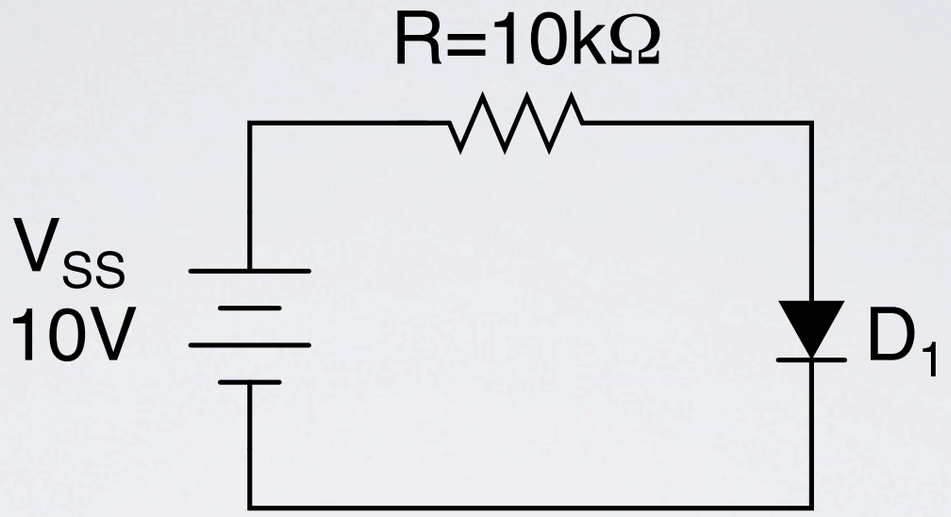
CIRCUIT WITH A DIODE

INEL 4076



Given: at v_D=0.7V, I_D=1mA

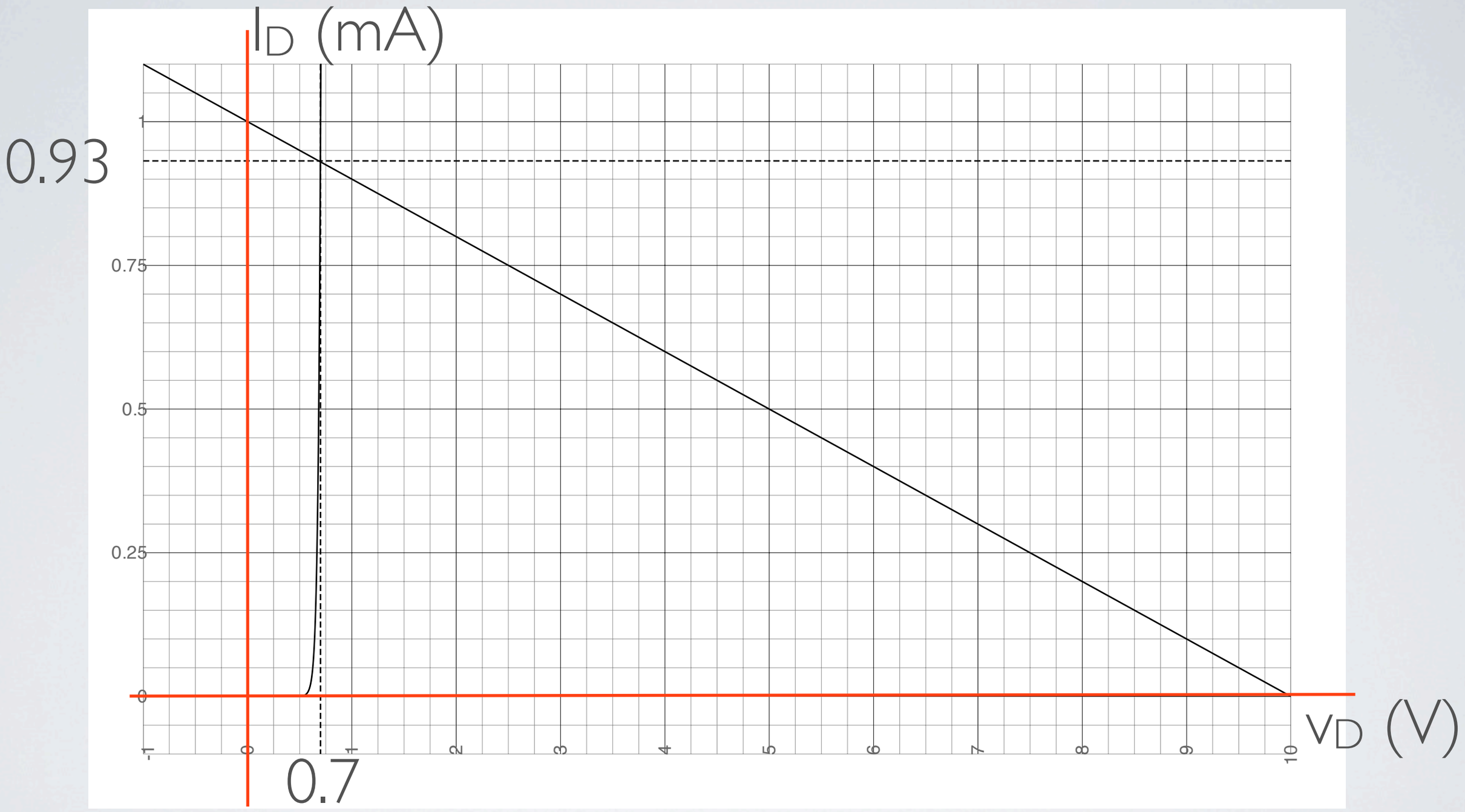
Diode's law:

$$I_D = I_S \exp\left(v_D/0.025V\right)$$

Ohms Law:

$$10V = I_D R + v_D \Rightarrow I_D = \frac{10V - v_D}{10k\Omega}$$

Graphical method: Plot both curves. Intercept between curves is solution.


I_D (mA)
1
0.75
0.5
0.25
0
0.93
-1
0
1
2
3
4
5
6
7
8
9
10
0.7
V_D (V)

1. Diode's equation, valid for all v_D and i_D:

$$I_D = I_S \exp\left(v_D/0.025V\right)$$

For the given point:

$$1mA = I_S \exp\left(0.7V/0.025V\right)$$

Divide second equation into first to get

$$I_D/1mA = \exp\left(\frac{v_D - 0.7V}{0.025V}\right)$$

In logarithmic form

$$v_D = 0.7V + 0.025V \log\left(\frac{I_D}{1mA}\right) \tag{1}$$

2. The Ohms Law:

$$I_D = \frac{10V - v_D}{10k\Omega} \tag{2}$$

3. Successive approximation method:

   (a) Start with a good guess of v_D (0.7V will do)

   (b) use (2) to find I_D,

   (c) substitute into equation (1) to find a (better) estimate of v_D.

   (d) Repeat steps (b) and (c) until new and old estimates are the same (up to the desired precision)

v_D (V)	I_D (mA)
0.700	0.9300
0.698	0.9302
0.698	0.9302

Very close to 0.7V - diode's voltage is close to constant for a large range of currents

Successive approx. is a numerical method, like the one use programs like Matlab

WolframAlpha

solve (10 -x)/10 = exp((x-0.7)/0.025)

Input interpretation:

$$\text{solve}\quad \frac{10-x}{10} = \exp\left(\frac{x-0.7}{0.025}\right)$$

Result:

$$x = 10 - \frac{W_n\left(400\, e^{372}\right)}{40} \quad \text{and} \quad n \in \mathbb{Z}$$

Real solution:

$$x = \frac{1}{40}\left(400 - W\left(400\, e^{372}\right)\right) \approx 0.698191$$

result from http://m.wolframalpha.com

For smaller values of V_{SS} the final result will be very different.

Example: find I_D if (a) $V_{SS} = 2V$ (b) $V_{SS} = 1V$ using

1. the graphical method
2. the successive approx. method

Use http://m.wolframalpha.com to confirm your result.