$$\frac{523}{23} v_L = \frac{790}{23}$$

$$v_L = \frac{790}{523}$$

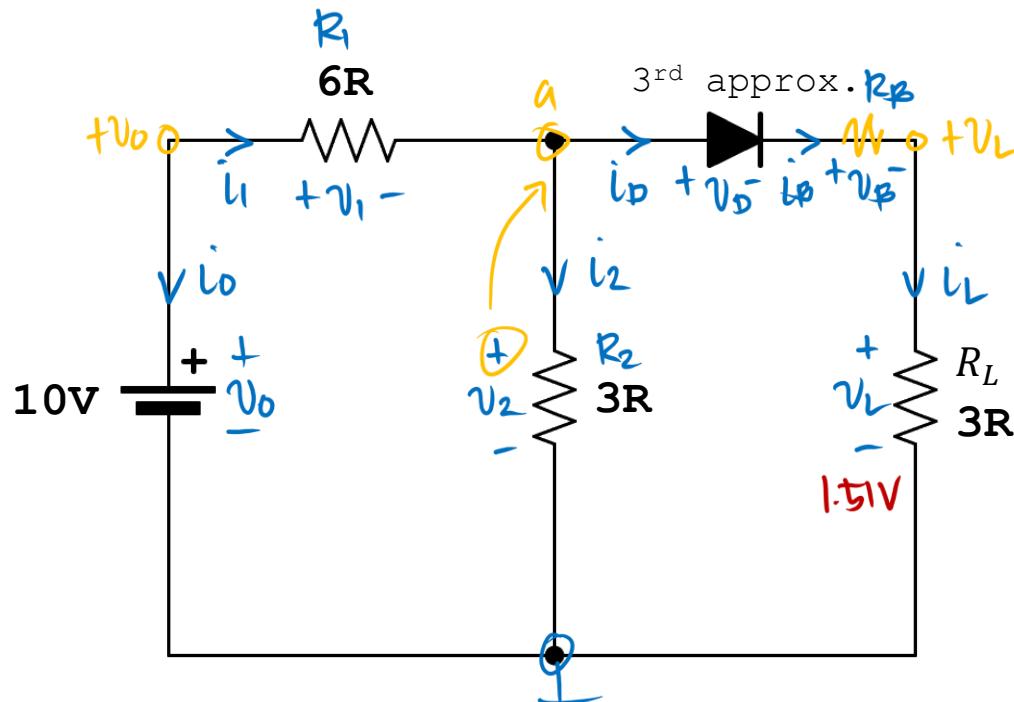
$$v_L = 1.51 \text{ V}$$

ans



EXERCISE

The 1N4001 of the given network has a bulk resistance of $0.23\ \Omega$. What is the load voltage, load current, and the power dissipated by the diode?



Solution

$$i_L = \frac{V_L}{R_L}$$

$$i_L = \frac{1.51}{3}$$

$$LL = 503.33 \text{ mA}$$

$$P_D = iDv_D + l_B^2 R_B$$

$$P_D = (503.33 \text{ m})(0.7) + (503.33 \text{ m})^2(0.23)$$

$$P_D = 410.60 \text{ mW}$$

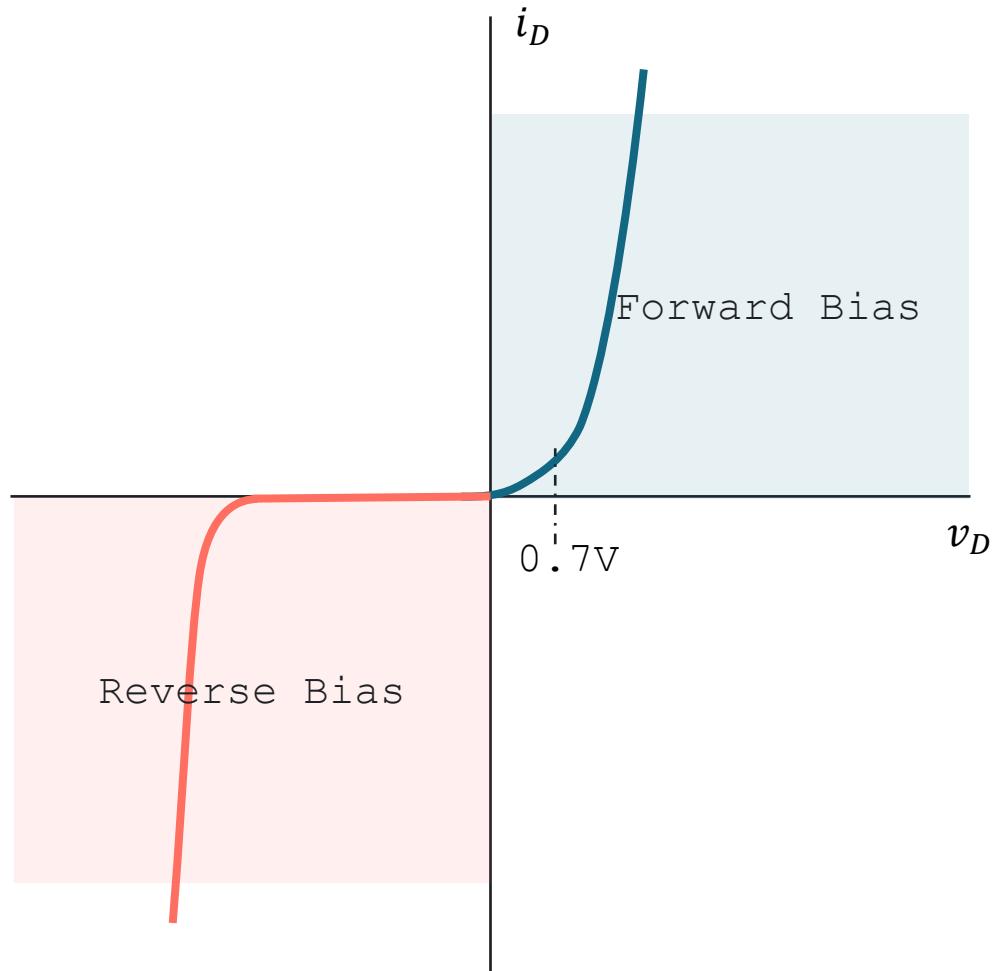


SHOCKLEY'S EQUATION



SHOCKLEY'S EQUATION

Characteristic Curve



Shockley's Equation

$$i_D = i_S \left(e^{\frac{v_D}{n v_T}} - 1 \right)$$

where:

i_D = diode current

i_S = reverse saturation current

v_D = voltage across the diode

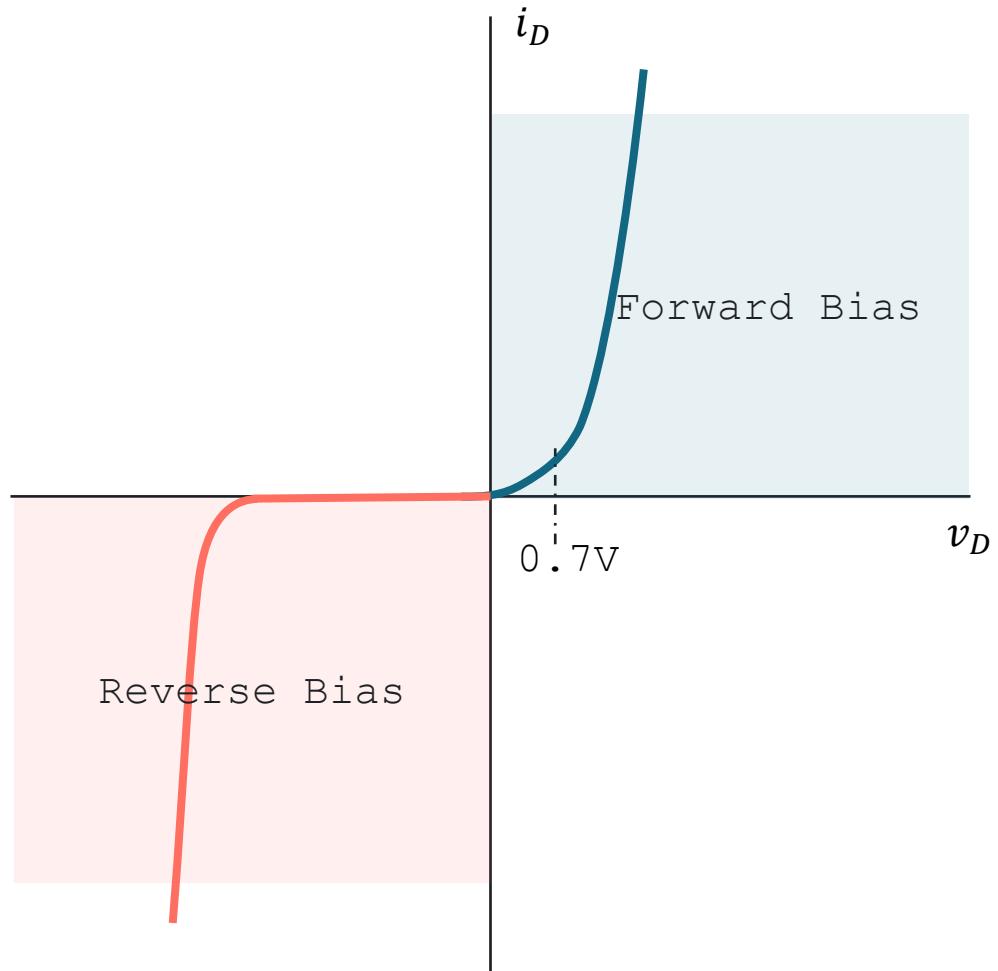
n = ideality factor ($1 \leq n \leq 2$)

- $n = 1$ for ideal diode

v_T = thermal voltage ($\approx 25.85mV$ at room temperature)

THERMAL VOLTAGE

Characteristic Curve



Thermal Voltage

$$v_T = \frac{kT}{q}$$

where:

k = Boltzmann's constant ($1.38 \times 10^{-23} \text{ J/K}$)

T = absolute temperature ($^{\circ}\text{C} + 273$)

q = electron charge ($1.602 \times 10^{-19} \text{ C}$)

EXERCISE

Determine the diode current at 20°C for silicon diode with a reverse saturation current of 50nA and an ideality factor of 2 , under the following applied voltages:

- 0V
 - 0.5V
 - 0.7V
 - 1V
- V_D

$$\underline{V_T = 25.24\text{mV}}$$

Solution

$$V_T = \frac{kT}{q}$$

$$V_T = \frac{1.38 \times 10^{-23} (20 + 273)}{1.602 \times 10^{-19}}$$

$$\underline{V_T = 25.24\text{mV}}$$

$$\textcircled{1} \underline{V_D = 0}$$

$$i_D = i_s \left(e^{\frac{V_D}{nV_T}} - 1 \right)$$

$$i_D = 50n \left(e^{\frac{0}{(2)(25.24\text{mV})}} - 1 \right)$$

$$\boxed{i_D = 0}$$

ans

EXERCISE

Determine the diode current at 20°C for silicon diode with a reverse saturation current of 50nA and an ideality factor of 2, under the following applied voltages:

- 0V
- 0.5V
- 0.7V
- 1V

V_D

$$V_D = 25.24 \text{ mV}$$

$$\textcircled{1} \quad V_D = 1$$

$$i_D = 50n \left(e^{\frac{0.7}{2(25.24 \text{ mV})}} - 1 \right)$$

$$i_D = 20 \text{ A}$$

ans

Solution

$$\textcircled{1} \quad V_D = 0.5$$

$$i_D = i_s \left(e^{\frac{V_D}{nV_T}} - 1 \right)$$

$$i_D = 50n \left(e^{\frac{0.5}{2(25.24 \text{ mV})}} - 1 \right)$$

$$i_D = 1 \text{ mA}$$

ans

$$\textcircled{1} \quad V_D = 0.7 \text{ V}$$

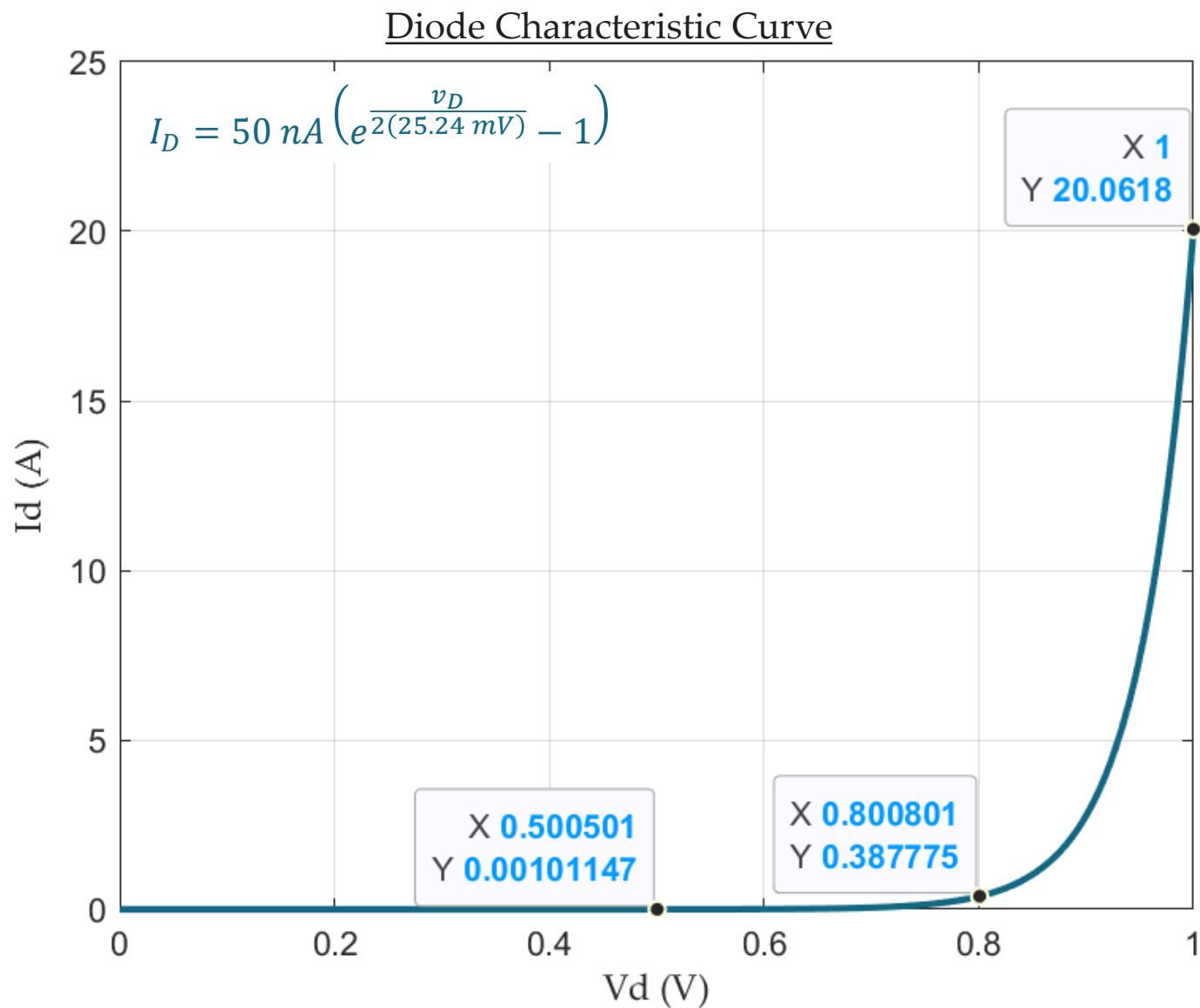
$$i_D = 50n \left(e^{\frac{0.7}{2(25.24 \text{ mV})}} - 1 \right)$$

$$i_D = 52.63 \text{ mA}$$

ans



EXERCISE



READING DATASHEET



REVERSE BREAKDOWN VOLTAGE

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
†Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
†Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	V
†RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
†Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75^\circ\text{C}$)	I_O				1.0				A

Destructive level to avoid under all operating conditions.

Practice safety factor of 2.

MAXIMUM FORWARD CURRENT

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
†Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
†Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	V
†RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
†Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75^\circ\text{C}$)	I_O	1.0							A

Level of forward current before the diode burns out

because of excessive power dissipation.

FORWARD VOLTAGE DROP

ELECTRICAL CHARACTERISTICS†

Rating	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage Drop, ($i_F = 1.0$ Amp, $T_J = 25^\circ\text{C}$)	v_F	0.93	1.1	V
Maximum Full-Cycle Average Forward Voltage Drop, ($I_O = 1.0$ Amp, $T_L = 75^\circ\text{C}$, 1 inch leads)	$V_{F(AV)}$	-	0.8	V
Maximum Reverse Current (rated DC voltage) ($T_J = 25^\circ\text{C}$) ($T_J = 100^\circ\text{C}$)	I_R	0.05 1.0	10 50	μA
Maximum Full-Cycle Average Reverse Current, ($I_O = 1.0$ Amp, $T_L = 75^\circ\text{C}$, 1 inch leads)	$I_{R(AV)}$	-	30	μA

The typical voltage across the diode.

LABORATORY