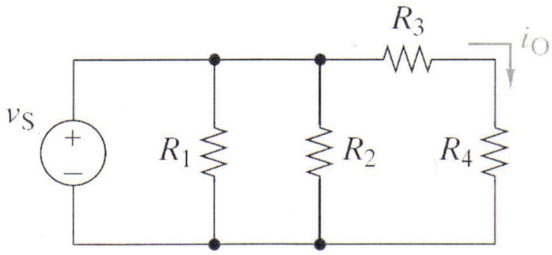
Problem#1: Problem 3-22 textbook

Find the proportionality constant $K = i_o / v_s$ for the given circuit.



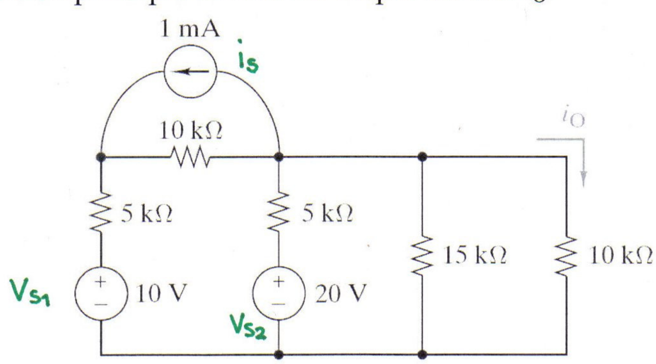
$$R_{EQ} = R_3 + R_4$$

$$i_o = \frac{V_S}{R_{EQ}} = \frac{V_S}{R_3 + R_4}$$

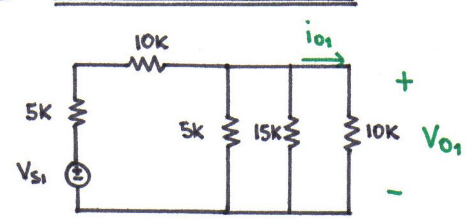
$$\boxed{K = \frac{i_o}{V_S} = \frac{1}{R_3 + R_4}}$$

Problem#2: Problem 3-29 textbook

Use the superposition principle to find the output current i_O.



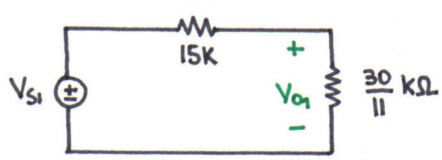
(1) CONSIDER ONLY V_{S1}



$$i_{o1} = \frac{V_{o1}}{10k}$$

$$R_{EQ} = 5K \,//\, 15K \,//\, 10K \qquad \frac{1}{R_{EQ}} = \frac{1}{5} + \frac{1}{15} + \frac{1}{10} = \frac{11}{30}$$

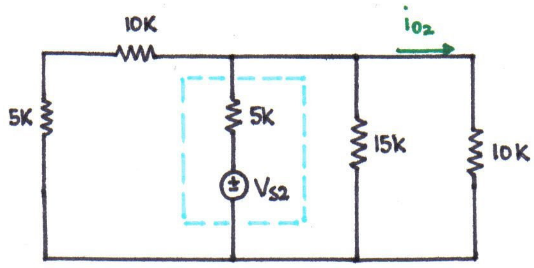
$$R_{EQ} = \frac{30}{11}\ k\Omega$$



$$V_{o1} = \frac{R_{EQ} \cdot V_{S1}}{(5K + 10K) + R_{EQ}} = \frac{30/11}{15 + 30/11} \cdot 10 = \frac{20}{13} = 1.538V$$

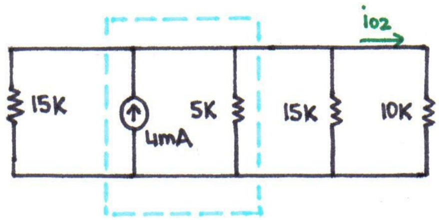
$$i_{o1} = \frac{V_{o1}}{10K} = \frac{2}{13}\ mA = \boxed{0.154\ mA}$$

② CONSIDER ONLY V_{S2}



SERIES $10K + 5K = 15K$

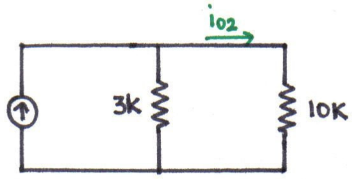
SOURCE TRANSFORMATION $i_{S2} = \frac{V_{S2}}{5K} = 4mA$



$R_{EQ} = 15K \,//\, 5K \,//\, 15K$

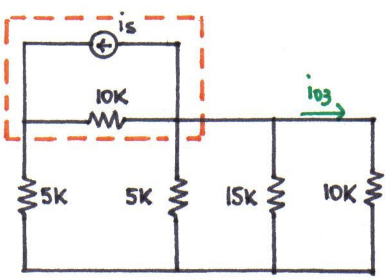
$$\frac{1}{R_{EQ}} = \frac{1}{15K} + \frac{1}{5K} + \frac{1}{15K} = \frac{1}{3K}$$

$R_{EQ} = 3K\Omega$



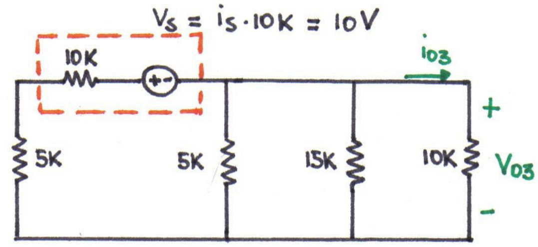
$$i_{o2} = \frac{3}{3+10} \cdot 4 \cdot 10^{-3} = \frac{12}{13}\,mA = \boxed{0.923\ mA}$$

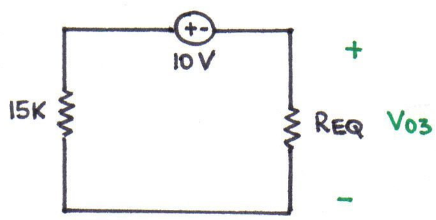
③ CONSIDER ONLY i_S



⇨

$V_S = i_S \cdot 10K = 10V$





$$i_{o3} = \frac{V_{o3}}{10K}$$

SERIES $5K + 10K = 15K$

$5K \,//\, 15K \,//\, 10K \;:=\; R_{EQ} = \frac{30}{11} K\Omega$

$$V_{o3} = -\left(\frac{30/11}{15 + 30/11}\right) \cdot 10 = -\frac{20}{13}\ V$$

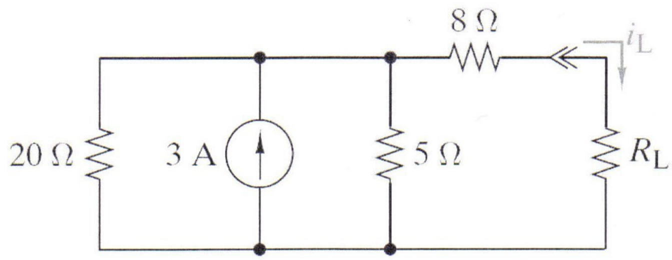
$$i_{o3} = \frac{V_{o3}}{10K} = -\frac{2}{13}\,mA = \boxed{-0.154\ mA}$$

④ SUM CONTRIBUTIONS

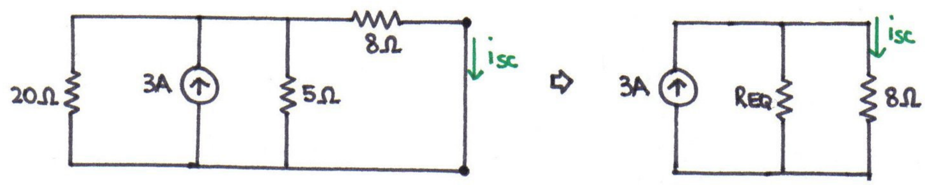
$$\boxed{i_o} = i_{o1} + i_{o2} + i_{o3} = \cancel{\frac{2}{13}} + \frac{12}{13} - \cancel{\frac{2}{13}} = \frac{12}{13}\,mA = \boxed{0.923\ mA}$$

Problem#3: Problem 3-38 textbook

Find the Norton equivalent circuit seen by R_L. Find the current when R_L=6Ω, 12 Ω, and 60 Ω.



① COMPUTE THE "SHORT CIRCUIT CURRENT" $i_{sc} = i_N$



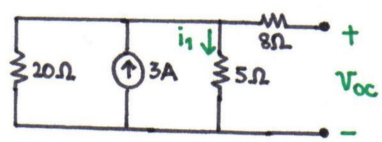
$R_{EQ} = 5 /\!/ 20 = \frac{100}{25} = 4\Omega$

$\boxed{i_N = i_{sc}} = \frac{R_{EQ}}{R_{EQ}+8} \cdot 3A$

$= \frac{4}{12} \cdot 3A = \boxed{1A}$

② COMPUTE THE RESISTANCE R_N . There are 2 ways to determine it

(a) $\boxed{R_N = V_{oc} / i_{sc}}$ where V_{oc} = "OPEN CIRCUIT VOLTAGE"

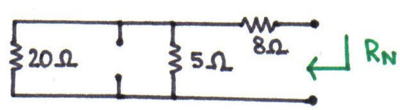


$i_1 = \frac{20}{20+5} \cdot 3 = \frac{60}{25}$ A

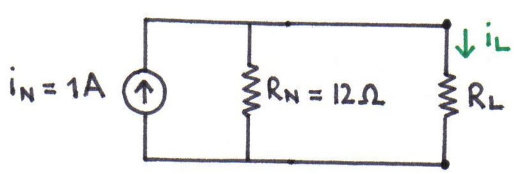
$V_{oc} = 5 \cdot \frac{60}{25} = 12V$

$\boxed{R_N} = \frac{V_{oc}}{i_{sc}} = \frac{12}{1} = \boxed{12\Omega}$

(b) $\boxed{R_N = \text{LOOKBACK RESISTANCE}}$



$\boxed{R_N} = 20 /\!/ 5 + 8 = 4 + 8 = \boxed{12\Omega}$



NORTON EQUIVALENT CIRCUIT

$i_L = \frac{12}{12+R_L} i_N$

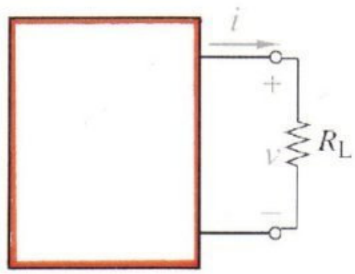
$R_L = 6\Omega$ ⇨ $i_L = \frac{12}{18} = \frac{2}{3} = 0.667 A$

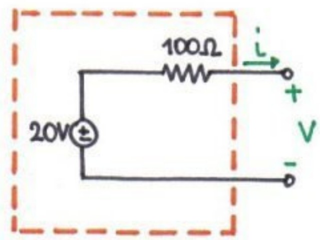
$R_L = 12\Omega$ ⇨ $i_L = \frac{12}{24} = 0.5A$

$R_L = 60\Omega$ ⇨ $i_L = \frac{12}{72} = \frac{1}{6}A$

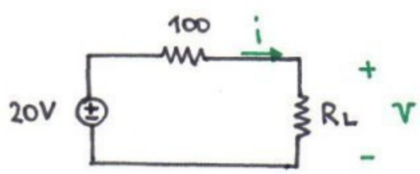
Problem#4: MATLAB Program

The i-v characteristics of an active circuit is $3v+300i=60$. Write a MATLAB program to plot the output voltage versus R_L curve when the load resistance is changing form 500 Ω to 3 kΩ.

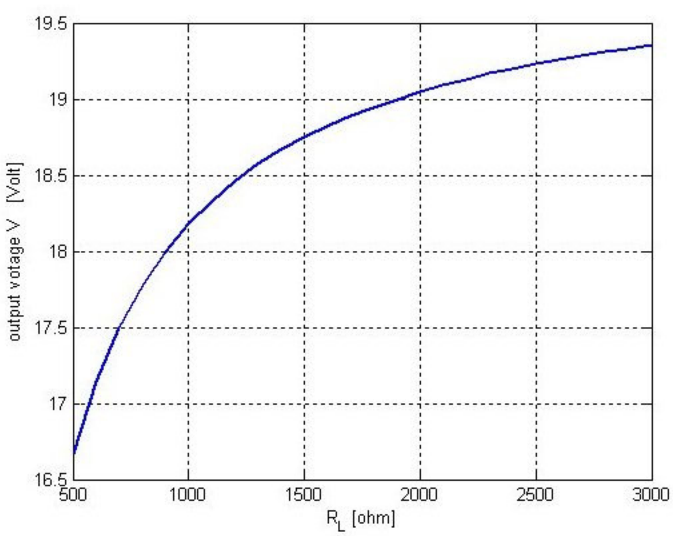




$$i = \frac{1}{5} - \frac{V}{100} \Rightarrow \boxed{V = 20 - 100i}$$



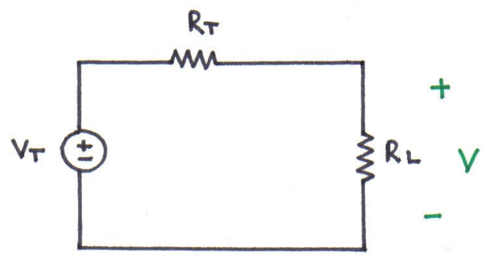
$$\begin{cases} V = \dfrac{R_L}{R_L+100} \cdot 20\,V \\ \text{for} \quad 500\,\Omega \le R_L \le 3000\,\Omega \end{cases}$$




```
>> RL=(500:100:3000);
>> V=20*RL./(RL+100);
>> plot(RL,V,'LineWidth',2);
>> grid
>> xlabel('R_L [ohm]')
>> ylabel('output votage V   [Volt]')
```

Problem#5: Problem 3-45 textbook

The Thevenin equivalent parameters of a voltage source are v_T=25 V and R_T=150 Ω. Find the smallest load resistance for which the load voltage exceeds 15 V.



$$V = \frac{R_L}{R_L + R_T} V_T$$

$$\frac{R_L}{R_L + R_T} V_T > 15V$$

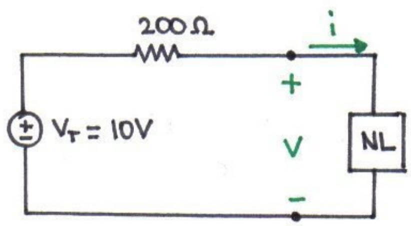
$$25 R_L > 15 (R_L + 150)$$

$$10 R_L > 2250$$

$$\boxed{R_L > 225 \Omega}$$

Problem#6: Problem 3-50 textbook (MATLAB Problem)

A nonlinear resistor is connected across a two terminal source whose Thevenin equivalent is v_T=10 V and R_T=200 Ω. The i-v characteristics of the resistor is $v=4000i^2$. Plot the i-v characteristics of the source and the resistor with **MATLAB** and graphically determine the voltage across and current through the nonlinear resistor.



SOURCE $V = 10 - 200i$

NL RESISTOR $V = 4000i^2$

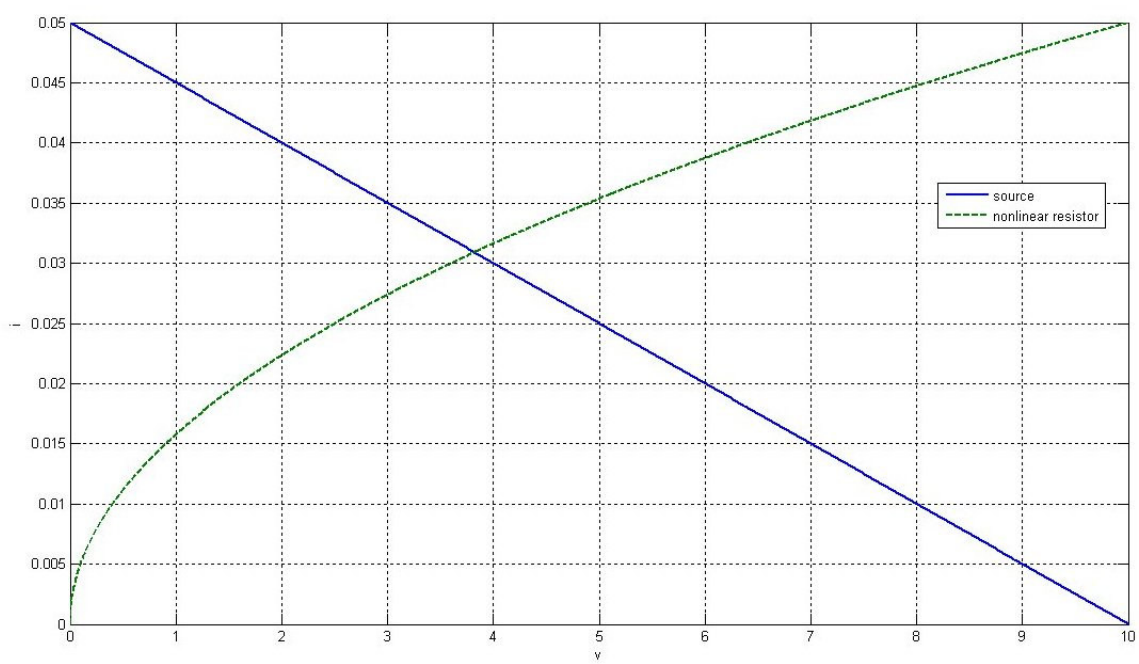
i-v characteristics
$$\begin{cases} i = \frac{1}{20} - \frac{V}{200} \\ i = \sqrt{\frac{V}{4000}} \end{cases}$$

```
>> V=(0:0.01:10);
>> i1=1/20-V/200;
>> i2=sqrt(V/4000);
>> plot(V,i1,V,i2,'--','LineWidth',2);
>> grid
>> legend('source','nonlinear resistor')
>> xlabel('v')
>> ylabel('i')
```

$$10 - 200i = 4000i^2$$

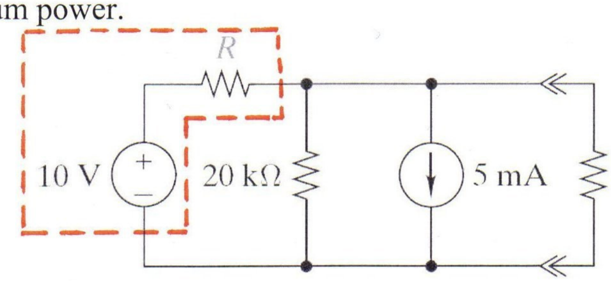
$$\begin{cases} 400i^2 + 20i - 1 = 0 \\ i > 0 \\ V = 10 - 200i \end{cases} \Rightarrow \boxed{\begin{array}{l} i = 0.031\text{ A} \\ V = 3.8\text{ V} \end{array}}$$

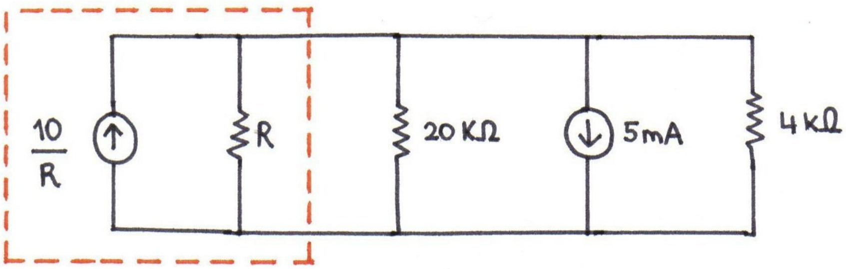
Q-POINT



Problem#7: Problem 3-56 textbook

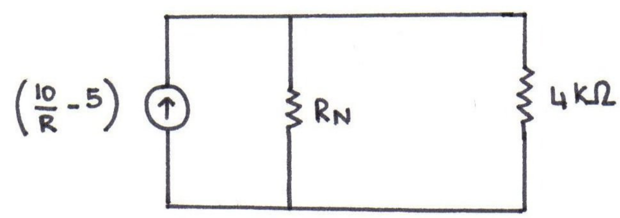
Find the value of R in the circuit so that maximum power is delivered to the 4kΩ load. Find the maximum power.





$R_N = R // 20k\Omega = \dfrac{20R}{20+R}$

(R and R_N in kΩ)



Since $R_T = R_N$ and max power delivered $\leftrightarrow$ $R_T = 4k\Omega$

then the max power is delivered to the 4kΩ load when

$$\frac{20R}{20+R} = 4 \quad \Rightarrow \quad 20R = 80 + 4R$$

$$R = \frac{80}{16}\ k\Omega$$

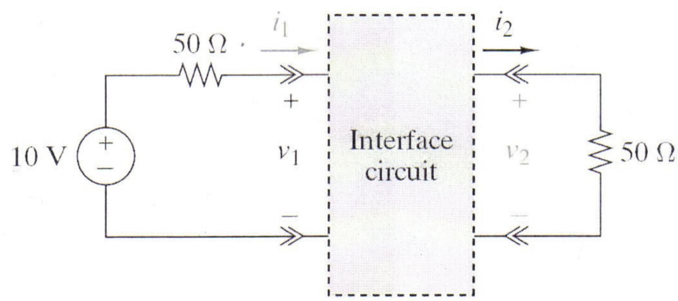
$$\boxed{R = 5k\Omega}$$

since $R_N = R_L$ and $V_L = V_N$ $\Rightarrow$ $i_L = \left(\frac{10}{R} - 5\right)\cdot\frac{1}{2} = (2-5)\cdot\frac{1}{2} = -1.5mA$

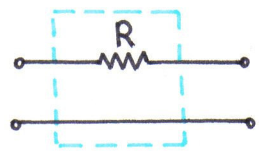
$$P = R_L i_L^2 = 4\cdot 10^3 \,(1.5\cdot 10^{-3})^2 = 9\cdot 10^{-3} = 9mW$$

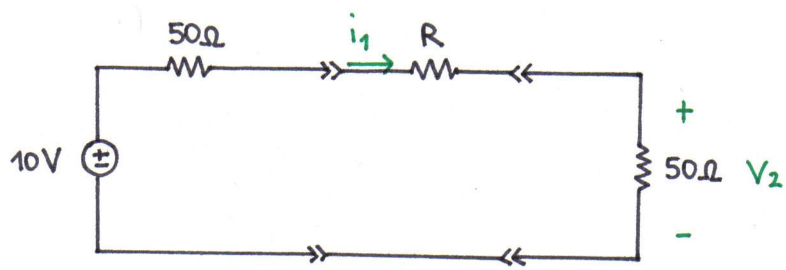
Problem#8: Problem 3-61 textbook

The output current of the voltage source in the Figure must be less than 100mA. Design an interface circuit so that the load voltage is v_2=4 V and the source current is i_1<100 mA.



Let's start considering the simpler interface





$$V_2 = \frac{50}{100+R} \cdot 10 = 4V$$

$$500 = 400 + 4R \quad \Rightarrow \quad R = 25\Omega$$

$$i_1 = \frac{10}{R_{TOT}} = \frac{10}{50+50+25} = \frac{10}{125} = 0.08\,A < 0.1\,A$$

R = 25Ω satisfies the specifics