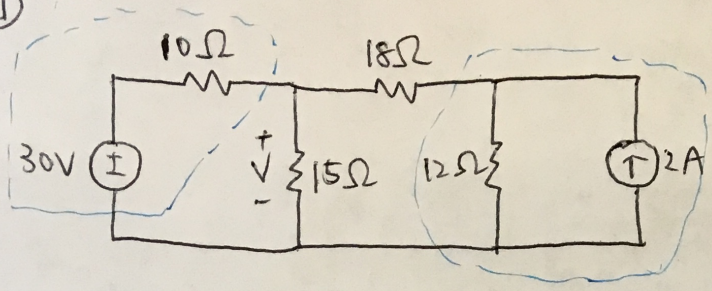
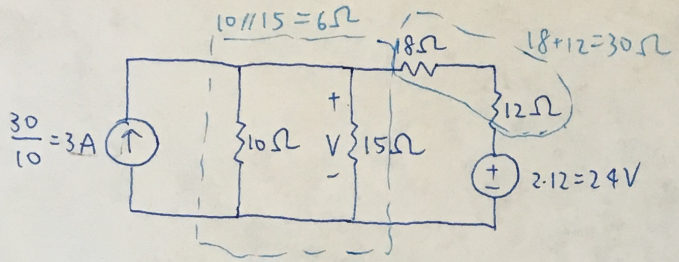
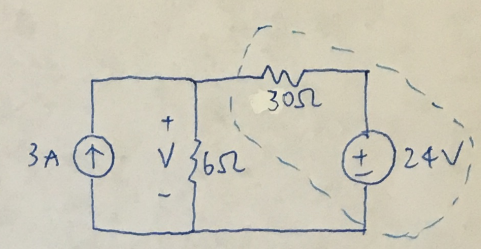
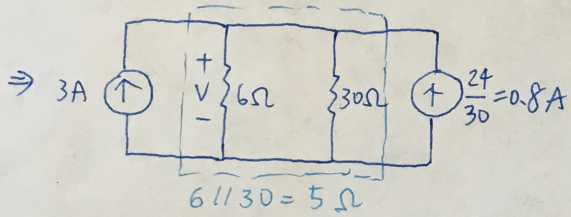
①

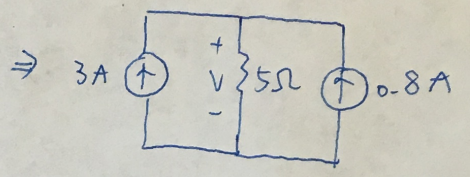


Use source transformation to find V.



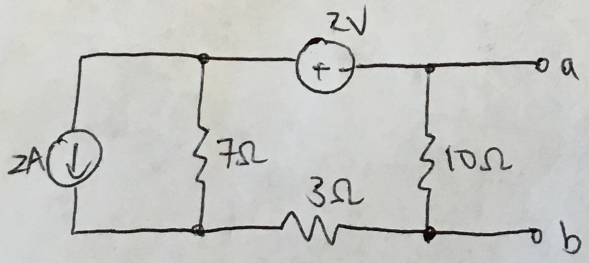




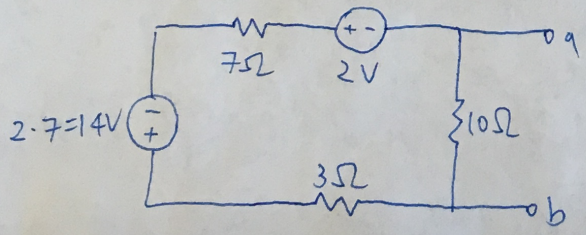


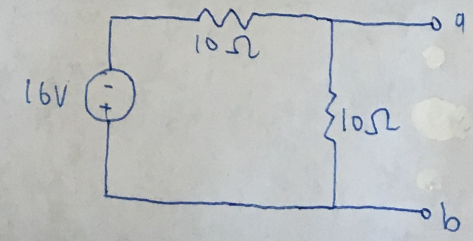
$V = (3+0.8)\cdot 5 = 19V$ #

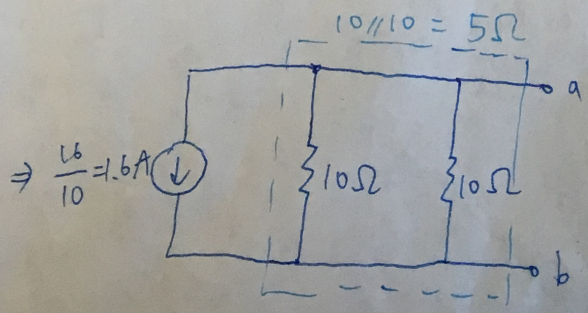
②

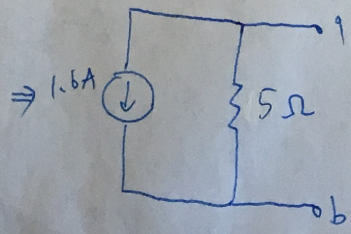


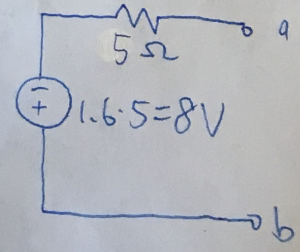
Find the Therevin equivalent from a to b.



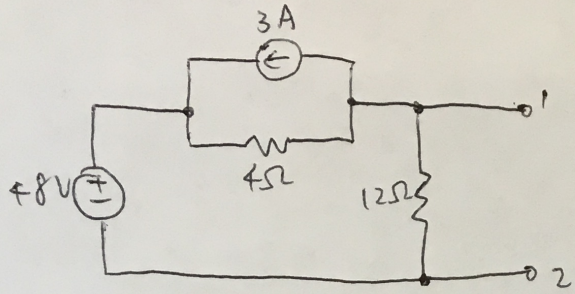




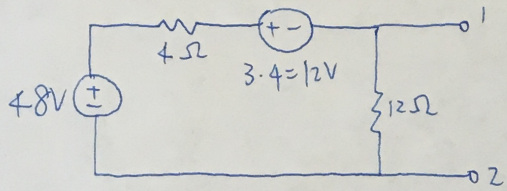




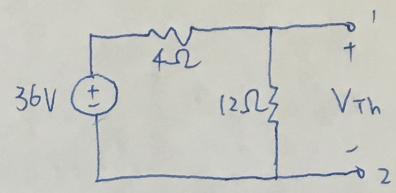
③



Find V_{Th} and R_{Th} at terminals 1, 2

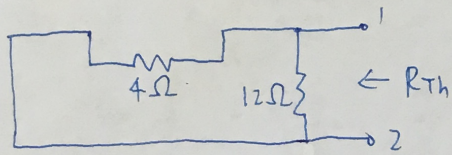


$\Rightarrow$



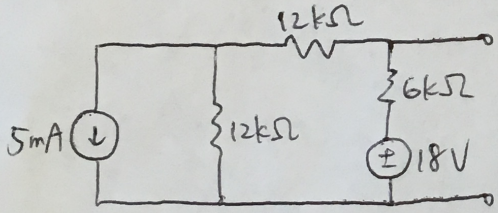
$$V_{Th} = 36 \cdot \frac{12}{12+4}$$

$$= 27\ V \ \#$$

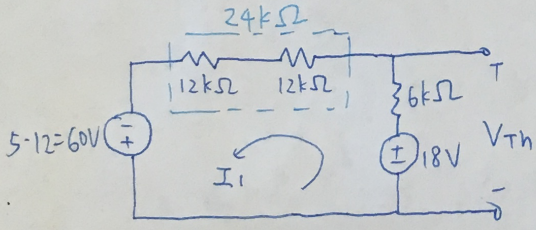


$$R_{Th} = 4 \parallel 12 = 3\ \Omega \ \#$$

④



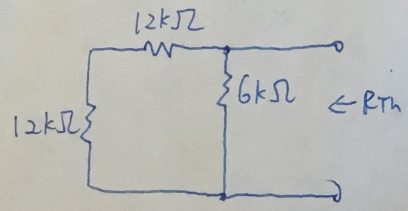
Find V_{Th}, R_{Th}, I_{sc}



KVL: $-18 + 6 \cdot I_1 + 24 I_1 - 60 = 0$

$$\Rightarrow I_1 = \frac{78}{30} = 2.6\ mA$$

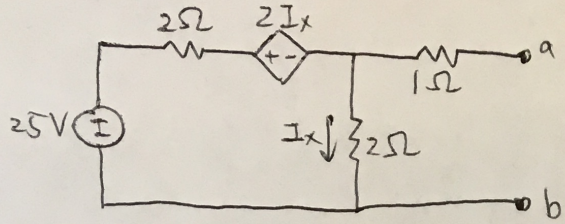
$$V_{Th} = 18 - 2.6 \cdot 6 = 2.4\ V \ \#$$



$$R_{Th} = (12k + 12k) \parallel 6k = 4.8\ k\Omega \ \#$$

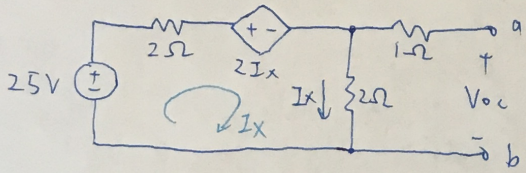
$$I_{sc} = \frac{V_{Th}}{R_{Th}} = 0.5\ mA \ \#$$

⑤



Find the Norton equivalent at terminals a, b

Find Voc first

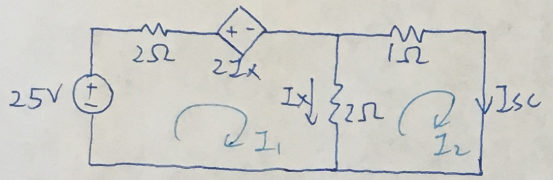


KVL: $-25+2I_x+2I_x+2I_x=0$

$\Rightarrow I_x = \frac{25}{6}$

$V_{oc} = I_x \cdot 2 = \frac{25}{3}$

Then find Isc



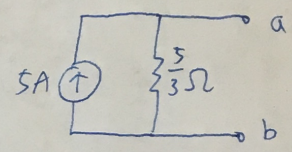
Mesh 1: $-25+2I_1+2I_x+2(I_1-I_2)=0$ — ①

Mesh 2: $2(I_2-I_1)+1\cdot I_2=0$ — ②

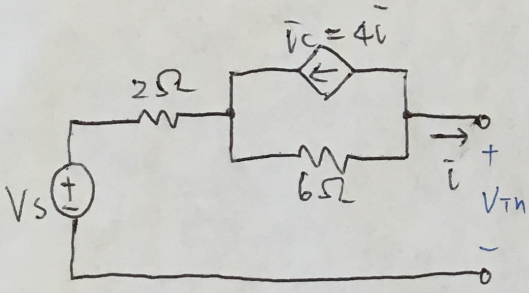
Dependent source: $I_x = I_1 - I_2$ — ③

$\Rightarrow I_{sc} = I_2 = 5\,A$

$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{5}{3}\,\Omega$



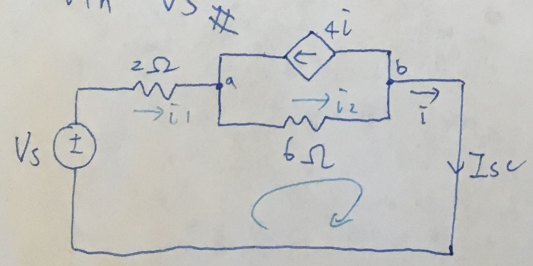
⑥



Find V_{Th} and I_{sc} in terms of V_s.

Then find R_{Th}.

$V_{Th} = V_s$ #



$I_{sc} = i$

KCL at b: $4i+i-i_2=0 \Rightarrow i_2=5i=5I_{sc}$

KCL at a: $-i_1-4i+i_2=0$

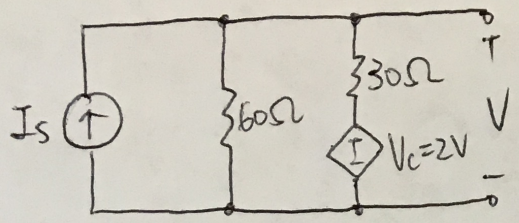
$\Rightarrow i_1 = -4i+i_2 = i = I_{sc}$

KVL: $-V_s+2i_1+6i_2=0$

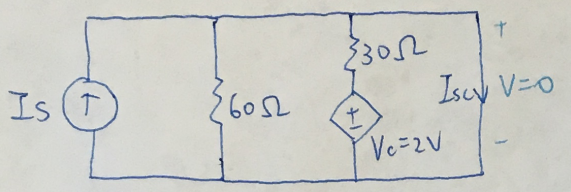
$-V_s+2I_{sc}+30I_{sc}=0 \Rightarrow I_{sc}=\frac{V_s}{32}$ #

$R_{Th} = \frac{V_{Th}}{I_{sc}} = 32\,\Omega$ #

⑦

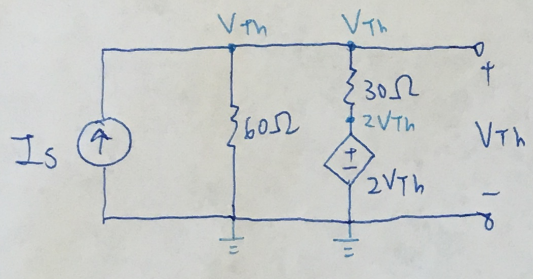


Find V_{Th}, R_{Th}, I_{sc} in terms of I_s.



$V_c = 2V = 0$

$I_{sc} = I_s$ #

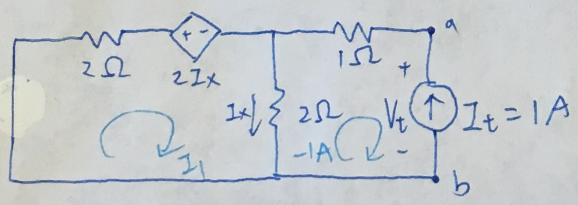


KCL: $-I_s + \frac{V_{Th}}{60} + \frac{V_{Th} - 2V_{Th}}{30} = 0$

$\Rightarrow V_{Th} = -60\, I_s$ #

$R_{Th} = \frac{V_{Th}}{I_{sc}} = -60\,\Omega$ #

Use test source to determine R_{Th} in ⑤



Find $V_t \Rightarrow R_{Th} = \frac{V_t}{I_t}$

Mesh 1: $2I_1 + 2I_x + 2(I_1 + 1) = 0$ — ①

Dependent source: $I_x = I_1 + 1$ — ②

①, ② $\Rightarrow I_1 = -\frac{2}{3}$

KVL: $2(-1 - I_1) + 1\cdot(-1) + V_t = 0$

$\Rightarrow V_t = \frac{5}{3} \Rightarrow R_{Th} = \frac{V_t}{I_t} = \frac{5}{3}\,\Omega$ #