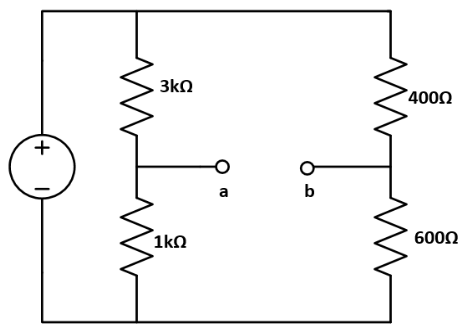
<u>SOLUTIONS</u>

Solution of pre-tutorial:

Thevenin equivalent across a-b are to be estimated.



Notice that 3 kΩ and 1 kΩ resistors are in parallel and so are the 400 Ω and 600 Ω resistors. The two parallel combinations form a series combination with respect to terminals **a** and **b**.

Hence, $R_{th} = 3000||1000 + 400||600 = 990\ \Omega$

Next, using the voltage division principle

$$V_a = \frac{1000}{1000 + 3000} \times 220 = 55\ V$$

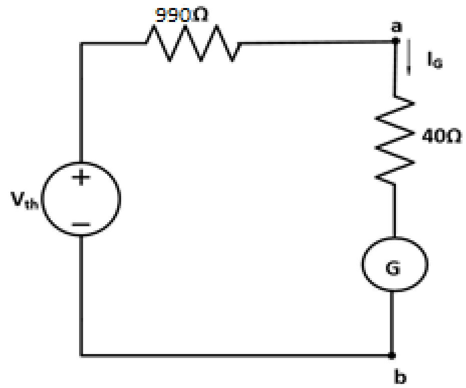
$$V_b = \frac{600}{600 + 400} \times 220 = 132\ V$$

Applying KVL around loop **ab** gives

$-V_a + V_{th} + V_b = 0$

$$\Rightarrow V_{th} = V_a - V_b = 55 - 132 = -77V$$

The equivalent circuit is:

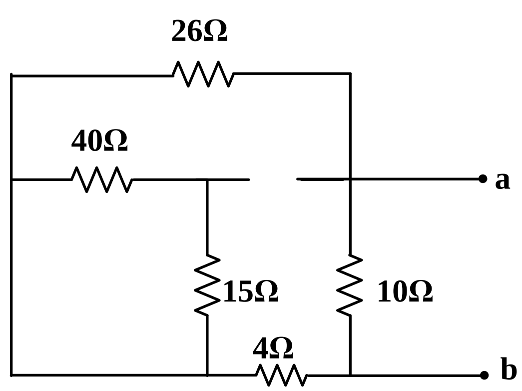


$$I_G = \frac{V_{Th}}{R_{Th} + R_m} = \frac{-77}{990 + 40} = -74.76mA$$

The negative sign indicates that the current flows in the direction opposite to the one assumed, that is, from terminal **b** to terminal **a**.

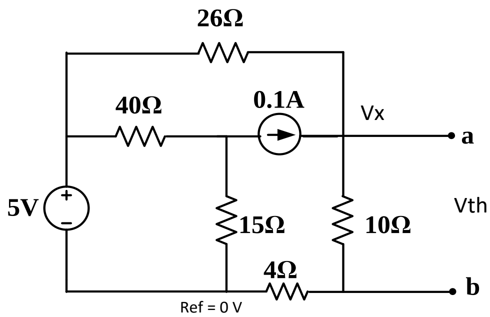
Solution of problem 2:

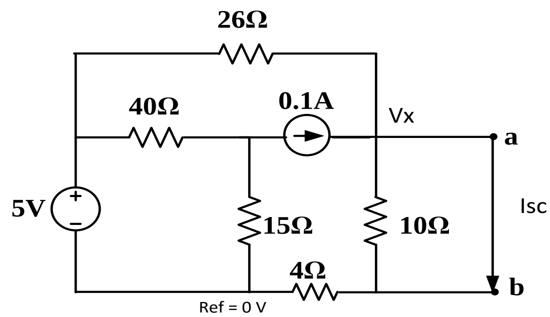
Method-1



Deactivating the independent sources to ZERO, both the resistors 26 Ω and 4 Ω get connected in series giving a total of 30 Ω. Further, this total 30 Ω appears in parallel with the 10 Ω between the terminals a-b. Thus, the Norton's equivalent resistance becomes 30 || 10 = 7.5 Ω.

Method -2 (Rth = Vth / Isc)





(Fig. 1 for finding Vth) (Fig. 2 for finding Isc)

Open circuit voltage Vth and short-circuit current Isc in a-b are estimated:

From Fig. 1, $(Vx - 5)/26 + Vx/14 = 0.1 \Rightarrow Vth = (10/14)\,Vx = 1.9$ V

From Fig. 2, $(Vx - 5)/26 + Vx/4 = 0.1 \Rightarrow Vx = 1.013$ and therefore, $Isc = Vx/4 = 0.253$ A

Then, $Req = Vth / Isc = 1.9/0.253 = 7.510$ (approx.)

Equivalent resistance obtained by open-circuit voltage/ short-circuit current method should yield the same 7.5 Ω and differences, if any, are due to rounding errors only.

Solution of problem 3:

After disconnecting R_L, let the voltage across 0.5 kΩ be Vx and the open circuit voltage across **a-b** be the Thevenin's voltage Vth.

Current through 20 Ω is I_0. Then, $9 + 20\,I_0 = 500\,I_0 \Rightarrow I_0 = 9/480$ giving $Vth = 9 + 20\,I_0 + 400\,I_0 = 16.875$ V.

Next, when a-b is short-circuited, let the current flowing from terminal a to terminal b be Isc. Let the node voltage between the resistors 20 Ω and 200 Ω be Vx.

Then, $(Vx - 9)/20 + Vx/500 + Vx/200 = 0 \Rightarrow Vx = 7.895$ V

$Isc = 2I_0 + Vx/200 = 2Vx/500 + Vx/200 = 0.071$ A

Now, Rth = Equivalent resistance across a-b = $Vth/Isc = 237.676$ Ω

Maximum power delivered to the load $R_L = 0.25\,Vth^2 / Rth = 0.3$ W (approx.)

Solution of problem 4:

(i) Assuming the transistor to be in the active region –

$$V_{CC} = R_C(I_C + I_B) + I_B R_B + 0.7 + I_E R_E$$

$$I_B = \frac{10 - 0.7}{R_C(\beta+1) + R_B + (\beta+1)R_E}$$

$$= \frac{9.3}{101*4.7 + 250 + 101*1.2} = 0.011\,\text{mA}$$

$$I_C = 1.1\,\text{mA}$$

$$V_C = 10 - 4.7*(1.1 + 0.011) = 4.78\,\text{V}$$

$$V_E = 1.2*101*(0.011) = 1.33\,\text{V}$$

Therefore $V_{CE} = V_C - V_E = 3.45\,\text{V}$

Note that V_B=2.03 V implying that the C-B junction is reverse biased as it should be for the transistor to operate in the active region.

(ii) Assuming the transistor to be in the active region –

Thevenin's Equivalent of the Base Voltage supply gives

$$V_{BB} = \frac{10}{3}\,\text{V} \qquad R_B = R_1 \parallel R_2 = 13.333\,K\Omega$$

$$V_{BB} = I_B R_B + 0.7 + I_E R_E$$

$$I_B = \frac{3.333 - 0.7}{13.333 + (101)1.2} = 0.0196\,\text{mA}$$

$$I_C = 1.96\,\text{mA}$$

$$V_C = 10 - 2.8*1.96 = 4.51\,\text{V}$$

$$V_E = 1.2*(101)*0.0196 = 2.38\,V$$

$$V_B = V_E + 0.7 = 3.08V$$

Therefore $V_{CE} = V_C - V_E = 2.13\,\text{V}$

Note that B-C junction will be reverse biased so transistor is indeed in the active region

Solution of problem 5:

In this case, V_{BB}=5V and R_B=10 KΩ.

If transistor is assumed to be in the active region, then –

$$I_B = \frac{5-0.7}{10+101*1.2} = 0.0328 \text{ mA}$$ I_C=3.28 mA I_E=3.313 mA

and V_E = 3.976 V V_B = 4.676 V V_C = 0.816 V

But this would make B-C forward biased which is clearly impossible. Therefore, **transistor cannot be in the active region.**

If transistor is assumed to be in the saturation region, then –

$$5-0.7 = 10I_B + 1.2(I_B + I_C) \qquad 11.2I_B + 1.2I_C = 4.3$$
$$10-0.1 = 2.8I_C + 1.2(I_B + I_C) \qquad 1.2I_B + 4I_C = 9.9$$

Solving, we get I_B=0.122 mA I_C=2.44 mA I_E=2.562 mA

Note that $I_C < \beta I_B$, therefore **the transistor is indeed in saturation**