Diode Problem 3.42

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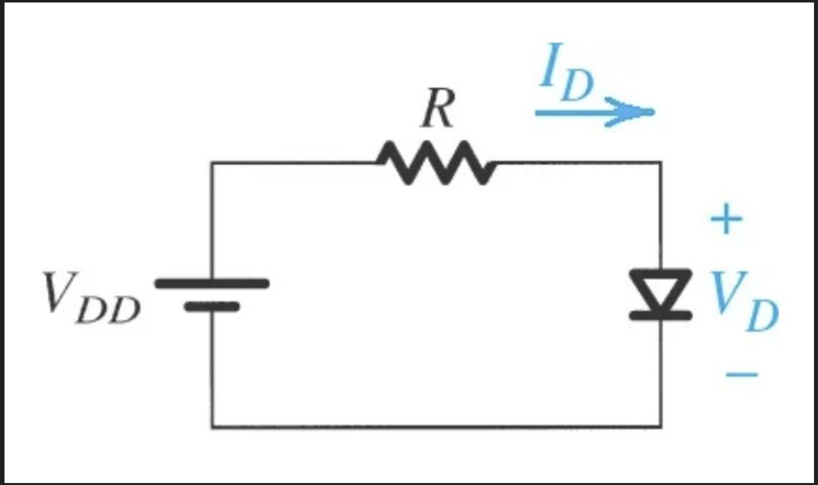
The Problem

3.42 Consider the circuit in Fig. 3.10 with $V_{DD} = 3$ V and $R = 3$ kΩ.

(a) Find the current using a constant-voltage-drop model.
(b) What value of I_S is required to make this solution exact?
(c) Approximately how much will the current change from this value if I_S increases by a factor of 100?



The Problem

<u>What's given:</u>

- V.DD = 3V
- R = 3 k Ohm

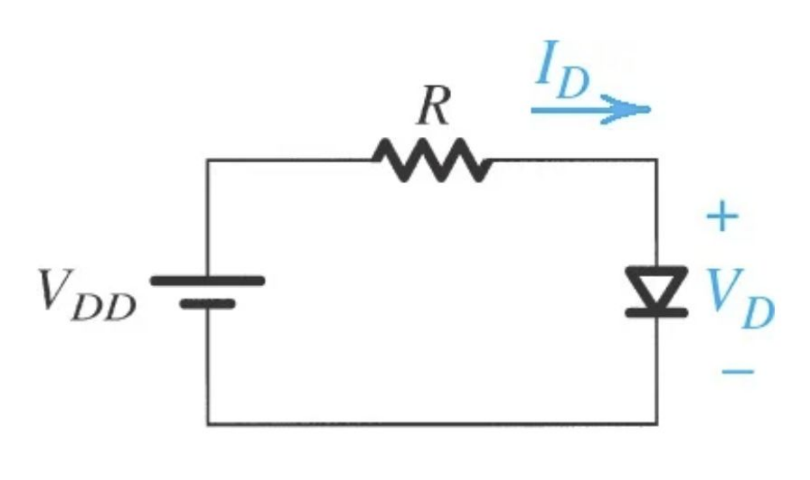
<u>What needs to be found:</u>

- Current using the constant voltage drop model
- Value of I.s
- Current change if the value I.s increases by factor of 100

Part A: Finding the Current

Diode is in the forward direction and have a voltage drop of 0.7V across.

<u>Apply simple KVL</u>
V.DD = 3V   V.D = 0.7V   R = 3000 ohms



$$I_D = \frac{V_{DD} - V_D}{R}$$

$$I_D = \frac{3V - 0.7V}{3000\Omega} = \boxed{0.767 \times 10^{-3} A}$$

Part B: Finding the value of I.s

Diode is in the forward direction and have a voltage drop of 0.7V across.

<u>Use the forward-biased diode current equation (in blue)</u>
I.D = 0.767mA   V.D = 0.7V   V.T = 25.9mA

$$I_S = \frac{I_D}{e^{V_D/V_T}}$$

$$I_S = \frac{0.767 \times 10^{-3} A}{e^{0.7V/25.9 \times 10^{-3} A}} = \boxed{1.40 \times 10^{-15} A}$$

Part C: Current change

Determine the value for I.s' when I.s is increased by a factor of 100

<u>Multiply I.s by 100</u>
I.s = 1.40 x 10^-15 A

$$I_s' = 100 \times I_s$$

$$I_s' = 100 \times (1.40 \times 10^{-15}) = \boxed{1.40 \times 10^{-13}\,A}$$

Part C: Current change

Determine the value for I.D when I.s is increased by a factor of 100

<u>Use the forward-biased diode current equation (in blue)</u>
I.s’ = 1.40 x 10^-13 A   V.D = 0.7V   V.T = 25.9x10 mA

$$I_D' = I_s' e^{V_D/V_T}$$

$$I_D' = 1.40 \times 10^{-13}\, e^{0.7V/25.9 \times 10^{-3}V} = \boxed{76.5 \times 10^{-3} A}$$

Part C: Current change

Determine the change between I.D’ and I.D

<u>Subtract I.D’ by I.D</u>

I.D’ = 76.5 mA   I.D = 0.767 mA

$$\Delta I = I_D' - I_D$$

$$\Delta I = 76.5 \times 10^{-3} A - 0.767 \times 10^{-3} = \boxed{75.7 \times 10^{-3} A}$$