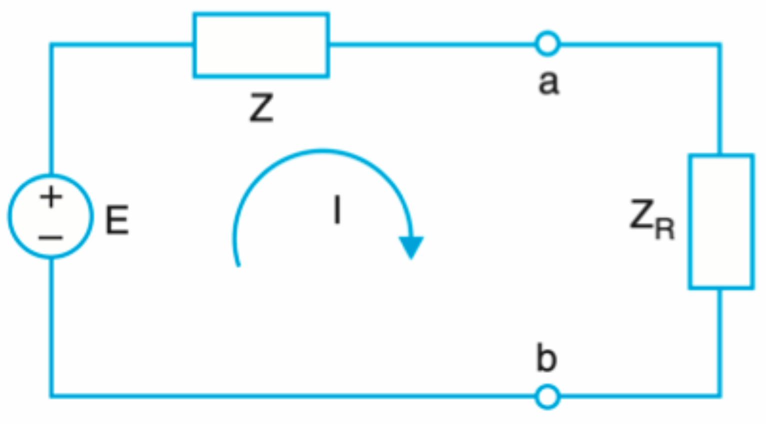
Maximum Power Transfer Theorem:

The maximum amount of power will be dissipated by a load impedance when that load impedance is the complex conjugate of the Thevenin/Norton impedance of the source network.

Suppose we have a network as shown with $Z = R + jX$ and $Z_R = R_R + jX_R$



Then, the power delivered to the load is:

$$P = I^2 R_R = \left[\frac{E}{\sqrt{(R_R + R)^2 + (X_R + X)^2}}\right]^2 R_R$$

For maximum power, $\dfrac{\partial P}{\partial R_R} = \dfrac{\partial P}{\partial X_R} = 0$

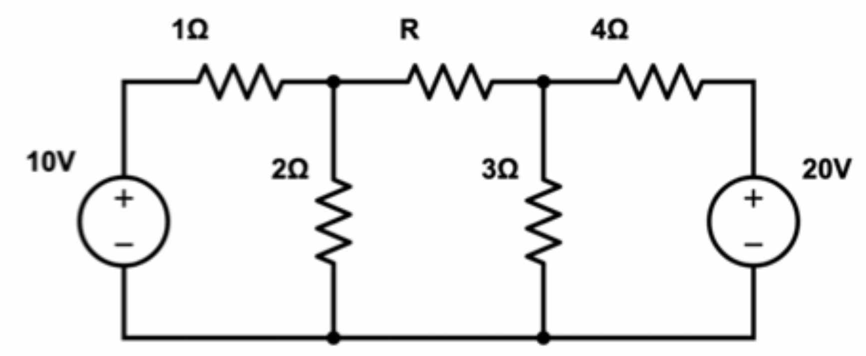
$\Rightarrow \quad R_R = R$ and $X_R = -X$

$\Rightarrow \quad Z_R = R - jX = (R + jX)^* = Z^*$

Hence, for maximum power transfer, $Z_R = Z^*$

and $P_{max} = \dfrac{E^2}{4R_R}$.

Q. Find the value of R for which the power transferred across R is maximum. Calculate that maximum power transferred.



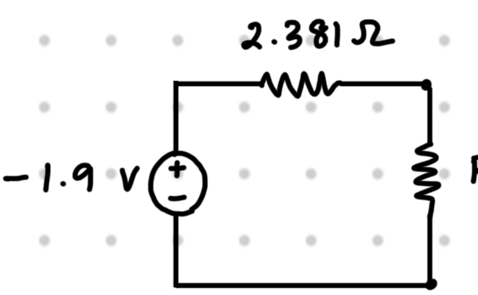
A. Calculating V_{TH} and Z_{TH} across R :

$$V_{TH} = \frac{10}{3}(2) - \frac{20}{7}(3) = -1.9\,V$$

$$Z_{TH} = \frac{1(2)}{1+2} + \frac{3(4)}{3+4} = 2.381\,\Omega$$

Hence, using the Thevenin's equivalent :

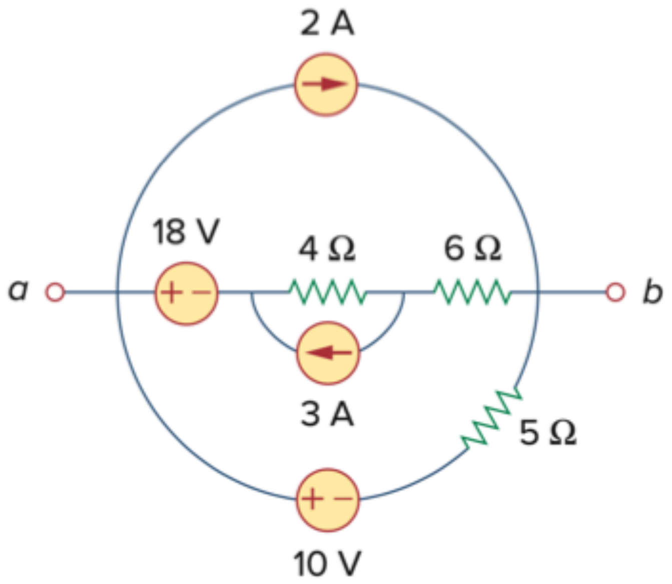
R = 2.381 Ω for maximum power transfer



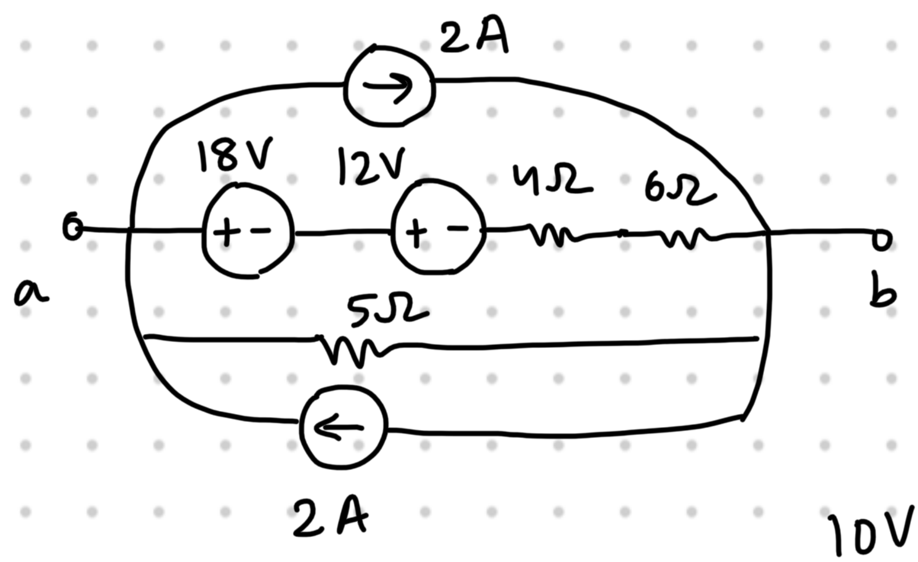
$$I = \frac{1.9}{(2.381)\cdot 2} = 0.4\,A$$

$$\Rightarrow P_R = (0.4)^2(2.381) = 0.381\,W$$

Q. Find the value of impedance to be connected across the terminals a-b for which the power transferred across it is maximum. Calculate that maximum power transferred.



A. Using source transformations,



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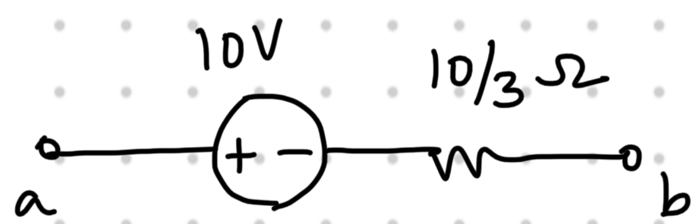
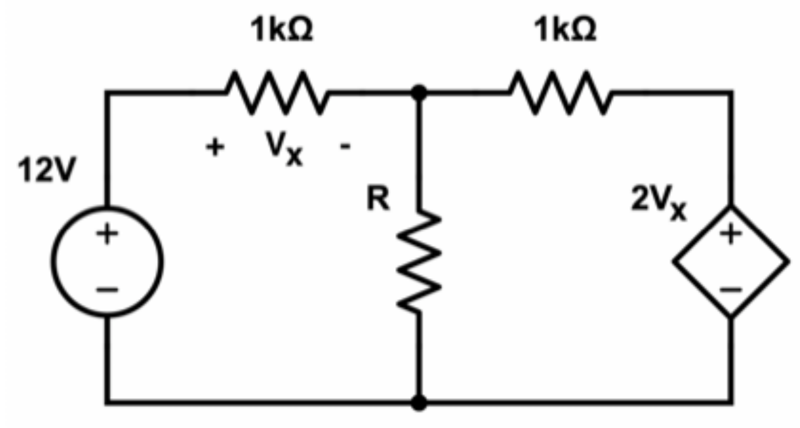


Hence, $R_L = \frac{10}{3}\,\Omega$

and $P_{max} = \dfrac{100}{4 \cdot \frac{10}{3}} = 7.5\,W$

Q. Find the value of R for which the power transferred across R is maximum. Calculate that maximum power transferred.



A. Calculating V_{TH} :

$$V_{TH} = 12 - 10^3 \cdot \frac{12}{4 \times 10^3} = 9V$$

Calculating I_{sc} :

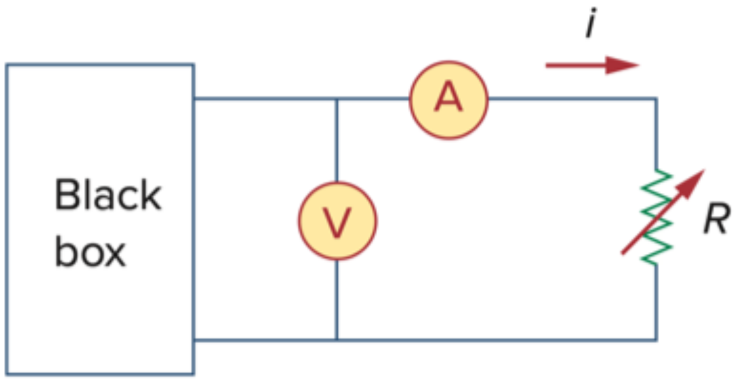
$$I_{sc} = \frac{12}{10^3} - \left(\frac{-24}{10^3}\right) = 36\,mA$$

$$\Rightarrow \quad R_{TH} = \frac{9V}{36\,mA} = 250\,\Omega$$

R should be equal to $R_{TH} = 250\,\Omega$ for maximum power transfer.

Hence, $$P_R = \left(\frac{9}{250+250}\right)^2 (250) = 81\,mW$$

Q. A linear network is connected to a variable resistor with an ideal voltmeter and ammeter as shown in the figure. Three readings were measured and tabulated as shown below.



$R(\Omega)$	V(V)	i(A)
2	6	3
8	16	2
14	21	1.5

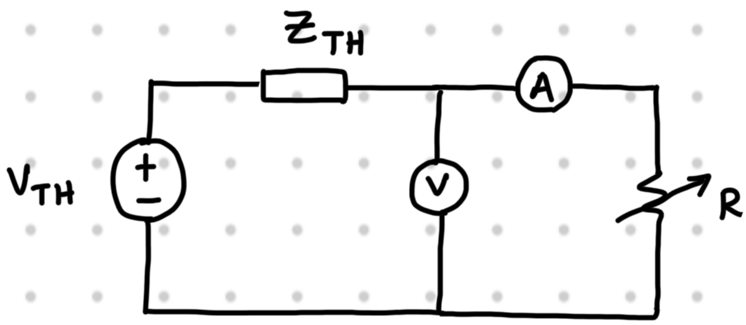
Calculate the maximum power from the box.

A. Using Thevenin's equivalent,

We have,

$$V_{TH} - i Z_{TH} = V$$

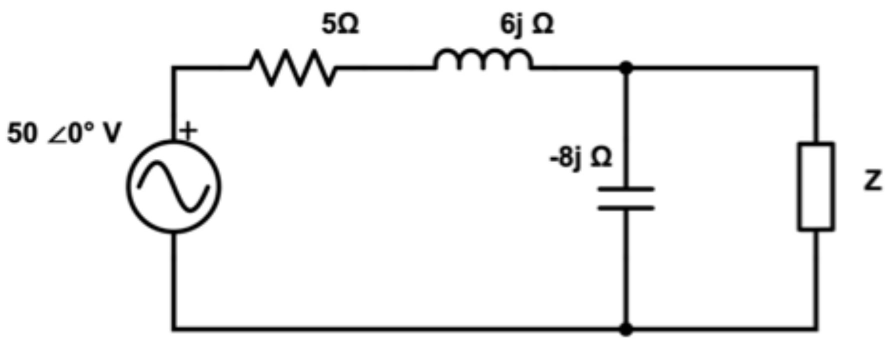
$$V = iR$$



$$\Rightarrow \left.\begin{aligned} V_{TH} - 3 Z_{TH} &= 6 \\ V_{TH} - 2 Z_{TH} &= 16 \end{aligned}\right\} \quad \begin{aligned} Z_{TH} &= 10\,\Omega \\ V_{TH} &= 36\text{ V} \end{aligned}$$

Hence, $P_{max} = \dfrac{V_{TH}^2}{4 Z_{TH}} = 32.4\text{ W}$

Q. Find the value of Z for which the power transferred across Z is maximum. Calculate that maximum power transferred.



A. Calculating V_{TH}:

$$V_{TH} = \frac{50\angle 0^\circ}{5+6j-8j}(-8j) = \frac{400}{29}(2-5j) \approx 74.28\angle -68.2^\circ$$

$$Z_{TH} = \frac{(5+6j)(-8j)}{(5+6j-8j)} = \frac{320-104j}{29}$$

For maximum power transfer, $Z = Z_{TH}^*$

$$\Rightarrow Z = \frac{320+104j}{29}$$

Maximum power transferred:

$$P_Z = \frac{|V_{TH}|^2}{4R_{TH}} = \frac{(74.28)^2}{4\left(\frac{320}{29}\right)}$$

$$\Rightarrow P_Z = 125\text{ W}$$