Faculty of Engineering

ELECTRICAL AND ELECTRONIC ENGINEERING DEPARTMENT

INFE221 – Electrical Circuits

Midterm Examination
Fall 2018-19

26 November 2018
Duration: 105 minutes

Instructor: M. K. Uyguroğlu

STUDENT'S	
NUMBER	
NAME	SOLUTIONS
SURNAME	

Problem		Points
1		15
2		15
3		15
4		15
5		20
6		20
7		20
TOTAL		120

Problem 1

The current through an element is shown in Fig.P1. Determine the total charge that passes through the element.

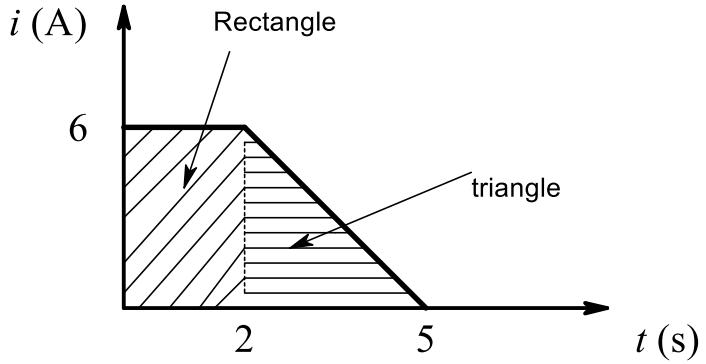


Figure P1

$$q_T = \int_0^5 i\,dt = \int_0^2 6\,dt + \int_2^5 (-2t+10)\,dt = 6t\Big|_0^2 + \left(-t^2+10t\right)\Big|_2^5$$

$$q_T = 12 - 25 + 50 + 4 - 20 = 66 - 45 = 21\ \text{C}$$

OR

By finding the area under the curve:

$$q_T = \underbrace{2\times 6}_{\text{area of the rectangle}} + \underbrace{\frac{3\times 6}{2}}_{\text{area of the trianle}} = 12 + 9 = 21\ \text{C}$$

Problem 2

Find the equivalent resistance R_{ab} in the circuit of Fig. P2.

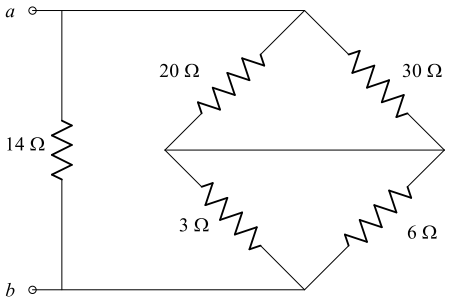


Figure P2

$$R_{ab} = \underbrace{14 \,//\, \underbrace{\left(\underbrace{20 \,//\, 30}_{12} + \underbrace{3 \,//\, 6}_{2} \right)}_{14}}_{7} = 7\ \Omega$$

Problem 3

Use nodal analysis to obtain v_a in the circuit of Fig.P3.

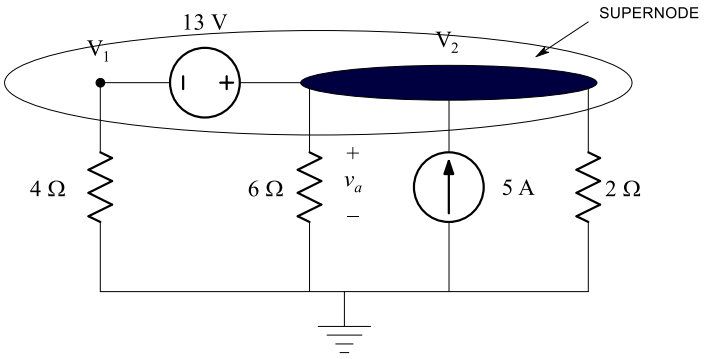


Figure P3

$v_a = V_2$

$V_2 - V_1 = 13$

$\boxed{V_1 = V_2 - 13}$

KCL at the SUPERNODE:

$$\frac{V_2 - 13}{4} + \frac{V_2}{6} + \frac{V_2}{2} = 5$$

Multiply both sides by 12 yields:

$$\frac{V_2 - 13}{4} + \frac{V_2}{6} + \frac{V_2}{2} = 5$$

$3V_2 - 39 + 2V_2 + 6V_2 = 60$

$11V_2 = 99$

$\boxed{V_2 = 9 \text{ V} = v_a}$

Problem 4

Use mesh analysis to obtain v_a in the circuit of Fig.P4.

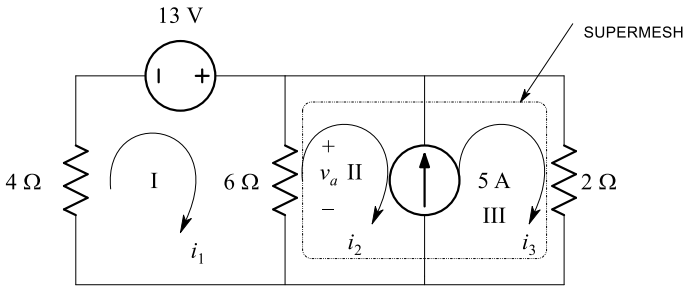


Figure P4

$i_3 - i_2 = 5$

$i_3 = 5 + i_2$

$\boxed{v_a = 6(i_1 - i_2)}$

KVL around mesh I:

$4i_1 - 13 + 6(i_1 - i_2) = 0$

$10i_1 - 6i_2 = 13 \text{.....(1)}$

KVL around the SUPERMESH:

$6(i_2 - i_1) + 2(5 + i_2) = 0$

$-6i_1 + 8i_2 = -10 \text{.....(2)}$

Multiply Eq.(1) by 4 and Eq.(2) by 3 and then add the equations:

$(40 - 18)i_1 = 22$

$i_1 = 1 \text{ A}$

Then using Eq. (1):

$i_2 = \frac{1}{6}\big(10(1) - 13\big) = -0.5 \text{ A}$

$v_a = 6\big(1 + 0.5\big) = 9 \text{ V}$

Problem 5

Use superposition to obtain v_a in the circuit of Fig.P5.

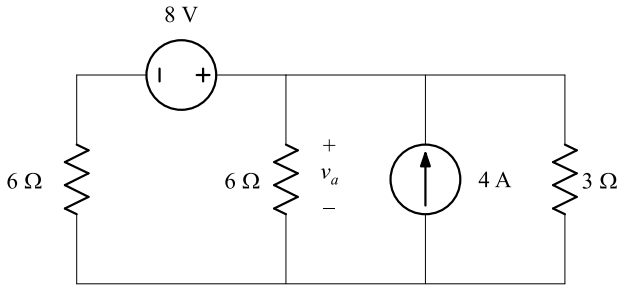
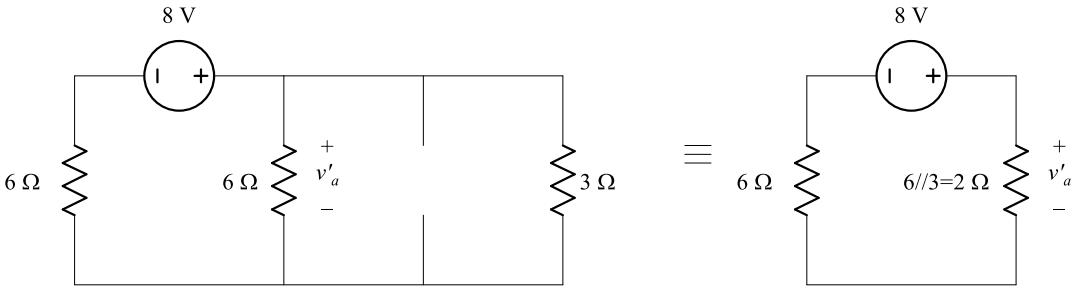


Figure P5

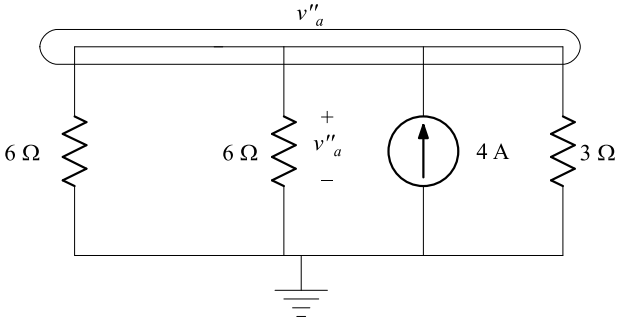
8 V voltage source is active: (Replace the current source with open circuit)



Using voltage division principle:

$$v'_a = 8 \times \frac{2}{8} = 2 \text{ V}$$

4 A Current Source is active: (Replace the voltage source with short circuit)



KCL at v''_a:

$$\frac{v''_a}{6} + \frac{v''_a}{6} + \frac{v''_a}{3} = 4$$

$$\frac{4}{6} v''_a = 4 \Rightarrow v''_a = 6 \text{ V}$$

$$v_a = v'_a + v''_a = 2 + 6 = 8 \text{ V}$$

Problem 6

Compute the value of ***R*** that results in **maximum power transfer** in the circuit of Fig.P6. Find the **maximum power**.

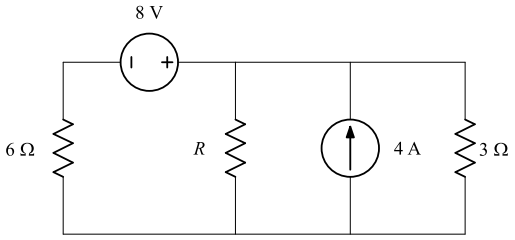
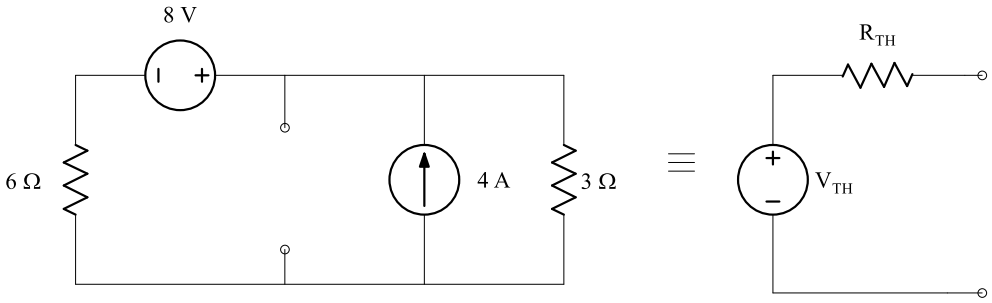


Figure P6

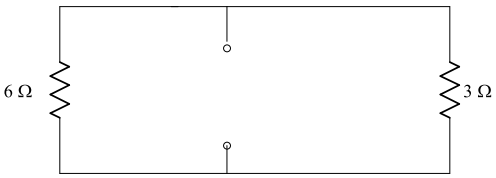
When the value of $R = R_{TH}$ it will absorb maximum power. Maximum power is

$$P_{\max} = \frac{V_{TH}^2}{4R_{TH}}$$

In order to find the value of R and $P_{\max}$ we need to find the Thevenin Euqivalent of the circuit seen by R.

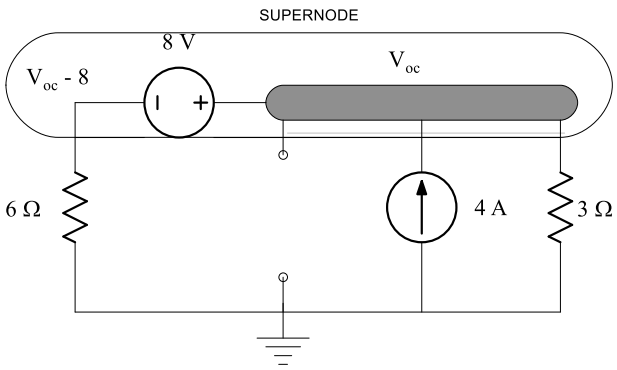


In order to find R_{TH} set all independent source values to 0.



$R_{TH} = 6//3 = 2\ \Omega$

In order to find V_{TH} we need to find open circuit voltage V_{oc} between the terminals.



KCL at V_{oc} :

$\frac{V_{oc}-8}{6} + \frac{V_{oc}}{3} = 4$ Multiply both sides by 6:

$V_{oc} - 8 + 2V_{oc} = 24$

$3V_{oc} = 32 \Rightarrow V_{oc} = \frac{32}{3}$ V

$$\therefore P_{\max} = \frac{\left(\frac{32}{3}\right)^2}{4\times 2} = 14.22 \text{ W}$$

Problem 7

Determine the output voltage in the op amp circuit of Fig. P7.

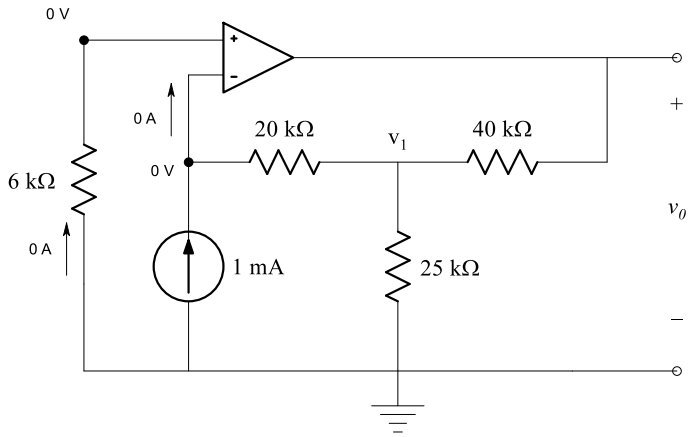


Figure P7

KCL at inverting input terminal:

$$1m + \frac{v_1}{20k} = 0 \Rightarrow \boxed{v_1 = -20 \text{ V}}$$

KCL at v_1:

$$\frac{v_1}{20k} + \frac{v_1}{25k} + \frac{v_1 - v_0}{40k} = 0 \text{ Multiply both sides by } 200k$$

$$10v_1 + 8v_1 + 5v_1 - 5v_0 = 0$$

$$v_0 = \frac{23}{5}v_1 = -\frac{23}{5} \times 20 = -92 \text{ V}$$