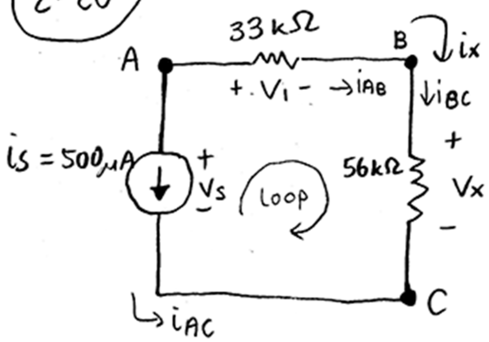
Homework 2 Solution

2-28



Set of connections: 1 loop and 3 nodes

Constraints:

KVL on loop 1 : $-V_s + V_1 + V_x = 0$

KCL on node A : $i_{AB} + i_{AC} = 0$

node B : $i_{BC} - i_{AB} = 0$

node C : $-i_{AC} - i_{BC} = 0$

Also $i_s = i_{AC}$, $i_x = i_{AB}$

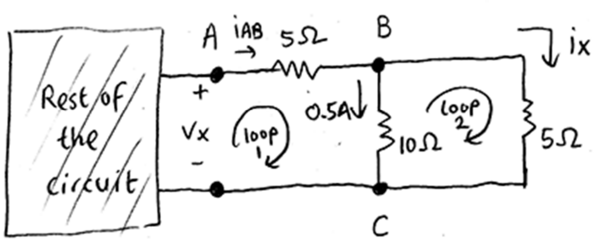
We only have 1 loop so all elements have the same current.

↳ $\boxed{i_x = -i_s = -500\mu A}$

Find Vx using Ohm's Low → $V_x = 56k\Omega \cdot i_x = 56\,k\Omega(-500\mu A)$

↳ $\boxed{V_x = -28V}$

2-32



We have 2 loops and 3 nodes. Find Vx and ix!

KVL

loop 1 → $-V_x + 5\Omega \cdot i_{AB} + 10\Omega\,(0.5A) = 0$ — ①

loop 2 → $10\Omega\,(-0.5A) + 5\Omega \cdot i_x = 0$ — ②

KCL

node B → $i_{AB} - 0.5A - i_x = 0$ — ③

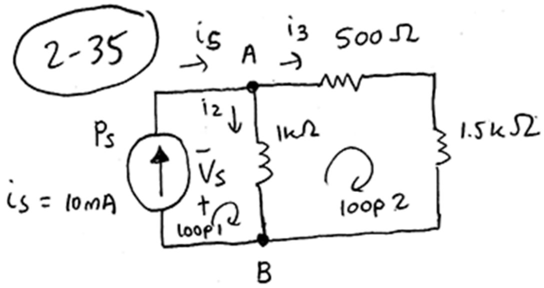
3 equations, 3 unknowns: V_x, i_x, i_{AB}

② → $10\Omega\,(-0.5A) + 5\Omega\, i_x = 0$ → $i_x = \frac{10\Omega}{5\Omega} \cdot (0.5A)$ → $\boxed{i_x = 1A}$ — ④

④+③ → $i_{AB} = 0.5A + i_x = 1.5A$ — ⑤

①+⑤ → $V_x = 5\Omega(1.5A) + 10\Omega\,(0.5A)$ → $\boxed{V_x = 12.5\,V}$

2-35



Find the power P_s!

KVL

loop 1 → $V_s + 1k\Omega \cdot i_2 = 0$ ——— ①

loop 2 → $1k\Omega(-i_2) + 500\Omega \cdot i_3 + 1.5k\Omega \cdot i_3 = 0$ — ②

KCL

node A → $i_s - i_2 - i_3 = 0$ ——— ③

3 equations, 3 unknowns: V_s, i_2, i_3

② → $(500\Omega + 1.5k\Omega)\, i_3 = 1k\Omega\, i_2$ → $i_3 = \frac{1}{2} i_2$ — ④

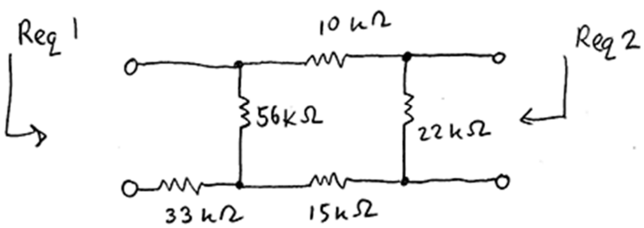
③ + ④ → $10mA - i_2 - \frac{1}{2} i_2 = 0$ → $i_2 = \frac{20}{3}\, mA$ — ⑤

① + ⑤ → $V_s = -1k\Omega\left(\frac{20}{3} mA\right)$ → $V_s = -20/3\ V$

Then, $P_s = V_s \cdot i_s = \left(-\frac{20}{3} V\right)(10mA)$ → $P_s = -200/3\ mW$

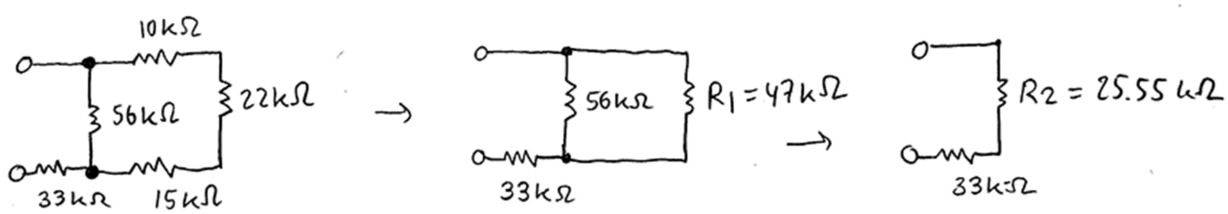
negative power → power source.

2-42



Find Req1 and Req2.

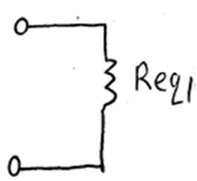
Req 1



R_1 → serial circuit → $R_1 = 10k\Omega + 22k\Omega + 15k\Omega = 47k\Omega$

R_2 → parallel circuit → $R_2 = \left(\frac{1}{56k\Omega} + \frac{1}{47k\Omega}\right)^{-1} = \left(\frac{56 \cdot 47}{56+47}\right) k\Omega$

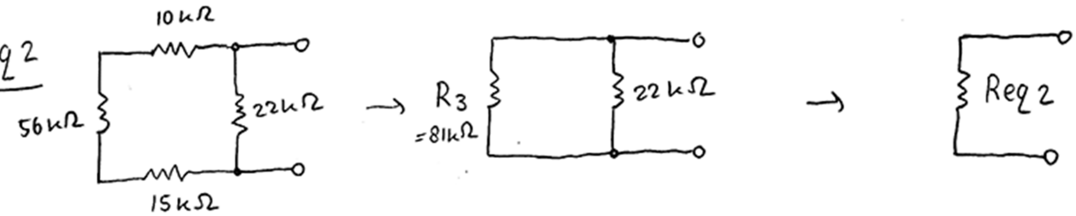
$= 25.55\ k\Omega$



Req1 → serial circuit → $Req_1 = 33k\Omega + 25.55k\Omega$

↳ $Req_1 = 58.55\ k\Omega$

Req 2

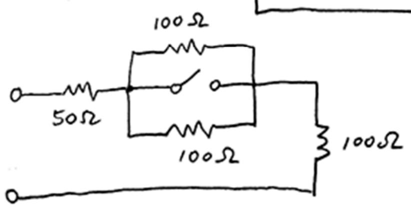


R3 → serial circuit → $R_3 = 10k\Omega + 56k\Omega + 15k\Omega$ → $R_3 = 81k\Omega$

Req2 → parallel circuit → $Req_2 = \left(\frac{1}{81k\Omega} + \frac{1}{22k\Omega}\right)^{-1} = \left(\frac{81 \cdot 22}{81+22}\right) k\Omega$

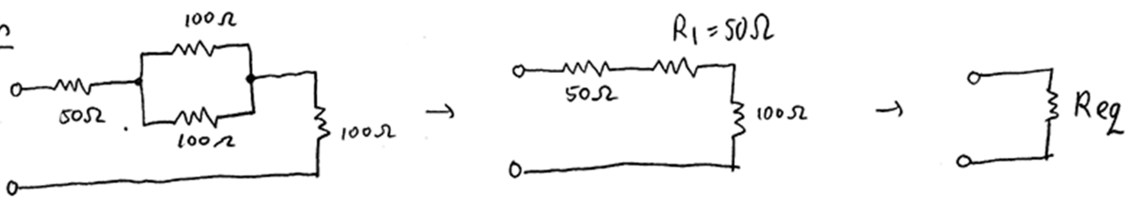
↳ **$Req\,2 = 17.30\ k\Omega$**

(2-43) Req ↳



Find Req when the switch is open and closed!

Open

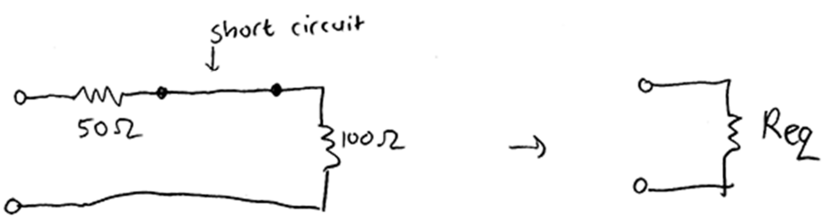


R_1 → parallel → $R_1 = \left(\frac{1}{100\Omega} + \frac{1}{100\Omega}\right)^{-1} = \left(\frac{100 \cdot 100}{100+100}\right)\Omega$ → $R_1 = 50\Omega$

Req → serial → $Req = 50\Omega + 50\Omega + 100\Omega$ → **$Req = 200\Omega$**

Closed → we will have a short circuit

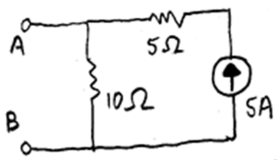
Req ↳



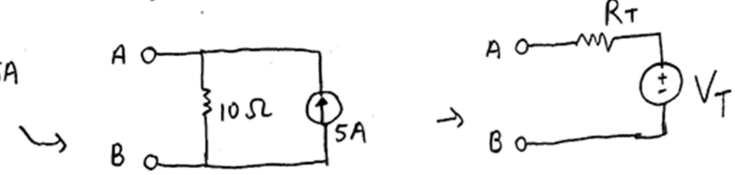
Req → serial → $Req = 50\Omega + 100\Omega$ → **$Req = 150\Omega$**

(2-51) Find equivalent practical voltage source at terminals A and B!

a)



Use equivalent source transformations.

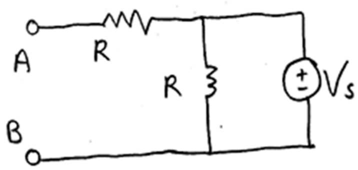


$R_T = 10\Omega$

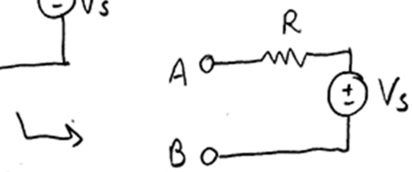
$V_T = (5A)(10\Omega) = 50V$

→ Practical voltage is 50V

b)

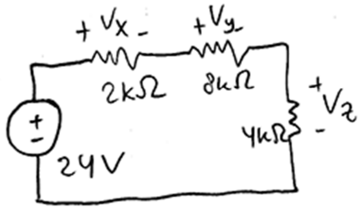


Same method as part a)



→ Practical voltage is V_s

(2-58) Use voltage division to find V_x, V_y, V_z. Show that the sum is equal to the source voltage!



Voltage division

↳ $V_x = \frac{2k\Omega}{2k\Omega + 8k\Omega + 4k\Omega} \cdot 24V$

$V_y = \frac{8k\Omega}{2k\Omega + 8k\Omega + 4k\Omega} \cdot 24V$

$V_z = \frac{4k\Omega}{2k\Omega + 8k\Omega + 4k\Omega} \cdot 24V$

→ $V_x = \frac{48}{14}V$

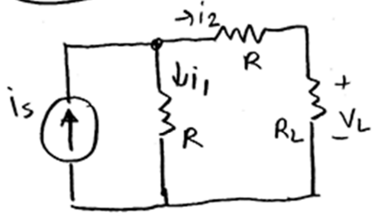
$V_y = \frac{192}{14}V$

$V_z = \frac{96}{14}V$

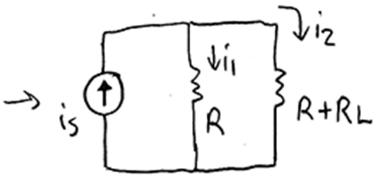
Sum of all voltage

↳ $V_x + V_y + V_z = \frac{48 + 192 + 96}{14}V = \frac{336}{14}V = 24V$ → shown

2-61 Use current division to find V_L!



→



Current division

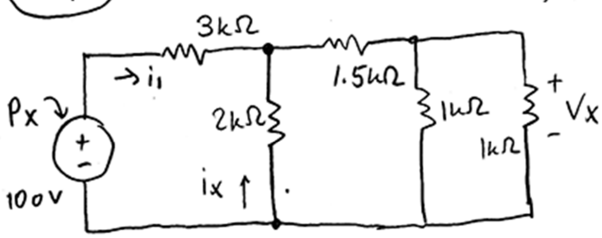
$$i_2 = \frac{1/(R+R_L)}{1/R + 1/(R+R_L)} \cdot i_s$$

$$\boxed{i_2 = \frac{R}{2R+R_L} \cdot i_s}$$

Then we have

$$\boxed{V_L = R_L \cdot i_2 = \frac{R R_L}{2R+R_L} i_s}$$

2-75 Use circuit reduction to find V_x, i_x, P_x

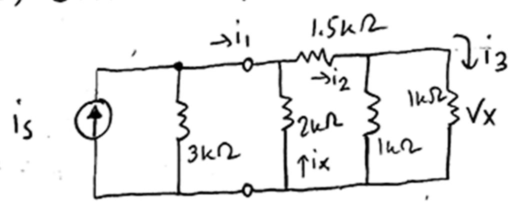


$P_x = -100V \cdot i_1$

↑ negative because it provides power

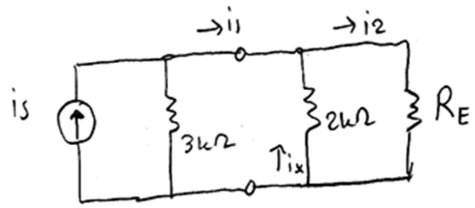
→ Source transformation the 100V,

$$i_s = \frac{100V}{3k\Omega} = \frac{1}{30} A$$



Solve for i_1, i_2, i_3

→ Circuit reduction → 1.5kΩ in series with parallel 1kΩ and 1kΩ



$$R_E = 1.5k\Omega + \left(\frac{1}{1k\Omega} + \frac{1}{1k\Omega}\right)^{-1} = 1.5k\Omega + 0.5k\Omega$$

$$R_E = 2k\Omega$$

Use current division to find i_x and i_1 and i_2

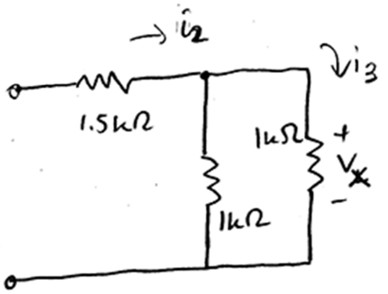
$$i_x = \frac{-1/2k\Omega}{1/3k\Omega + 1/2k\Omega + 1/2k\Omega} \cdot \frac{1}{30} A = \boxed{-12.5 mA}$$

$$i_2 = \frac{1/2k\Omega}{1/3k\Omega + 1/2k\Omega + 1/2k\Omega} \cdot \frac{1}{30} A = 12.5 mA$$

$i_1 = -i_x + i_2$

$i_1 = 25 mA$

Then from the 2nd circuit, we have:



Solve i_3 using current division.

$$i_3 = \frac{1/1k\Omega}{\frac{1}{1k\Omega}+\frac{1}{1k\Omega}} \cdot i_2 = \frac{1}{2}\cdot(12.5mA)$$

$$= 6.25mA$$

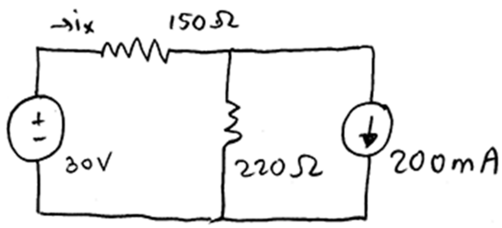
Then $V_x = i_3 \cdot 1k\Omega =$ **6.25V**

$P_x = -i_1(100V) = -(25mA)(100V) =$ **−2.5W**

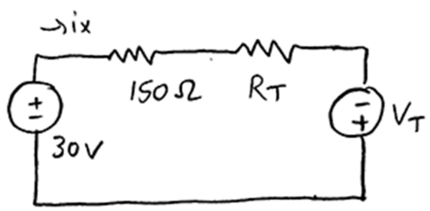
→

$i_x = -12.5mA$
$V_x = 6.25V$
$P_x = -2.5W$

(2-77) Use source transformation to find ix



↓



$R_T = 220\Omega$

$V_T = 200mA \cdot 220\Omega$
$= 44V$

Then solve for ix

$$i_x = \frac{30V + 44V}{150\Omega + 220\Omega} = \frac{74}{370}A$$

$i_x = 200mA$