Q. What is the maximum current that a $\frac{1}{2}W$, 100Ω resistor can carry?

$$P = I^2 R$$

$$0.5W = I^2 (100\Omega)$$

$$\boxed{I_{max} = 70.7\ mA}$$

Q Suppose you must dissipate 10W and require 100Ω of resistance, but you only have 2W resistors. Suggest the minimal part solution

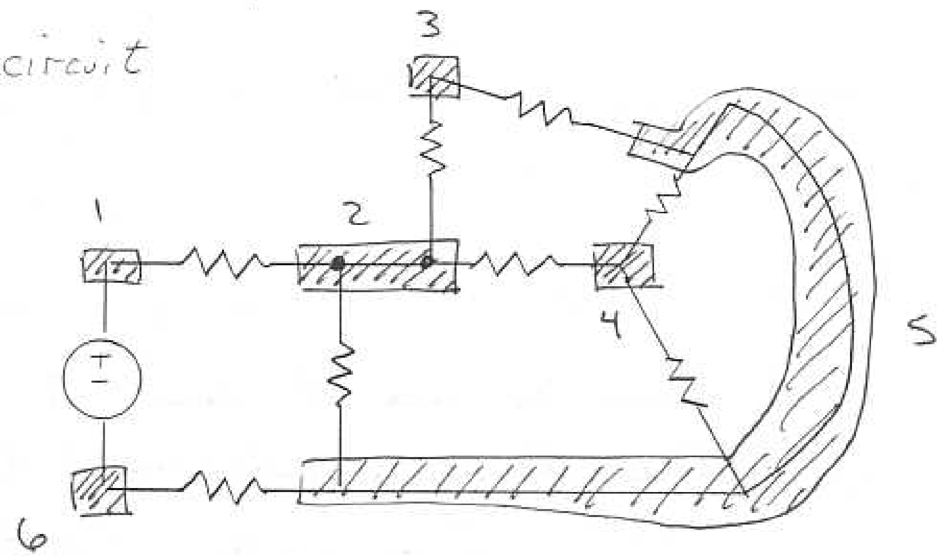
Will have to use at least 5 resistors, each dissipating the full rated 2W. Can achieve 100Ω with 5 identical resistors by putting (5) 20Ω resistors in series or (5) 500Ω resistors in parallel.

Q. A 6V battery is rated for 7Ah, what resistance must be attached across it for the battery to last 5hrs?

$$\frac{7\,A\cdot hr}{I} = 5\,hr \Rightarrow I = 1.4\,A$$

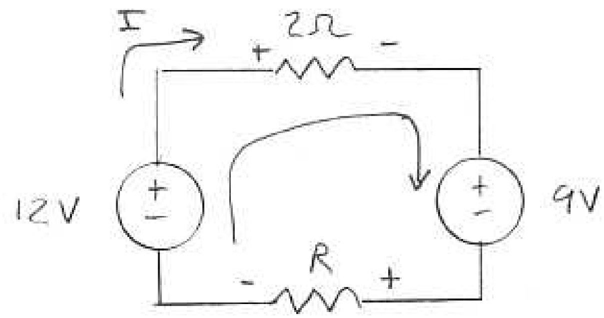
$$V = IR \rightarrow 6V = (1.4A)R \rightarrow \boxed{R = 4.29\,\Omega}$$

Q. How many nodes are in the following circuit



6

Q what value of R will cause the 2Ω resistor to absorb 1W



Find $V_{2\Omega}$:

$$P = \frac{V^2}{R}$$

$$1W = \frac{V_{2\Omega}^2}{2\Omega}$$

$$V_{2\Omega} = 1.41V$$

KVL: $-12V + V_{2\Omega} + 9V + V_R = 0$

$-12V + 1.41V + 9V + V_R = 0 \rightarrow V_R = 1.59V$

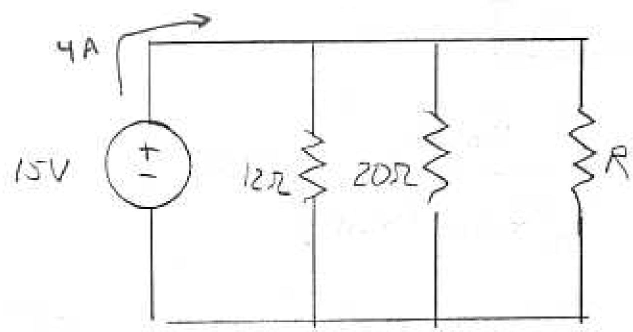
Ohm's Law on 2Ω to find I: $V = IR$

$1.41V = I(2\Omega) \rightarrow I = 0.705A$

Ohm's Law on R:

$1.59V = (0.705A)R \rightarrow$ $\boxed{R = 2.26\Omega}$

Q.



What R is required to have the supply source no more than 4A? What power does 12Ω absorb?

$15V = (4A)R_{eq} \rightarrow R_{eq} = 3.75\Omega$

$12\Omega \| 20\Omega = 7.5\Omega$

$7.5\Omega \| R = \frac{(7.5)R}{7.5 + R} = 3.75\Omega$

$\boxed{R = 7.5\Omega}$

$$P_{12\Omega} = \frac{V^2}{R}$$

$$P_{12\Omega} = \frac{(15V)^2}{12\Omega}$$

$\boxed{P_{12\Omega} = 18.75W}$

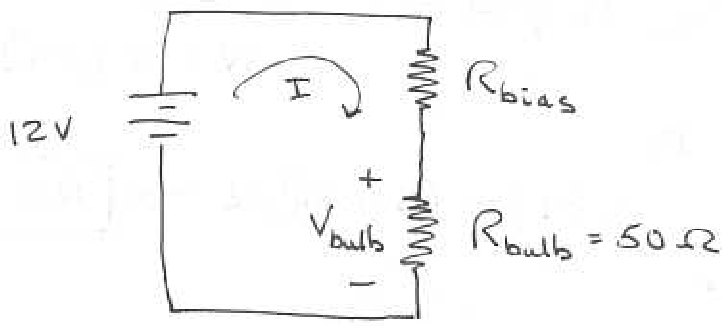
Q. IF you have a 12V battery and a bulb rated for 5V at 0.1A, what series resistance is required and at what standard wattage ($\frac{1}{8}$W, $\frac{1}{4}$W, $\frac{1}{2}$W, 1W, 2W)

bulb resistance:

$$V = I R_{bulb}$$

$$5V = (0.1A) R_{bulb}$$

$$R_{bulb} = 50\Omega$$



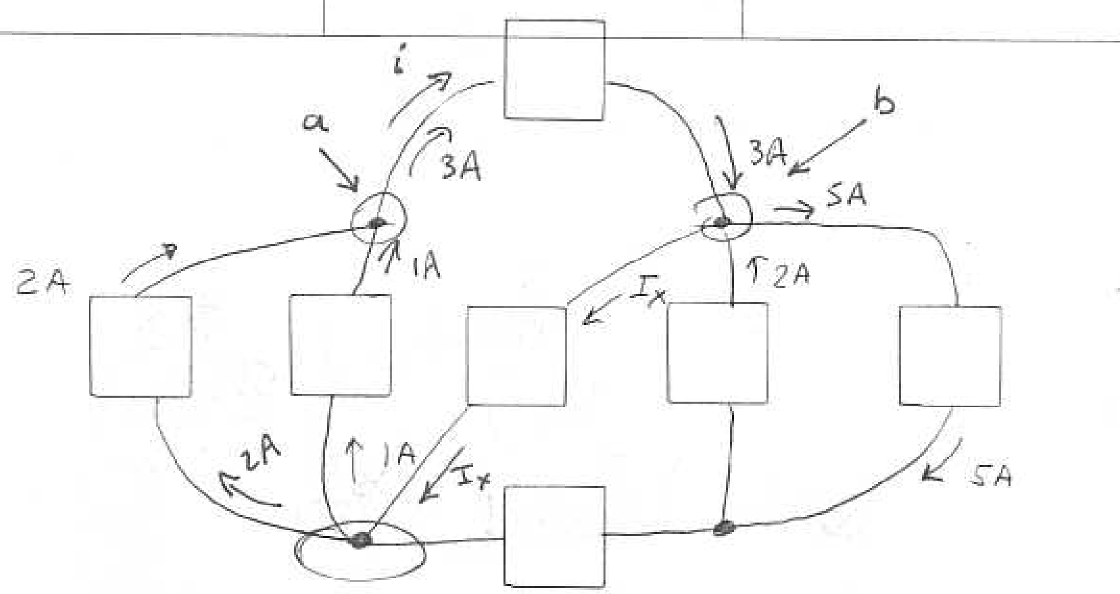
$$V_{bulb} = \left(\frac{R_{bulb}}{R_{bias} + R_{bulb}}\right) 12V$$

$$5V = \left(\frac{50\Omega}{R_{bias} + 50\Omega}\right) 12V \longrightarrow \boxed{R_{bias} = 70\Omega}$$

$$I = \frac{12V}{120\Omega} = 0.1A$$

$$P_{bias} = I^2 R_{bias} = (0.1A)^2 (70\Omega) = 0.7W$$

$\Longrightarrow$ **1W resistor required**

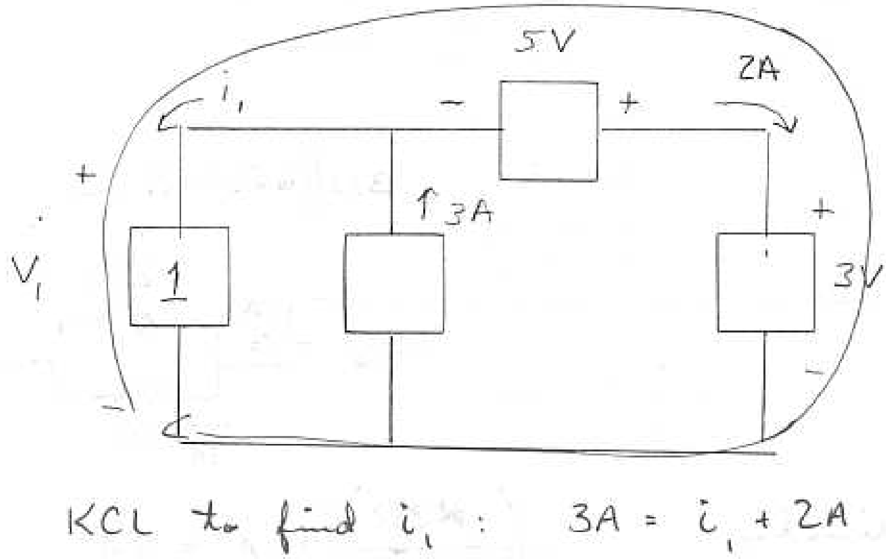


KCL @ a : $2A + 1A = i$; KCL @ b: $3A + 2A = I_x + 5A$

Q. Find I_x $\boxed{I_x = 0\,A}$

~~KCL: $I_x = 2A + 1A = 3A$~~

Q. Find the power absorbed by component 1



KCL to find i_1: $3A = i_1 + 2A \rightarrow i_1 = 1A$

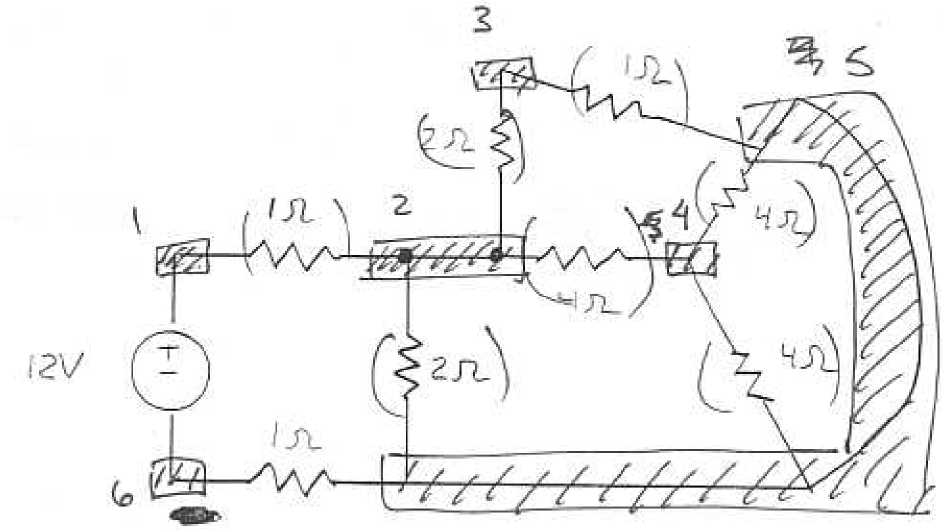
KVL around outside to find V_1:

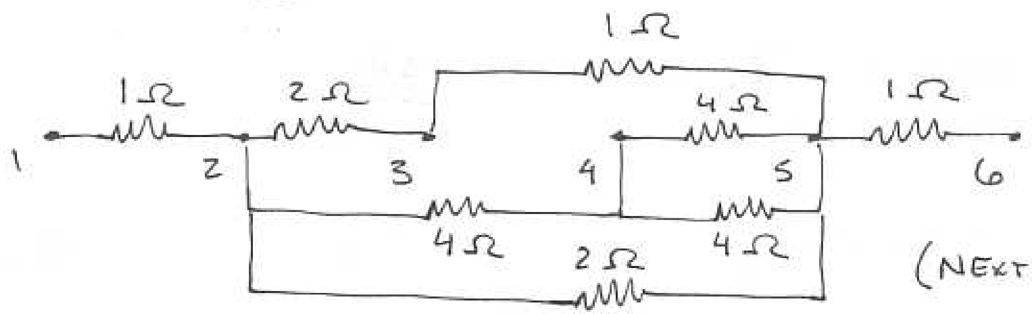
$-V_1 - 5V + 3V = 0 \rightarrow V_1 = -2V$

$P = VI = (-2V)(1A) = \boxed{-2W}$

note: power <u>absorbed</u> is "−" because it is acting like a <u>source</u>

Q. Find the equivalent resistance "seen" by the 12V source





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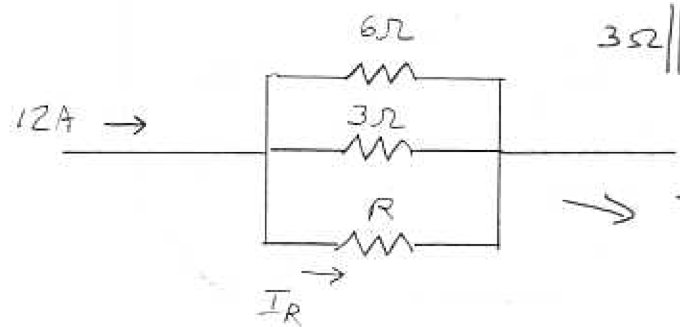
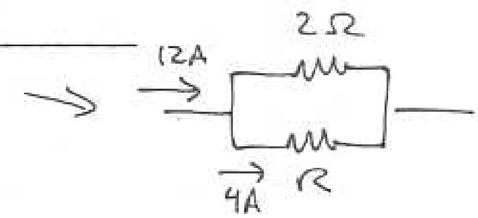
Q. Find R so that $I_R = 4A$

$3\Omega \| 6\Omega = 2\Omega$



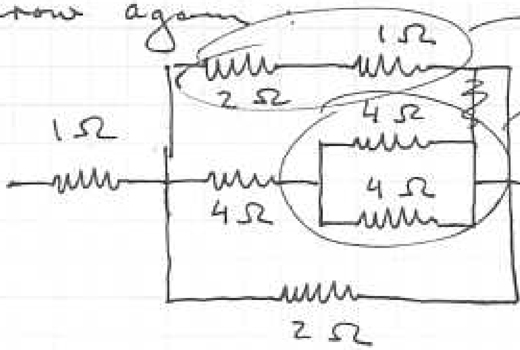


Current divider

$$I_R = \left(\frac{2\Omega}{R+2\Omega}\right) 12\,A = 4\,A$$

$$\boxed{R = 4\Omega}$$

Redraw again:



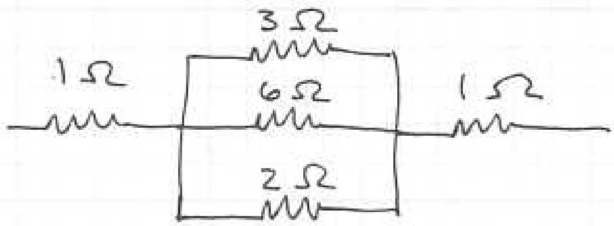
→ series → 2Ω + 1Ω = 3Ω

→ parallel: 4Ω||4Ω = 2Ω

combo in series with other 4Ω:

4Ω + 2Ω = 6Ω

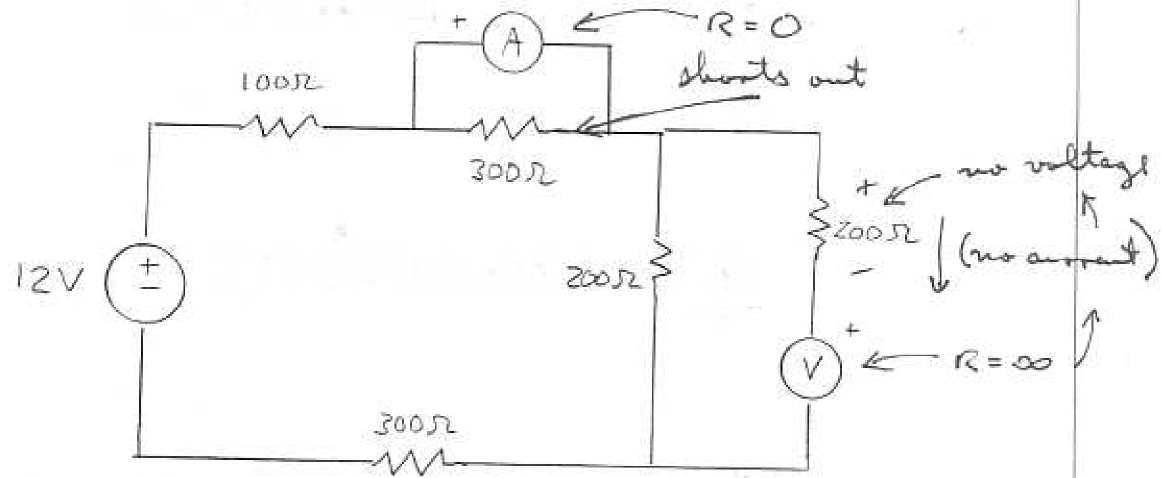
Now have:



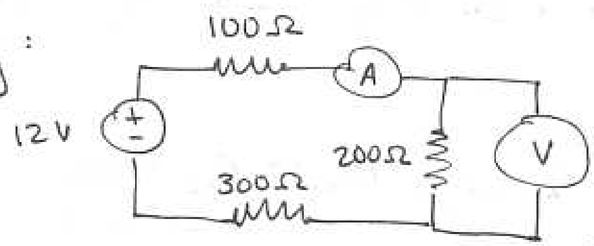
$$R_{eq} = 1\Omega + 3\Omega || 6\Omega || 2\Omega + 1\Omega$$

$$1\Omega + 1\Omega + 1\Omega = \boxed{3\Omega}$$

Q. Consider ideal voltmeter and ammeter, what does each meter read?



effectively:

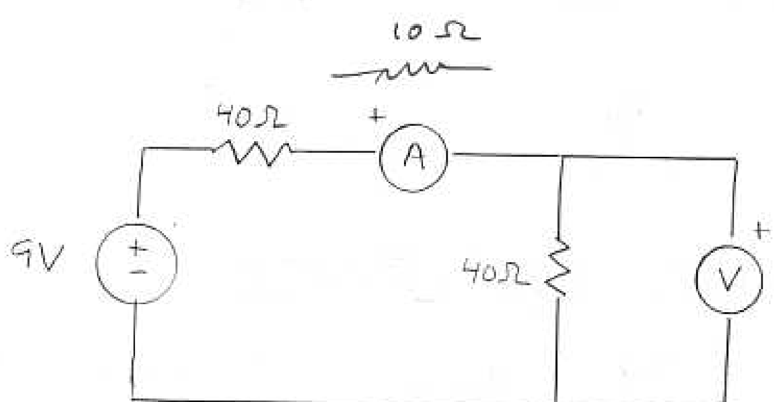


$$I = \frac{12V}{100\Omega + 200\Omega + 300\Omega}$$

$$\boxed{I = 20mA}$$

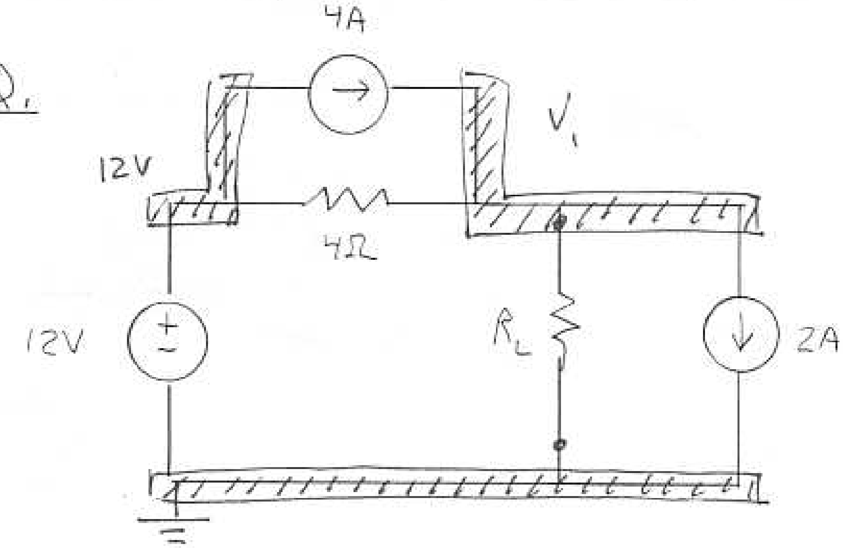
$$V_{200\Omega} = \left(\frac{200\Omega}{600\Omega}\right)12V = \boxed{4V}$$

Q. If the ammeter has an internal resistance of 10Ω and the voltmeter is ideal, what does the voltmeter read?



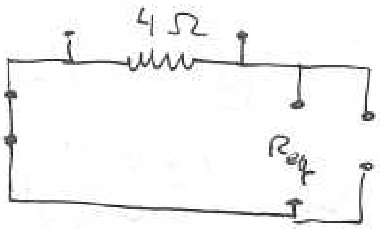
$$V_{40\Omega} = \left(\frac{40\Omega}{40\Omega + 10\Omega + 40\Omega}\right)9V = \boxed{4V}$$

Q.

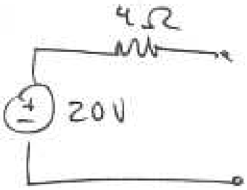


Find the Thevenin Equivalent "seen" by R_L

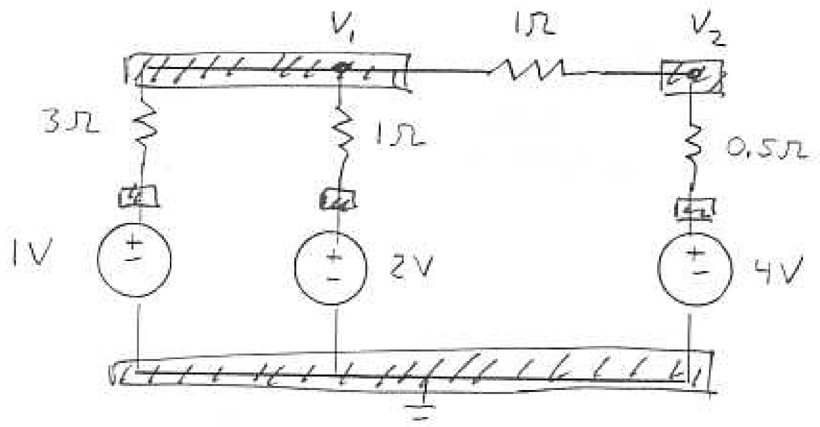
$$-4A + \frac{V_1 - 12V}{4\,\Omega} + 2A = 0 \longrightarrow V_1 = 20V = V_{Th}$$



$\longrightarrow R_{eq} = R_{Th} = 4\,\Omega$



Q. Determine node voltages V_1 and V_2



$$\frac{V_1 - 1V}{3\,\Omega} + \frac{V_1 - 2V}{1\,\Omega} + \frac{V_1 - V_2}{1\,\Omega} = 0$$

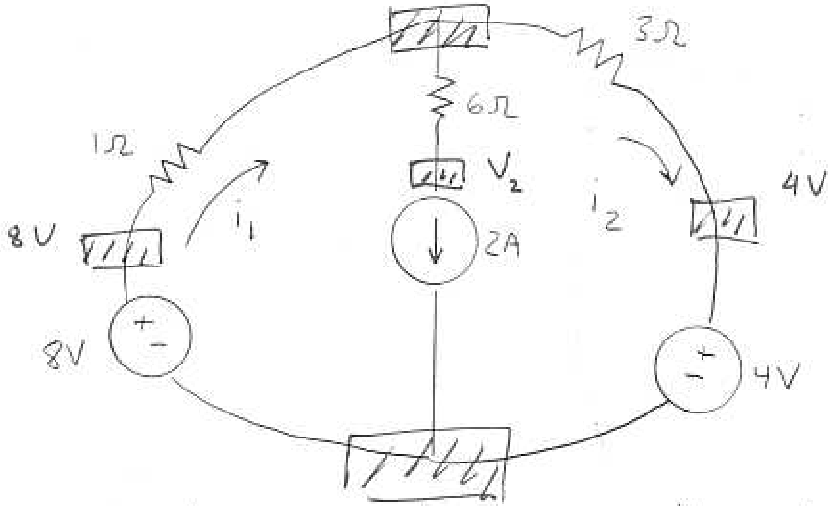
$$\frac{V_2 - V_1}{1\,\Omega} + \frac{V_2 - 4V}{0.5\,\Omega} = 0$$

$V_1 = 2.5V$

$V_2 = 3.5V$

Find i_1 and i_2 V_1

Q.

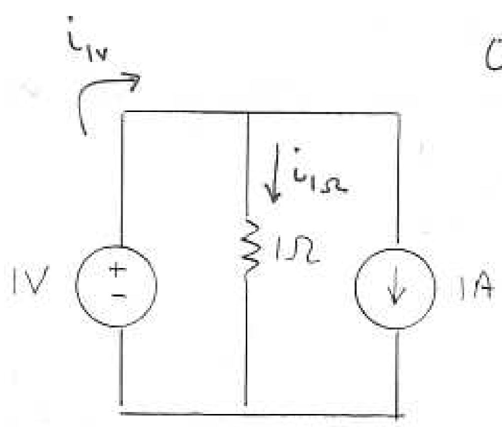


Use nodal to find V_1. Since we don't need V_2 & we know that the current through the 6Ω resistor is 2A, I'll use that instead of writing $\frac{V_1 - V_2}{6\Omega}$

$$\frac{V_1 - 8V}{1\Omega} + 2A + \frac{V_1 - 4V}{3\Omega} = 0 \longrightarrow V_1 = 5.5V$$

$$i_1 = \frac{8V - V_1}{1\Omega} = \frac{8V - 5.5V}{1\Omega} = \underline{2.5A} \qquad i_2 = \frac{V_1 - 4V}{3\Omega} = \frac{5.5V - 4V}{3\Omega} = \underline{0.5A}$$

Q. Find the power delivered by the 1V source



Ohm's Law to find $i_{1\Omega}$

$$1V = i_{1\Omega}(1\Omega)$$

$$i_{1\Omega} = 1A$$

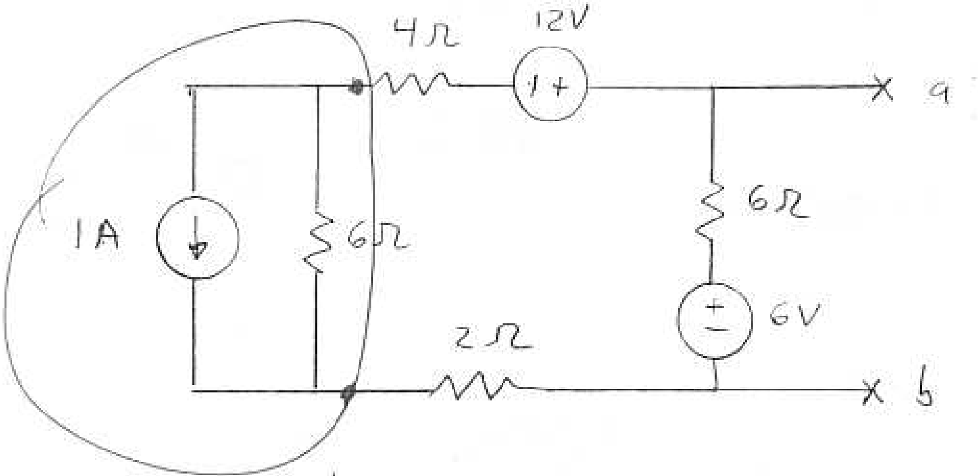
KCL to find i_{1V}

$$i_{1V} = i_{1\Omega} + 1A$$

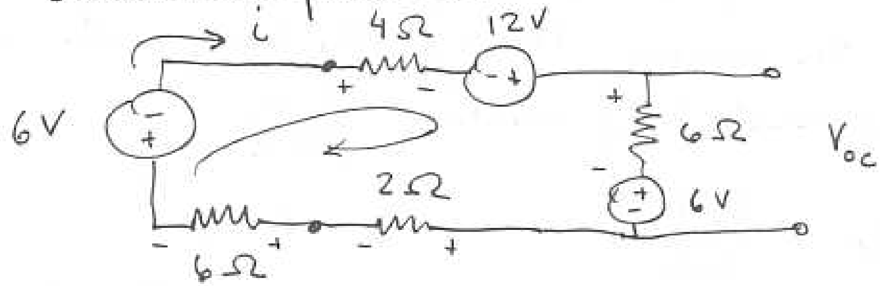
$$= 1A + 1A = 2A$$

$$P_{1V} = (1V)(2A) = \boxed{2W}$$

Q. Find the Thevenin Equivalent at a-b



Source transformation



Use KVL to find current i :

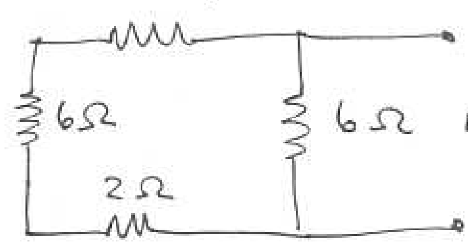
$$+6V + i(4\Omega) - 12V + i(6\Omega) + 6V + i(2\Omega) + i(6\Omega) = 0$$

solve → $i = 0$

no current → no voltage across resistors

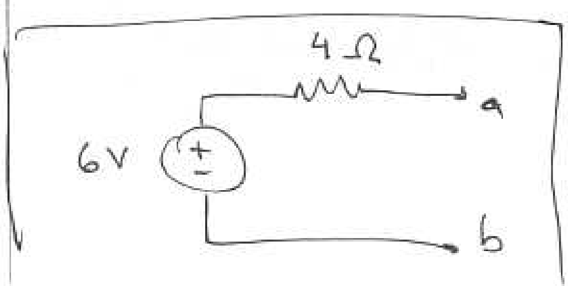
→ $\boxed{V_{oc} = 6V}$

R_{Th}

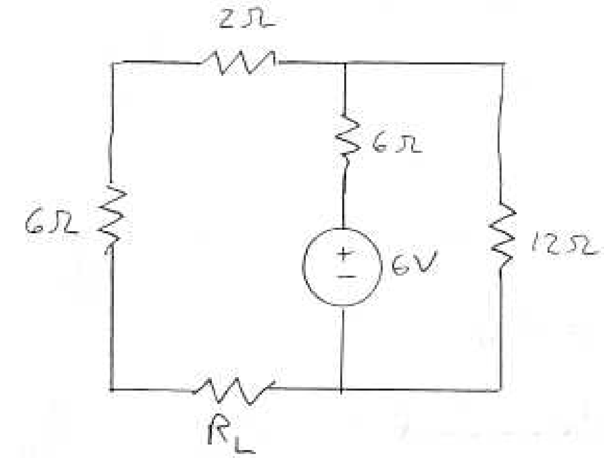


$$R_{eq} = 6\Omega \,||\, (4\Omega + 6\Omega + 2\Omega)$$
$$= 6\Omega \,||\, 12\Omega$$

$\underline{R_{eq} = 4\Omega}$



Q. If R_L is chosen to give maximum power transfer, what is the maximum power transferred?



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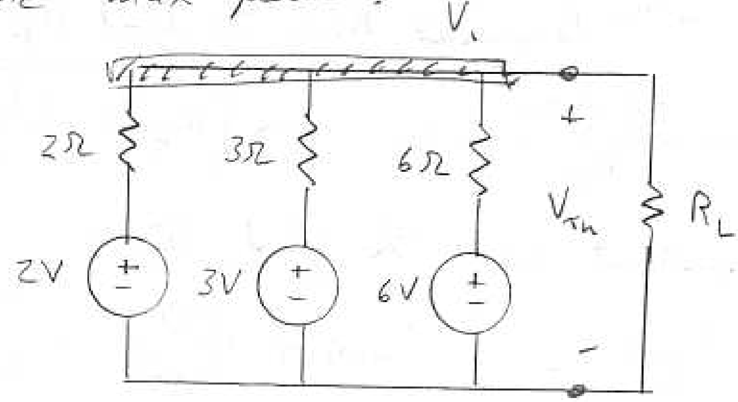
Q. Find R_L for max power transfer and find the max power.



$$\frac{V_1 - 2V}{2\Omega} + \frac{V_1 - 3V}{3\Omega} + \frac{V_1 - 6V}{6\Omega} = 0$$ ~~NEXT PAGE~~

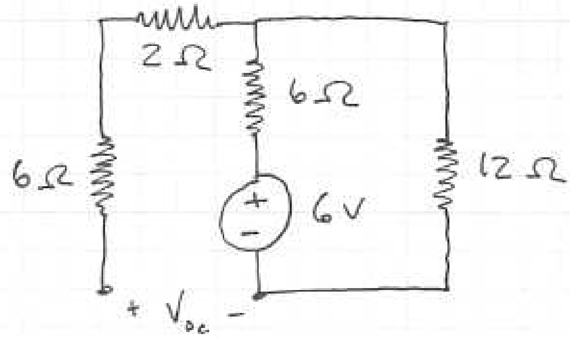
$V_1 = 3V = V_{Th}$

$\boxed{R_{L,max} = 1\Omega}$

$R_{Th} = 2\Omega \| 3\Omega \| 6\Omega = 1\Omega$

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(3V)^2}{4(1\Omega)} = \boxed{2.25W}$$

Thevenize "as seen by" R_L:



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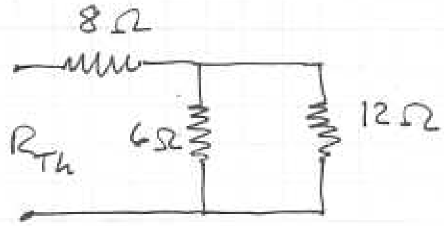


After removing R_L, no current through the "orphaned" 2 Ω & 6 Ω resistors → no voltage across them, so

$$V_{Th} = V_{oc} = V_{12\Omega}$$

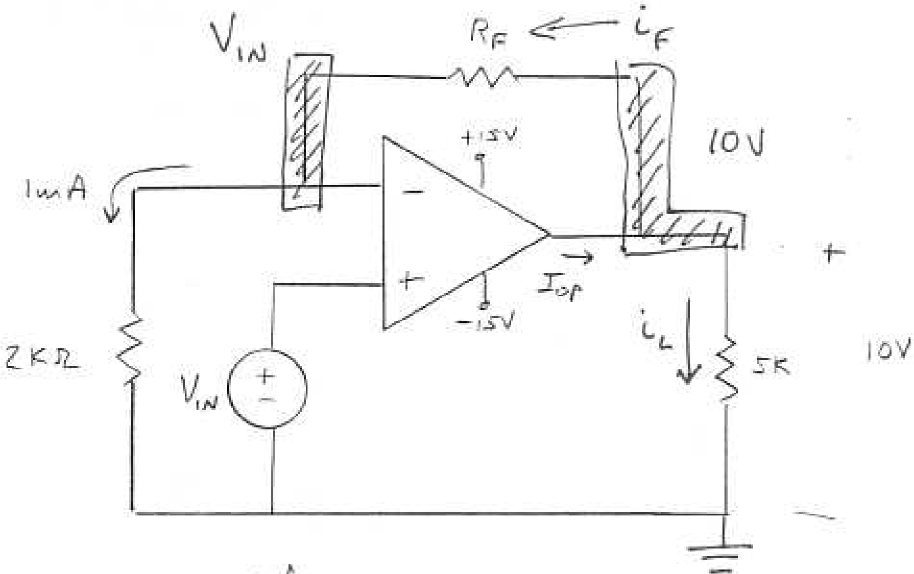
$$V_{Th} = \left(\frac{12\,\Omega}{6\,\Omega + 12\,\Omega}\right) 6\,V = \underline{\underline{4V}}$$

$$R_{Th} = 8\,\Omega + 6\,\Omega \| 12\,\Omega$$

$$= 8\,\Omega + 4\,\Omega = 12\,\Omega$$

$$P_{L,max} = \frac{V_{Th}^2}{4 R_{Th}} = \frac{(4V)^2}{4(12\,\Omega)} = \boxed{0.333\,W}$$

Q. Given the following, find V_{IN}, R_F and I_{OP}



$$v^+ = v^- = V_{IN}$$

KCL at "−" terminal: $\dfrac{V_{IN}}{2k\Omega} + \dfrac{V_{IN} - 10V}{R_F} = 0$

Ohm's law across $2k\Omega$ to find V_{IN}:

$$V_{IN} = (1mA)(2k\Omega) = \boxed{2V}$$

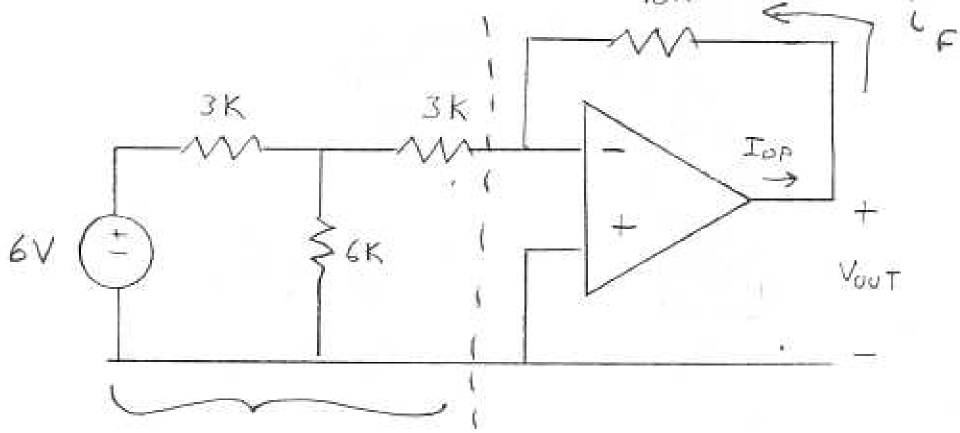
Plug into "−" terminal KCL to find R_F:

$$\frac{2V}{2k\Omega} + \frac{2V - 10V}{R_F} = 0 \longrightarrow \boxed{R_F = 8\,k\Omega}$$

KCL at output node to find I_{op}:

$$I_{op} = i_F + i_L = 1mA + \frac{10V}{5k\Omega} = \boxed{3\,mA}$$

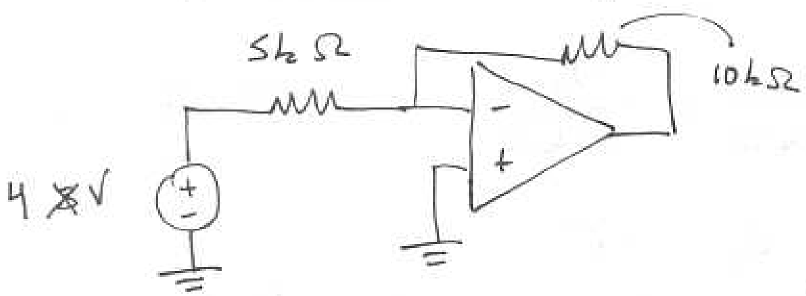
Q Find V_{OUT} and I_{OP}



Thevenize to get conventional inverting amplifier

$$V_{Th} = \left(\frac{6\,k\Omega}{3\,k\Omega + 6\,k\Omega}\right) 6\,V = 4\,V$$

$$R_{Th} = 3\,k\Omega + 3\,k\Omega \parallel 6\,k\Omega = 5\,k\Omega$$

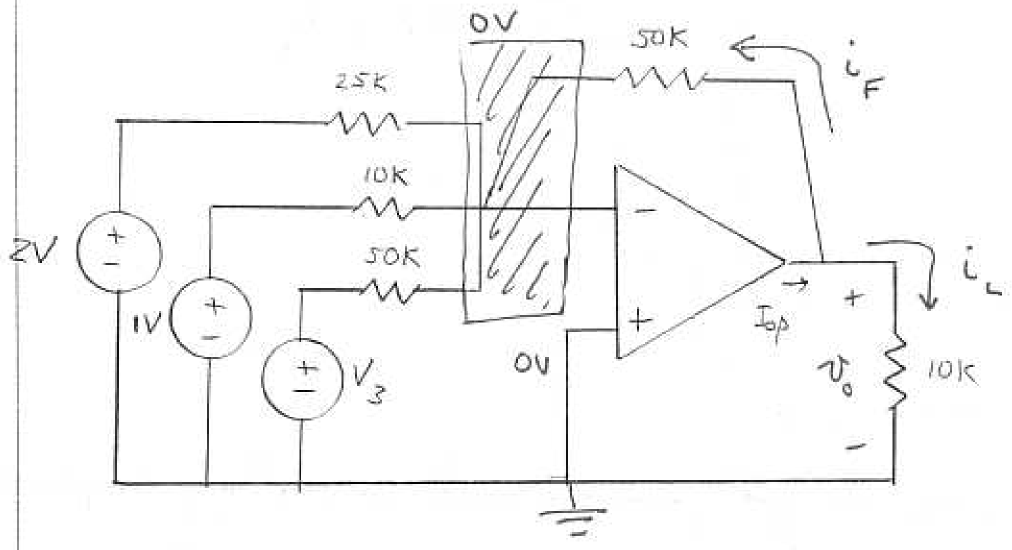


~~KCL at~~

$$v_o = -\frac{R_F}{R_1} v_1 = -\left(\frac{10\,k\Omega}{5\,k\Omega}\right) 4\,V = \boxed{-8\,V}$$

$$I_{op} = i_F = \frac{v_o}{R_F} = \frac{-8\,V}{10\,k\Omega} = \boxed{-0.8\,mA}$$

Q Find V_3 so $I_{op} = -0.72\,mA$



KCL at output node: $I_{op} = i_F + i_L$

$$i_F = \frac{v_o - 0V}{50k\Omega} \qquad i_L = \frac{v_o - 0V}{10k\Omega}$$

$$I_{op} = \frac{v_o}{50k\Omega} + \frac{v_o}{10k\Omega} = -0.72mA$$

$$v_o = -6V$$

Conventional summing amplifier topology:

$$v_o = -\left(\frac{R_F}{R_1} v_1 + \frac{R_F}{R_2} v_2 + \frac{R_F}{R_3} v_3\right)$$

$$-6V = -\left(\frac{50k\Omega}{25k\Omega} 2V + \frac{50k\Omega}{10k\Omega} 1V + \frac{50k\Omega}{50k\Omega} V_3\right)$$

$$\Rightarrow \boxed{V_3 = -3V}$$