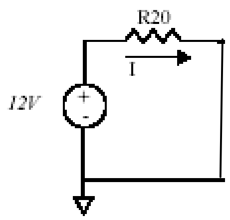
EECS 40 Homework #2 Solutions Fall 2003

Problem 1

c) Start off with what we know:
Bulb rated for power = 20W and works with voltage supply = 12 V DC
Model our circuit as shown in the figure below:

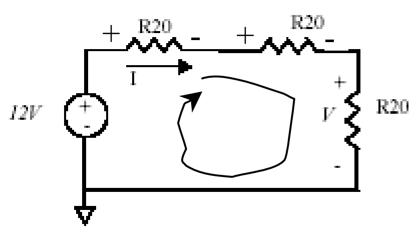
- Voltage supply is modeled as an ideal independent voltage source supplying 12V
- Light bulb is modeled as a resistor



Then $P = VI$ or $P = V^2/R20$ so solving for R20, we get $R20 = V^2/P$ which implies:
$R20 = 144/20\ [(J/C)^2/J/s] = 7.2\ [(J/C)/(C/s)] = 7.2\Omega$

Similarly, for a light bulb rated for 50W operation, $R50 = 144/50\ [V/A] = 2.9\Omega$

b)

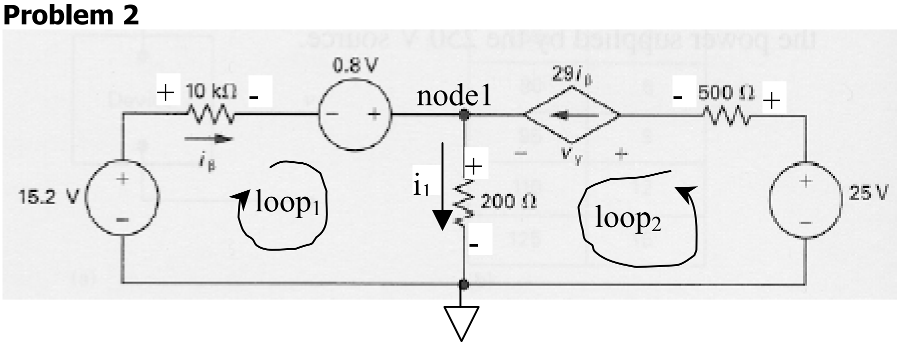


Note that we have three resistors in series so $R_{eq} = 3 \cdot R20 = 3 \times 7.2\Omega = 21.6\Omega$.
Using KVL for the loop shown we get: $I \cdot R_{eq} - 12\ [V] = 0$ which implies that:
$I = 12/21.6\ [A] = 0.56\ A$

Then $V = IR20 = 0.56 \times 7.2\ [A \cdot \Omega] = 4\ V$ and the power dissipated in each bulb is given by:
$P = VI = 4 \times 0.56\ [V \cdot A] = 2.2\ W$

c) As in part b) we use KVL for the loop but replace the last resistance with a 50W-rated bulb as shown in the figure of the problem. We get the following equation:
$7.2I + 7.2I + 2.9I\ [\Omega \cdot A] - 12\ [V] = 0$ which implies $I = 0.7A$, and
$V = I \cdot R50 = 0.7 \times 2.9 = 2\ V$. The power dissipated in the 50W-bulb is:
$P = V \cdot I = 2V \cdot 0.7A = 1.4\ W$

Problem 2



a) To find the voltage v_y we first need to find the current i1 and then perform KVL in loop 2. To find i1, we perform KCL at node 1 and then use KVL in loop 1.

KCL at node 1: iβ + 29iβ = i1 which implies i1 = 30iβ
KVL at loop 1: iβ x 10[kΩ] - 0.8[V] + 30iβ x 200[Ω] – 15.2[V] = 0 which gives
16 000 [Ω] x iβ = 16 [V] which implies iβ = 1mA

KVL at loop 2: 30[mA] x 200[Ω] – 25[V] + 29[mA] x 500[Ω] + v_y = 0 which gives
6 – 25 + 14.5 + v_y = 0 which implies v_y = 4.5 V

b)

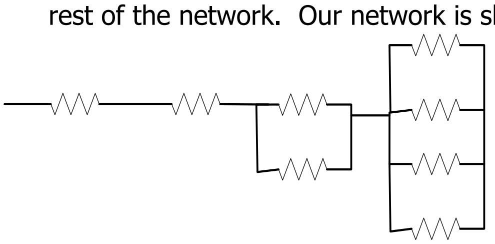
Element	**Power generated**	**Power absorbed**
10 kΩ resistor		$P = I^2R$: 1 [mA^2] x 10 kΩ = 0.01 W
200 Ω resistor		$P = I^2R$: 30^2 [mA^2] x 200 Ω = 0.18 W
500 Ω resistor		$P = I^2R$: 29^2 [mA^2] x 500 Ω = 0.42 W
Dep. current source		P = IV: 29[mA] x 4.5 V = 0.13 W
15.2 V source	P = IV: 1mA x 15.2 V = 0.015 W	
0.8 V source	P = IV: 1mA x 0.8 V = 0.0008 W	
25 V source	P = IV: 29mA x 25 V = 0.72 W	
TOTAL	**0.74 W**	**0.74 W**

Problem 3

c) We know for any two resistances in parallel we have R1·R2/R1 + R2 (see equation 3.15 of textbook); if R1=R2=R then the expression reduces to $R^2/2R$ which is equivalent to R/2.

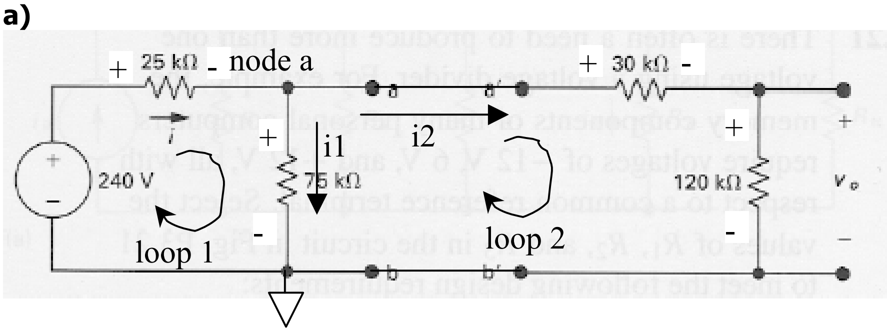
c) For n resistors of value R in parallel, we obtain the following:
1/Req = 1/R + 1/R + 1/R + … + 1/R which implies that 1/Req = n/R or Req = R/n.

c) We need an equivalent resistance of 5.5kΩ using only 2kΩ resistors. To get 0.5 kΩ we can put 4 2kΩ resistances in parallel: Req = 2/4 = 0.5 kΩ. Now we need to construct 5 kΩ circuit that we can put in series with the 0.5 kΩ circuit. This can be obtained by putting 2 2kΩ resistors in series to get 4 kΩ and 2 2kΩ in parallel which can be put in series with the rest of the network. Our network is shown below; all the resistors shown are 2kΩ.



Problem 4

a)



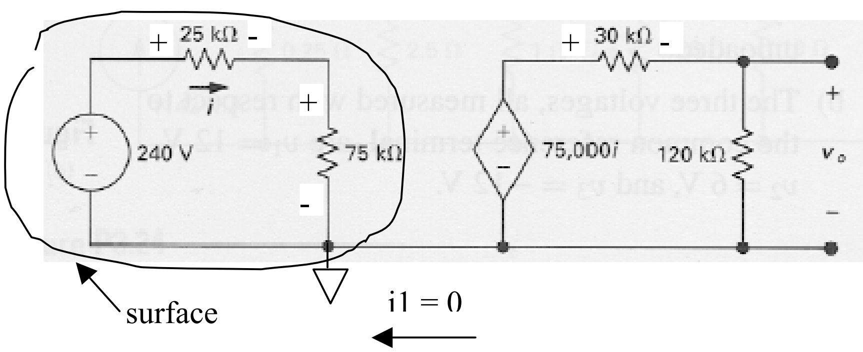
KVL at loop 2: 30 000 x i2 + 120 000 x i2 – 75 000 x i1 = 0 implies that i1 = 2 x i2

Then KCL at node a: i = i1 + i2 implies that i = 3 x i2

KVL at loop 1: 25 000 x i + 75 000 x i1 - 240 = 0 and substituting for i1 and i in terms of i2, we obtain 225 x i2 = 240 which implies i2 = 1.07 mA.

Then v_o = i2 x 120 000 = 1.07mA x 120 000 = 128 V.

b)



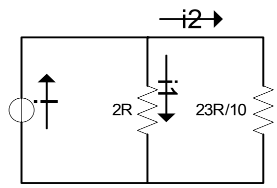
Using the voltage divider formula, the voltage across the 75kΩ resistor is given by:
(75/100) x 240 V = 180 V. This implies that: i = 180/75 000 = 2.4 mA.

Then the dependent voltage source is 75 000 x 2.4 = 180 V. Using the voltage divider formula again for the second part of the circuit, v_0 is given by (120/150) x (75 000 x i) = 144 V.

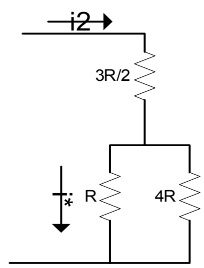
c) It has no effect since the current i1 = 0.

Problem 5

First reduce the circuit given to the one below using series and parallel resistance rules. 2R||2R is simply R. Then R in series with R is 2R. 3R||3R is 3R/2. R||4R is 4R/5. Then 3R/2 in series with 4R/5 is 23R/10. Then we obtain the i2 in terms of i using the current divider rule: i2 = i x 2R/(2R + 23R/10) = 20i/43.



Then we use the current divider rule again for the portion of the circuit on the right shown below



So we get i* = i2 x 4R/5R = (20i/43) x (4/5) = 16i/43