Solution

EE101 Midterm Examination, February 7, 2019

Name_____ Student ID_____

1 page of formulas and tables only is allowed. But, you must show all your work even when you apply formulas to get full credits. Otherwise, you will lose points.

Problem 1 [20] _____

Problem 2 [20] _____

Problem 3 [25] _____

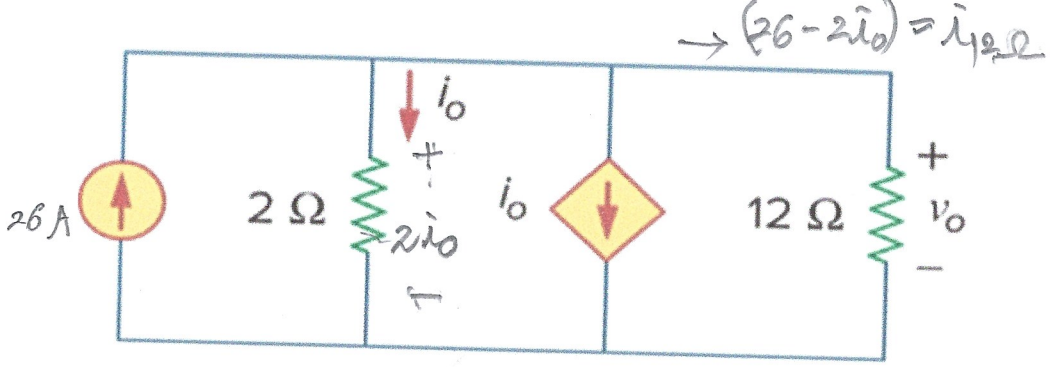
Problem 4 [15] _____

Problem 5 [20] _____

_____

TOTAL [100] _____

[1] (20 points) Consider the following circuit with one independent 26 [A]- current source, one dependent current source and two resistors.



Step 1 (10 points) Express v_0 in terms of i_0 and solve for i_0 for the given current source amount.

$v_0 = 12 \times i_{12\Omega} = 12(26 - 2i_0) = 2i_0$

$12 \times 26 = (24+2) i_0 = 26 i_0$, $i_0 = \frac{12 \times 26}{26}$

$\Rightarrow \underline{i_0 = 12\ [A]}$

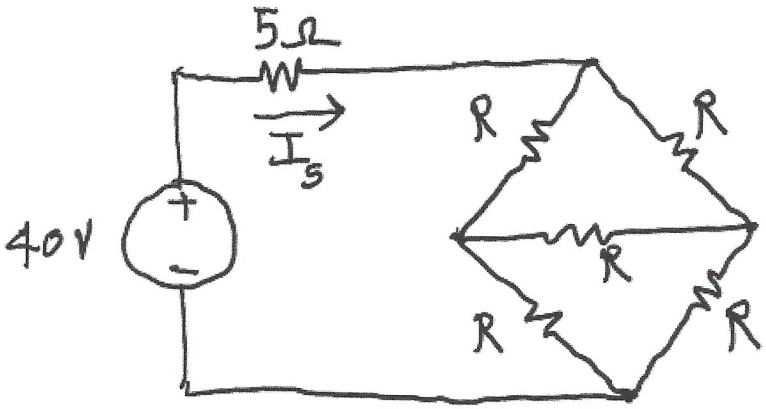
Step 2 (10 points) Calculate the power delivered to or generated by the current-controlled current source. Is it generating or consuming power?

Voltage across the dependent source $= v_0 = 2 \times 12 = 24\ V$

Power $= 12\ [A] \times 24\ [V] = \underline{+288\ [W]}$

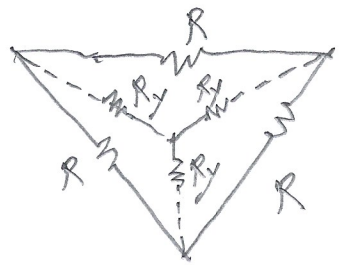
consumed

[2] (20 points) Find the current I_s from the 40V voltage source as shown in the figure.

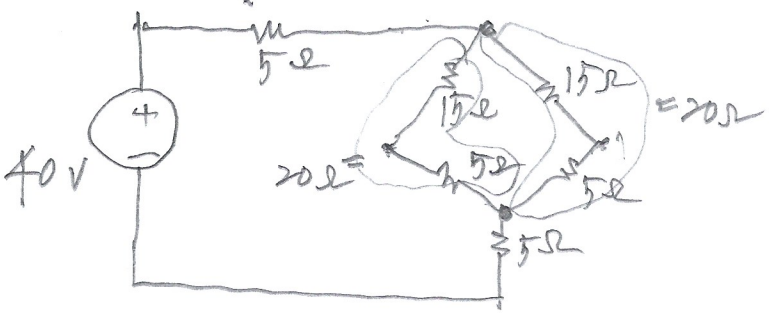


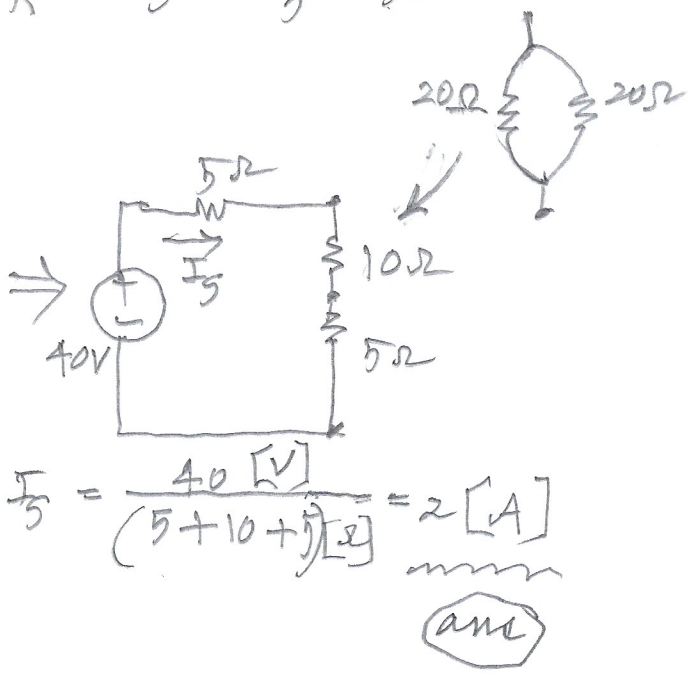
Hint: One Delta-Wye transformation of (15Ω, 15Ω, 15Ω) resistors would simplify the problem.

Δ-Y transformation



$$R_Y = \frac{R \times R}{R+R+R} = \frac{R}{3} = \frac{15}{3} = 5\,\Omega$$

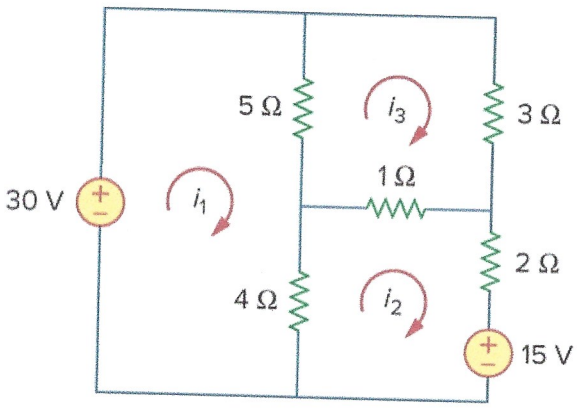




$$I_s = \frac{40\,[V]}{(5+10+5)\,[\Omega]} = 2\,[A]$$

ans

[3] (25 points) Find the mesh currents i_1, i_2 and i_3.



(a) (15 points) Write down a matrix equation to find mesh currents as Ax=b, where A is a 3x3 matrix, x is a 3x1 matrix, and b is a source vector.

By inspection,

$$\begin{bmatrix} 9 & -4 & -5 \\ -4 & 7 & -1 \\ -5 & -1 & 9 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 30 \\ -15 \\ 0 \end{bmatrix}$$

Alternatively, KVL in each mesh

mesh 1
$-30 + 5(i_1 - i_3) + 4(i_1 - i_2) = 0$

mesh 2
$+4(i_2 - i_1) + 1(i_2 - i_3) + 2i_2 + 15 = 0$

mesh 3
$+3i_3 + 1(i_3 - i_2) + 5(i_3 - i_1) = 0$

(b) (10 points) Then find the mesh currents.

row 1 − row 2 × 5 ⇒

$$\begin{array}{rrrr} 9 & -4 & -5 & 30 \\ -20 & 35 & -5 & -75 \\ \hline 29 & -39 & 0 & 105 \end{array} \quad \text{——— (1)}$$

row 2 × 9 + row 3 ⇒

$$\begin{array}{rrrr} -36 & 63 & -9 & -135 \\ +) -5 & -1 & +9 & 0 \\ \hline -41 & 62 & 0 & -135 \end{array} \quad \text{——— (2)}$$

(1) × 41 + (2) × 29 ⇒

$$\begin{array}{rrr} 29\times41 & -39\times41 & 105\times41 \\ +)\ -41\times29 & 62\times29 & -135\times29 \\ \hline 0 & (-39\times41 + 62\times29)i_2 = 105\times41 - 135\times29 & \end{array}$$

$$i_2 = \frac{105\times41 - 135\times29}{62\times29 - 39\times41} = \frac{390}{199} = 1.96\ \text{A} \quad (3)$$

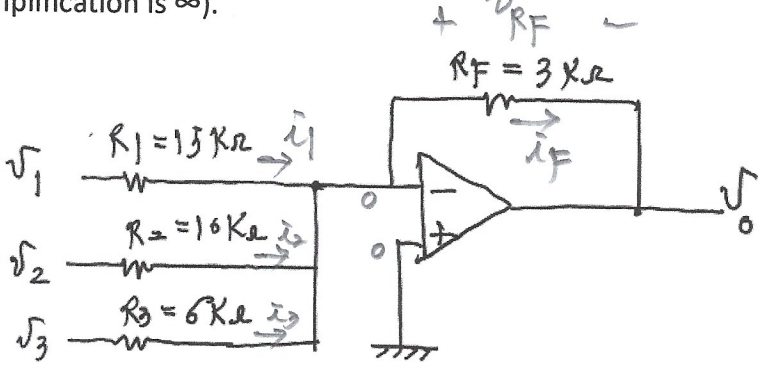
(3) → (1) $\quad 29i_1 = 39\left(\frac{390}{199}\right) + 105$

$$i_1 = \frac{39\left(\frac{390}{199}\right) + 105}{29} = 6.26\ \text{A} \quad (4)$$

(3), (4) → 3rd row $\quad i_3 = \frac{1}{9}(5i_1 + i_2) = \frac{1}{9}(5\times6.26 + 1.96) = 3.69\ \text{A}$

(continued)

[4]. (15 points) The OP amp circuit below calculates a weighted sum of input voltages V_1, V_2, and V_3. Express the output voltage V_o as a function of three input voltages. In this calculation OP amp is assumed to be ideal (input resistance is ∞, output resistance is zero and voltage amplification is ∞).



$$i_1 = \frac{v_1}{15K}, \quad i_2 = \frac{v_2}{10K}, \quad i_3 = \frac{v_3}{6K}$$

$$i_F = i_1 + i_2 + i_3$$

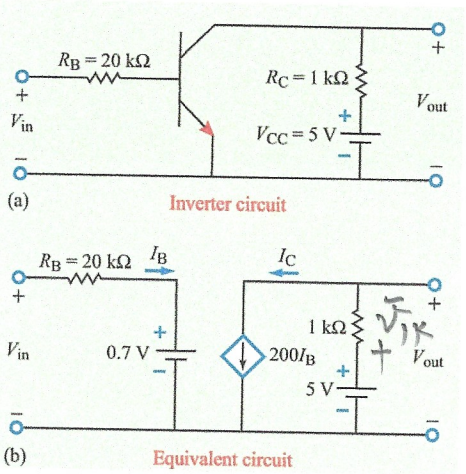
$$v_{RF} = R_F i_F$$

$$v_o = -v_{RF} = -3K\left[\frac{v_1}{15K} + \frac{v_2}{10K} + \frac{v_3}{6K}\right]$$

$$= -(0.2v_1 + 0.3v_2 + 0.5v_3)$$

Ans

[5]. (20 points) A bipolar junction transistor circuit (Figure (a) and its equivalent circuit (Figure (b)) is shown below. For V_{in}= 2.7 [V], find the corresponding output voltage V_{out}.



2-7

$$I_B = \frac{2.7 - 0.7}{20K} = \frac{1}{10K}\,[A] = 0.1\ mA$$

$$I_C = 200\, I_B = 200(0.1\ mA) = 20\ mA$$

$$V_{out} = 5\,V - 20\ mA\,(1\ K\Omega) = -15\,V$$

Ans