American University of Beirut
Faculty of Engineering and Architecture
Department of Electrical and Computer Engineering

EECE 210 – Electric Circuits – Spring 2009
EXAM 1 – Monday March 16, 2009

Name: MASTER SOLUTION_____ ID Number: Version 1_____

Circle your instructor's name:

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Read the following instructions carefully:

- The duration of the exam is **90 minutes**.
- The exam consists of 8 pages and 20 questions. All questions have the same weight.
- Total achievable points: **100**.
- **No questions** will be answered during the exam.
- Programmable calculators are not allowed.
- **Provide your answers on the computer card only using a pencil.**
- Mark with a pencil your last name.
- Mark with a pencil your ID number.
- When using an eraser, make sure you erased well.
- Make sure to write your name and ID number on the question sheet and the scratch booklet.
- You are required to return the computer card and the question sheet within the scratch booklet.
- **Enjoy and Good Luck!**

1. A room is lit by two 100 W lamps. How much energy do the lamps consume per week if the lamps are lit an average of 6 hours per day (kJ is kilo-joules, MJ is mega-joules)?

   a) 30.24 MJ

   b) 8.4 kJ

   c) 25.2 MJ

   d) 7 kJ

   e) 15.2 MJ

   *E = P*T = 2*100*6*3600*7 = 30.24 MJ (Mega W-s)*

2. Given an electric heater with the following electrical specifications: 220 V, 10 kW. Calculate the equivalent resistance of the heater.

   a) 4.84 Ω

   b) 44 Ω

   c) 2.42 Ω

   d) 11 Ω

   e) 22 Ω

   $P = V^2/R \Rightarrow R = (220)^2/10{,}000 = 4.84\ \Omega$

3. Zaher lives in the mountains. In a letter to his uncle in the US, he complains about the cold weather. His uncle sends him two electric heaters bought in a local appliance store. In the US, the common line voltage is 120 V. One heater is rated at 2000 W whereas the other is rated at 1000 W. The power outlet in Zaher's home delivers 220 V. Zaher decides to connect the heaters in series before connecting them to the power outlet. Before powering the heaters, he asks advice from a mechanical engineering student at AUB. The student analyzes the case and computes the voltages that each of the heaters would be subjected to. The greater of the two voltages is nearly equal to:

   a) 157 V

   b) 152 V

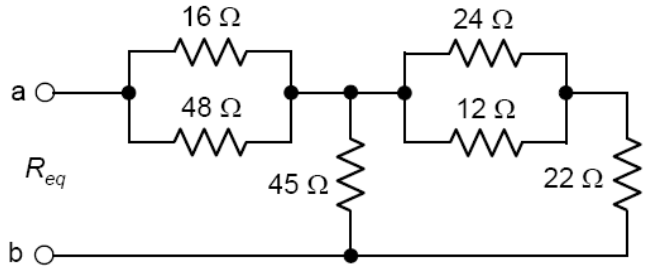
   c) 147 V

   d) 142 V

   e) 138 V

   We determine the resistance of each heater:
   $R_1 = v^2/p_1 = 120^2/2000 = 7.2\ \Omega$ *and* $R_2 = v^2/p_2 = 120^2/1000 = 14.4\ \Omega$. *Then, we apply voltage division over the greater resistance:* $v_2 = 220*R_2/(R_1+R_2) = 220*14.4/21.6 = 147$ V)

4. Calculate the equivalent resistor between terminals a and b in the following circuit.

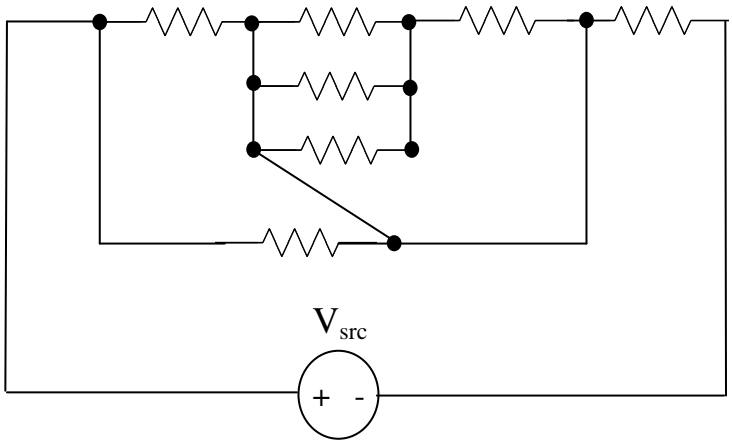


a) 55 Ω
b) 33 Ω
c) 15 Ω
d) 42 Ω
e) 30 Ω

R = ((22 // 12) + 22) // 45 + (16 // 48) = 30 Ω

5. All resistors in the following circuit have resistance equal to 2 Ω. Moreover, the voltage source is V_{src} = 6 V. Calculate the total power generated in the circuit.

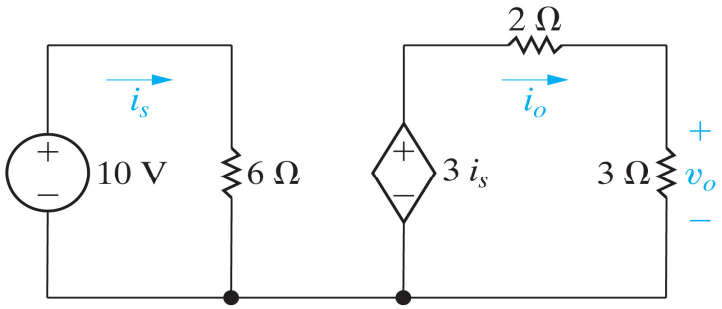
a) 16.3 W
b) 33.3 W
c) 12 W
d) 21.3 W
e) 27 W



R_{eq}= (2 // 2) + 2 = 3 Ω
$P_{gen} = P_{diss} = V_{src}^2 / R_{eq}=6^2/3 = 12$ W

6. Calculate i_o in the following circuit.

a) 1.67 A
b) 1 A
c) 2 A
d) 2.34 A
e) 3 A



i_s = 10/6 A, i_o = 3 i_s /5 = 1 A

7. Given the following four circuits: A, B, C, D.

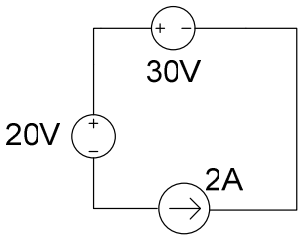


Figure A

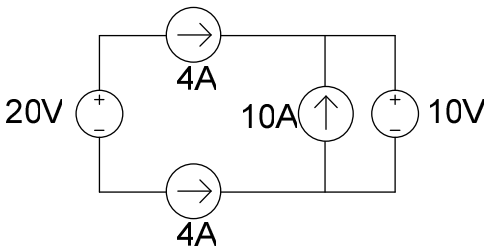


Figure B

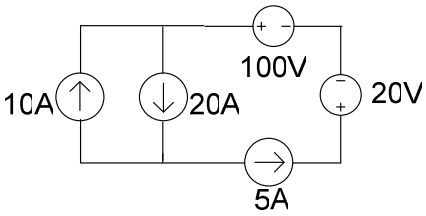


Figure C

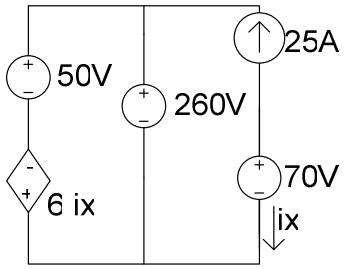


Figure D

Which of the following statements is **correct**?

a) Valid connections: only A

b) Valid connections: A and B; Invalid connections: C and D

c) Valid connections: A and D; Invalid connections: B and C

d) Valid connections: A and C; Invalid connections: B and D

e) Valid connections: only C

Figure A: A voltage source connected to current source which is a valid connection.
Figure B: In the same branch two current sources but opposite in direction are flowing. Therefore the connection is invalid.
Figure C: Apply KCL at the lower node: 20 is not equal to 10+5 so invalid connection.
Figure D: i_x=-25A therefore the voltage across the leftmost node branch is:
$50+(-6i_x)=50+150=200$, which is different than the voltage source connected in parallel (260V).
Therefore it is an invalid connection.

8. Calculate the power dissipated or generated by the current source if all resistances are 10 Ω in the following circuit.

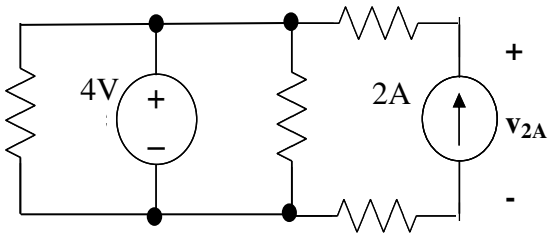
a) 72 W, dissipated

b) 88 W, generated

c) 10 W, dissipated

d) 88 W, dissipated

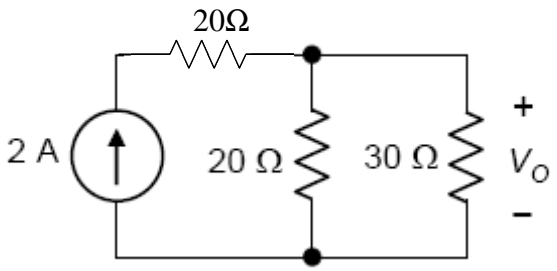
e) 72 W, generated



*KVL: 4V + 2A*10 Ω - v_{2A} - 2A*10 Ω = 0, therefore v_{2A} = 44 V*

*Since 2A current is going through a voltage rise: $P_{generated,\ 2A}$ = 2*44 = 88 W*

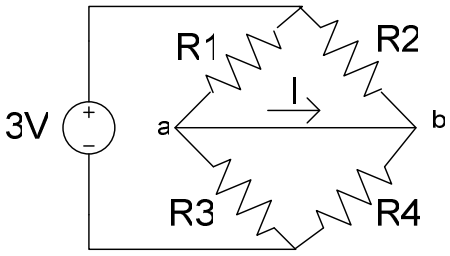
9. Calculate V_O in the following circuit.



a) 36 V
b) 40 V
c) 80 V
d) 24 V
e) 60 V

*20 // 30 = 20*30/50 = 12 Ω.*
*V_o = 12 * 2A = 24 V*

10. Given that the current I between terminals a and b is equal to zero, R1 = 4 Ω, R2 = 1 Ω, R3 = 8 Ω. Calculate the value of R4.



a) 1/12 Ω
b) 0.5 Ω
c) 12 Ω
d) 2 Ω
e) 4 Ω

Balanced Wheatstone Bridge:

$$\frac{R_1}{R_3} = \frac{R_2}{R_4}$$

R_4=2Ω

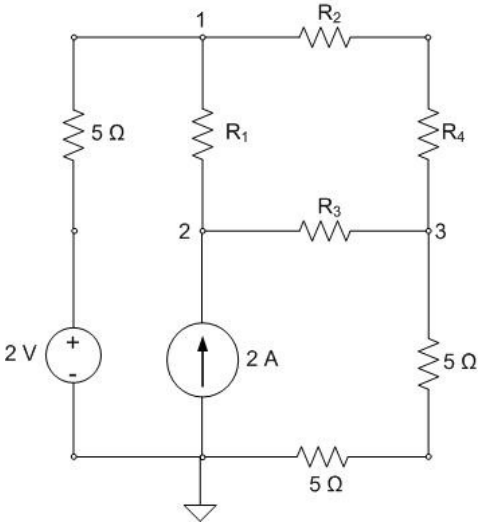
11. In the circuit of the previous part, find the total power dissipated in R1 and R3 together.

a) 0.25 W
b) 0.375 W
c) 8/3 W
d) 0.75 W
e) 1.125 W

I = 0. Therefore the branch where I is flowing can be omitted.

$$P = \frac{V^2}{R} = \frac{3^2}{(R_1 + R_3)} = \frac{9}{12} = 0.75W$$

12. In the following circuit, you are required to apply the node voltage method for analysis. Given the following parameters: $R_1 = 1\ \Omega$, $R_2 = 6\ \Omega$, $R_3 = 12\ \Omega$, $R_4 = 6\ \Omega$.



Which of the following is the node voltage equation for node 2?

a) $-24 - 12\,v_1 + 13\,v_2 - v_3 = 0$

b) $-24 - 6\,v_1 + 8\,v_2 - 2\,v_3 = 0$

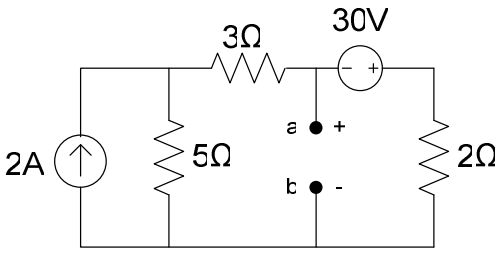
c) $-24 - 4\,v_1 + 7\,v_2 - 3\,v_3 = 0$

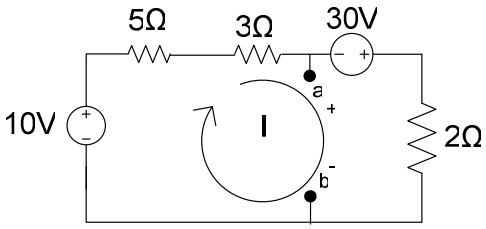
d) $-24 - 3\,v_1 + 7\,v_2 - 4\,v_3 = 0$

e) $-24 - 2\,v_1 + 8\,v_2 - 6\,v_3 = 0$

Add the three outgoing currents from node 2 and set equal to 0: $-2+(v_2-v_1)/R_1+(v_2-v_3)/R_3=0$ ➔ $-2+(v_2-v_1)/1+(v_2-v_3)/12=0$, *multiply by 12 and collect terms:* $-24 - 12\,v_1 + 13\,v_2 - v_3 = 0$

13. Calculate the Thevenin equivalent voltage as seen from terminals and b in the following circuit.





a) 22 V

b) -22 V

c) -38 V

d) 38 V

e) 8 V

Do source transformation (see figure above). Apply KVL: $-10 + 10I - 30 = 0$, $I = 4A$
Apply KVL again: $-V_{ab} - 30 + 2I = 0$, $V_{ab} = 2I - 30 = -22V$, $V_{ab} = -22V$

14. In the circuit of the previous part, calculate the Thevenin equivalent resistance as seen from terminals and b.

a) 10 Ω

b) 1.6 Ω

c) 1.2 Ω

d) 5 Ω

e) 3 Ω

Open circuit current sources. Short circuit voltage sources. Find R_{eq} seen from terminals a and b.

$$R_{th} = R_{eq} = \frac{3+5}{2} = 1.6\Omega$$

15. In the following circuit, you are required to apply the mesh current method for analysis. Why is it enough to write two mesh equations?

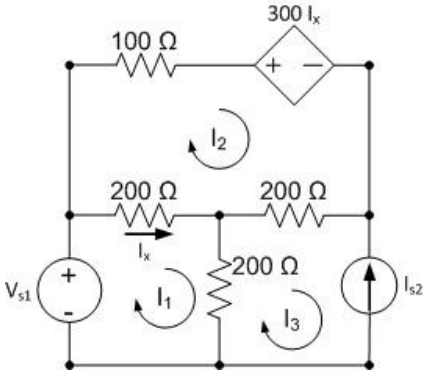
a) Because there is a voltage source in the circuit.

b) Because one of the mesh currents is completely determined by a current source. ($I_3 = -I_{s2}$)

c) Because there is a voltage source dependent on a current in the circuit.

d) Because in a circuit with three meshes it is always sufficient to write two mesh equations.

e) Because of the number of independent branches.



16. For V_{s1} = 200 V and I_{s2} = 0.6 A in the circuit of the previous part, select the mesh equation for mesh 1 (lower left mesh):

a) $100 - 400\,I_1 + 200\,I_2 = 0$

b) $120 - 400\,I_1 + 200\,I_2 = 0$

c) $90 - 400\,I_1 + 200\,I_2 = 0$

d) $80 - 400\,I_1 + 200\,I_2 = 0$

e) $45 - 400\,I_1 + 200\,I_2 = 0$

Clockwise adding voltage rises, subtracting voltage drops: V_{s1}-$I_1$200+$I_2$200-$I_1$200+$I_3$200=0, we substitute I_3=-I_{s2}=-0.6, V_{s1}= 200 and collect terms: $80 - 400\,I_1 + 200\,I_2 = 0$

17. For the same values of the independent sources as given in the previous part, select the mesh equation for mesh 2 (upper mesh):

a) $-150 - 100\,I_1 - 200\,I_2 = 0$

b) $-100 - 100\,I_1 - 200\,I_2 = 0$

c) $-120 - 100\,I_1 - 200\,I_2 = 0$

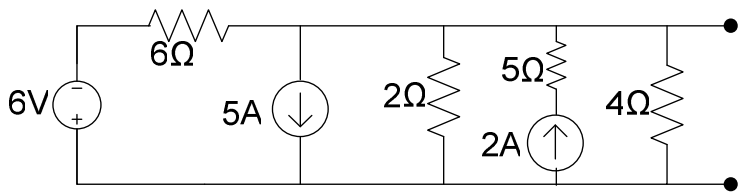
d) $-60 - 100\,I_1 - 200\,I_2 = 0$

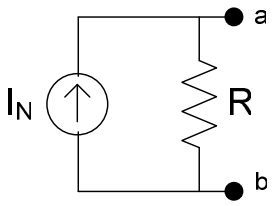
e) $-80 - 100\,I_1 - 200\,I_2 = 0$

Clockwise adding the voltage rises, subtracting the voltage drops:

$+I_1200-I_2200-I_2100-I_2200+I_3200-I_x300=0$, we substitute $I_x=I_1-I_2$, $I_3=-I_{s2}=-0.6$ and collect terms: $-120 - 100\,I_1 - 200\,I_2 = 0$

18. Use source transformations to find Norton equivalent as seen from end terminals a and b in the following circuit.





a) I_N = -4 A, R = 60/67 Ω

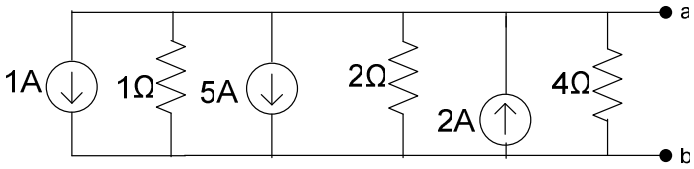
b) I_N = -2 A, R = 12/11 Ω

c) I_N = -4 A, R = 12/11 Ω

d) I_N = -2 A, R = 60/67 Ω

e) I_N = -1 A, R = 20/19 Ω

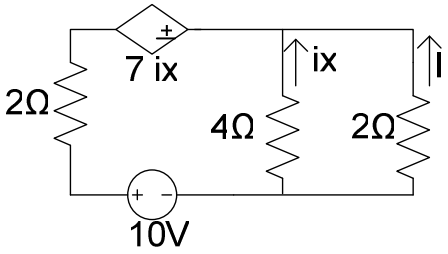
Perform source transformation to obtain the following circuit:



$I_N = 2 - 5 - 1 = -4A$

$$R = \frac{\frac{6}{2}}{4} = \frac{12}{11}\Omega$$

19. Find the value of I in the following circuit. Hint: use mesh current method.



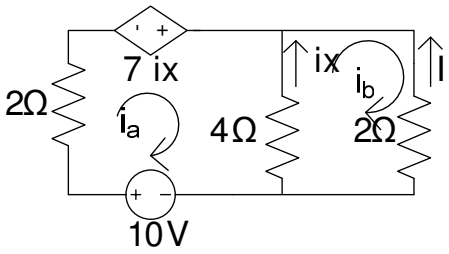
a) 20/17 A

b) -20/3 A

c) 20/29 A

d) 20/3 A

e) -20/17 A



Apply mesh current equation in the 2 meshes:

$$\textit{mesh } a\text{: } -10 + 2i_a - 7i_x + 4(i_a - i_b) = 0$$

$$\textit{mesh } b\text{: } 4(i_b - i_a) + 2i_b = 0$$

$$i_x = i_b - i_a$$

Substitute and solve:

$$-10 + 2i_a - 7(i_b - i_a) + 4(i_a - i_b) = 0$$

$$\frac{6}{4} i_b = i_a$$

$$-10 + 13i_a - 11i_b = 0$$

$$-10 + \frac{39}{2} i_b - 11i_b = 0$$

$$i_b = \frac{20}{17} A$$

$$I = -\frac{20}{17} A$$

20. Which of the following statements is **not correct**?

a) The Wheatstone bridge is used to measure resistance

b) A voltmeter is used to measure voltages

c) A voltmeter is normally connected in parallel

d) The current in an open circuit is always zero

e) The voltage across an open circuit is always zero