

Find R such that gain $\frac{V_{out}}{V_s} = +5$

KVL: $-V_s + 0 + IR + I(150) = 0$

KVL: $-V_{out} + I(1k) + IR + I(150) = 0$

$V_s = I(R + 150)$

$V_{out} = I(R + 1150)$

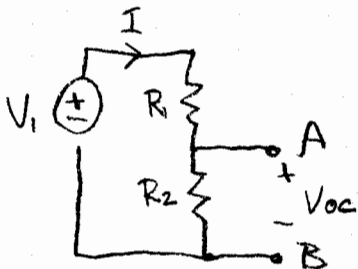
$\frac{V_{out}}{V_s} = \frac{I(R + 1150)}{I(R + 150)} = \frac{R + 1150}{R + 150} = 5$

$5R + 750 = R + 1150$

$4R = 400$

$R = 100\Omega$

2a



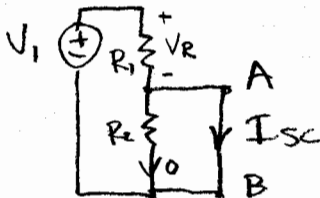
O.L.: $V_{oc} = I \cdot R_2$

$-V_1 + IR_1 + IR_2 = 0$

$V_1 = I(R_1 + R_2)$

$I = \frac{V_1}{R_1 + R_2}$

Voc:



KVL: $-V_1 + V_R + 0 = 0$

$V_1 = V_R$

O.L.: $I_{sc} = \frac{V_R}{R_1} = \frac{V_1}{R_1} = I_{sc}$

Isc:

$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{I \cdot R_2}{V_1 / R_1} = \frac{I \cdot R_1 \cdot R_2}{V_1}$

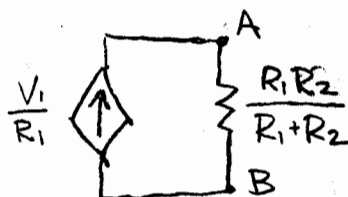
$= \frac{V_1}{R_1 + R_2} \cdot R_1 R_2 = \frac{R_1 R_2}{R_1 + R_2} = R_{TH}$

or substitute further to simplify

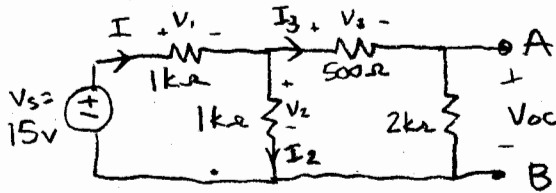
Thevenin Equivalent



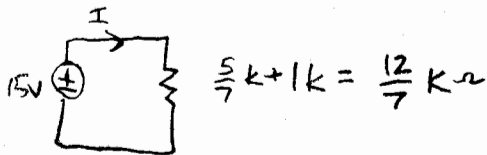
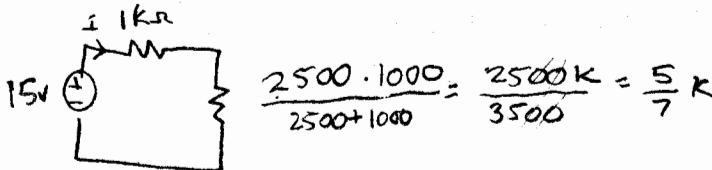
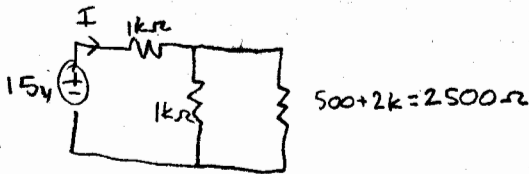
Norton Equivalent:



2b



Voc:



$$I = \frac{V_s}{R} = \frac{15}{12/7k} = \frac{15(7)}{12k} = \frac{35}{4k}$$

KVL: $-V_s + V_1 + V_2 = 0$
 $-15 + I(1k) + V_2 = 0$
 $-15 + \frac{35}{4k}k + V_2 = 0$

$$V_2 = 15 - \frac{35}{4} = \frac{60 - 35}{4}$$

$$V_2 = \frac{25}{4} V$$

O.L. $I_2 = \frac{V_2}{1k} = \frac{25}{4k} A$

K.C.L. $I = I_2 + I_3$

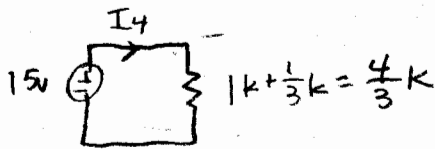
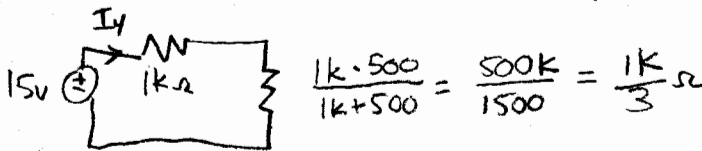
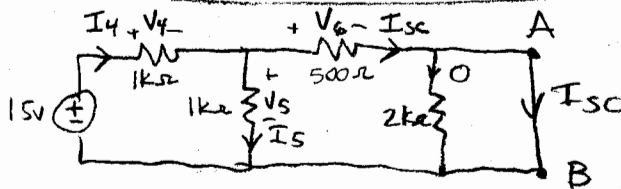
$$I_3 = I - I_2 = \frac{35}{4k} - \frac{25}{4k}$$

$$I_3 = \frac{10}{4k} = \frac{5}{2k}$$

O.L. $V_{oc} = I_3 \cdot 2k = \frac{5}{2k} \cdot 2k$

$$V_{oc} = 5V$$

Isc:



$$I_4 = \frac{V_s}{4/3k} = \frac{15}{4/3k} = \frac{15(3)}{4k} = \frac{45}{4k} A$$

O.L. $V_4 = I_4 \cdot 1k\Omega = \frac{45}{4k} \cdot 1k$

$$V_4 = \frac{45}{4} V$$

KVL: $-V_s + V_4 + V_6 = 0$

$$V_6 = V_s - V_4 = 15 - \frac{45}{4} = \frac{60 - 45}{4}$$

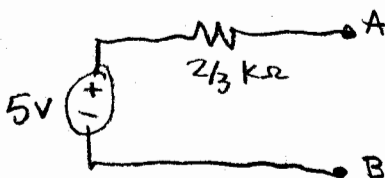
$$V_6 = \frac{15}{4}$$

O.L. $I_{sc} = \frac{V_6}{500} = \frac{15}{4} \cdot \frac{1}{500}$

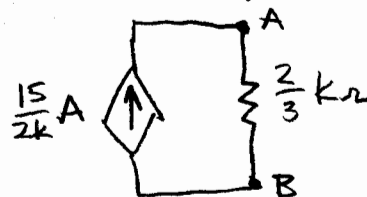
$$I_{sc} = \frac{15}{2k}$$

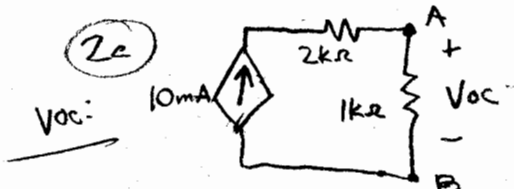
$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{5}{15/2k} = \frac{10k}{15} = \frac{2}{3} k\Omega$$

Thevenin Equivalent:



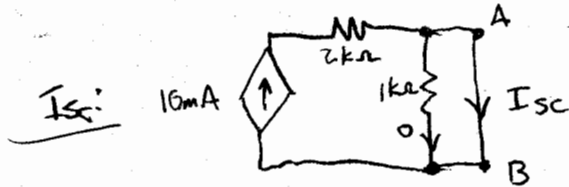
Norton Equivalent:





$$V_{oc} = 10\text{mA} \cdot 1\text{k}\Omega = 10 \cdot 10^{-3} \cdot 10^3$$

$$V_{oc} = 10\text{V}$$



$$10\text{mA} = 0 + I_{sc}$$

$$I_{sc} = 10\text{mA}$$

$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{10}{10 \times 10^{-3}} = 10^3 = 1\text{k}\Omega$$

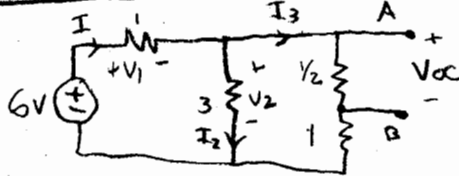
Thvenin Equivalent:



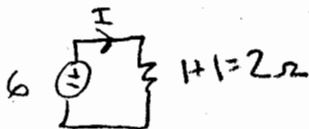
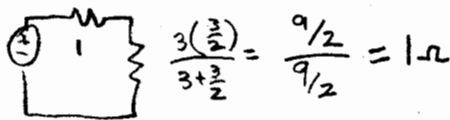
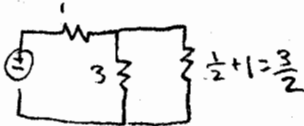
Norton Equivalent:



2d



Voc:



$$I = \frac{6}{2} = 3\text{A}$$

O.L. $V_1 = I \cdot 1 = 3 \cdot 1 = 3\text{V}$

KVL: $-6 + V_1 + V_2 = 0$

$$V_2 = 6 - 3 = 3\text{V}$$

O.L. $I_2 = \frac{V_2}{3} = \frac{3}{3} = 1\text{A}$

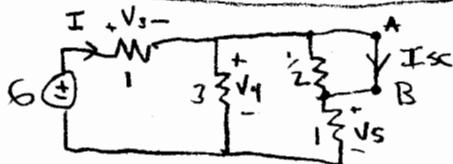
KCL: $I = I_2 + I_3$

$$I_3 = 3 - 1 = 2\text{A}$$

O.L. $V_{oc} = I_3 \cdot \frac{1}{2} = 2 \cdot \frac{1}{2} = 1\text{V}$

$$V_{oc} = 1\text{V}$$

Isc:



$$I = \frac{6}{7/4} = \frac{24}{7}\text{A}$$

O.L. $V_3 = I \cdot 1 = \frac{24}{7}\text{V}$

KVL: $-6 + V_3 + V_5 = 0$

$$V_5 = 6 - \frac{24}{7} = \frac{42 - 24}{7} = \frac{18}{7}\text{V}$$

O.L. $I_{sc} = \frac{V_5}{1} = \frac{18}{7}\text{A}$

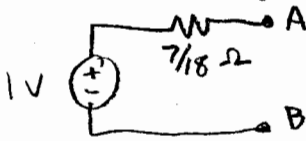
$$I_{sc} = \frac{18}{7}\text{A}$$

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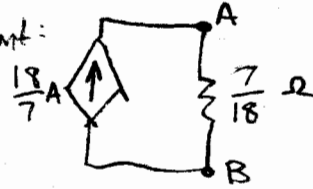
(2d) continued

$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{1}{18/7} = \frac{7}{18} \Omega = R_{TH}$$

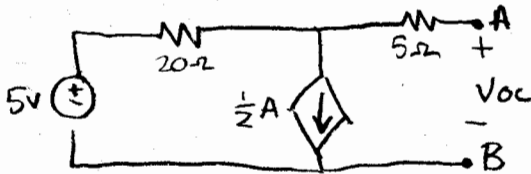
Thevenin Equivalent:



Norton Equivalent:



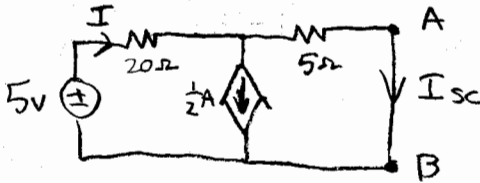
(2e)

V_{oc}:

$$KVL: -5 + \frac{1}{2}(20) + V_{oc} = 0$$

$$V_{oc} = 5 - 10$$

$$V_{oc} = -5V$$

I_{sc}:

$$KCL: I = \frac{1}{2} + I_{sc}$$

$$KVL: -5 + 20I + 5I_{sc} = 0$$

$$-5 + 20\left(\frac{1}{2} + I_{sc}\right) + 5I_{sc} = 0$$

$$-5 + 10 + 20I_{sc} + 5I_{sc} = 0$$

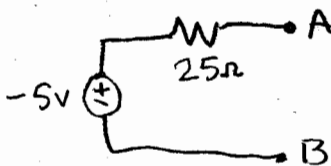
$$5 + 25I_{sc} = 0$$

$$I_{sc} = \frac{-5}{25}$$

$$I_{sc} = -\frac{1}{5} A$$

$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{-5}{-1/5} = +25 \Omega$$

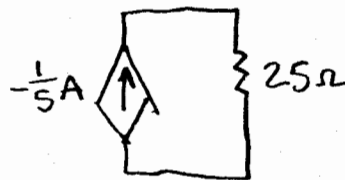
Thevenin Equivalent:



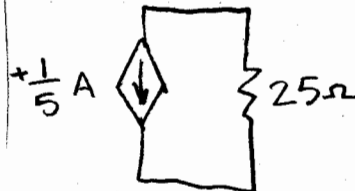
OR



Norton Equivalent

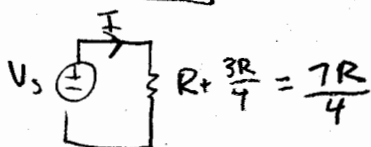
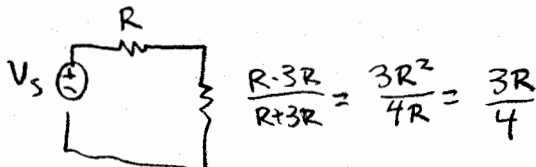
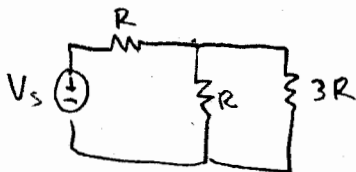
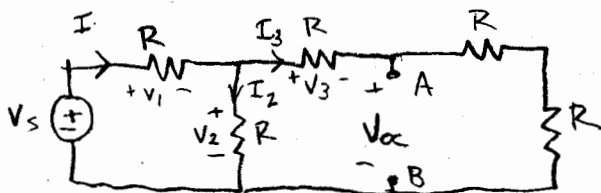


OR



3

Voc:



$$I = \frac{V_s}{7R/4} = \frac{4V_s}{7R}$$

O.L.: $V_1 = I \cdot R = \frac{4V_s}{7R} \cdot R = \frac{4V_s}{7}$

KVL: $-V_s + V_1 + V_2 = 0$

$$V_2 = V_s - \frac{4V_s}{7} = \frac{3V_s}{7}$$

O.L.: $I_2 = \frac{V_2}{R} = \frac{3V_s}{7} \cdot \frac{1}{R} = \frac{3V_s}{7R}$

KCL: $I = I_2 + I_3$

$$I_3 = \frac{4V_s}{7R} - \frac{3V_s}{7R} = \frac{V_s}{7R}$$

O.L.: $V_3 = I_3 \cdot R = \frac{V_s}{7R} \cdot R$

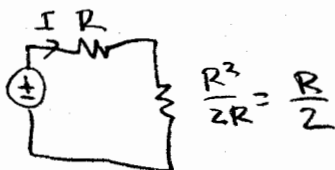
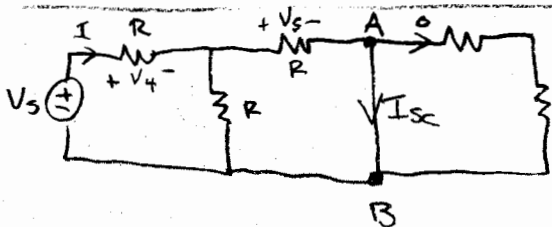
$$V_3 = \frac{V_s}{7}$$

KVL: $-V_2 + V_3 + V_{oc} = 0$

$$V_{oc} = \frac{3V_s}{7} - \frac{V_s}{7}$$

$$V_{oc} = \frac{2V_s}{7}$$

Isc:



$$I = \frac{V_s}{3R/2} = \frac{2V_s}{3R}$$

O.L.: $V_4 = I \cdot R = \frac{2V_s}{3R} \cdot R = \frac{2V_s}{3}$

KVL: $-V_s + V_4 + V_5 = 0$

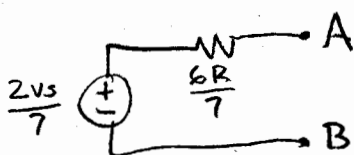
$$V_5 = V_s - \frac{2V_s}{3} = \frac{V_s}{3}$$

O.L.: $I_{sc} = \frac{V_5}{R} = \frac{V_s}{3R}$

$$I_{sc} = \frac{V_s}{3R}$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{\frac{2V_s}{7}}{\frac{V_s}{3R}} = \frac{2V_s}{7} \cdot \frac{3R}{V_s} = \frac{6R}{7} \Omega$$

Thevenin Equiv:



Norton Equivalent:

