ESE 271 First Exam Name:

Spring, 2003 ID Number:

Do not place your answers on this front page.

Every problem is worth 25 points.

Prob. 1:

Prob. 2:

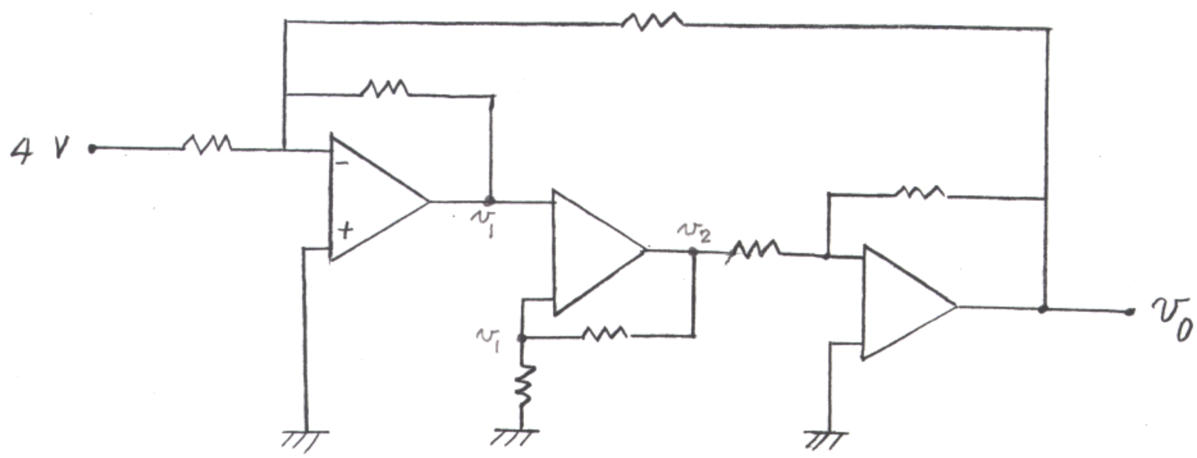
Prob. 3:

Prob. 4:

Prob. 1:

Every resistor is 2 Ω. Find v_0.

(Use the ideal op-amp wherein every input voltage and every input current for each op-amp is 0. That is, use the "virtual short and virtual open" principle.)



$$\frac{4}{2} + \frac{v_1}{2} + \frac{v_0}{2} = 0$$

$$v_1 = \frac{2}{2+2} v_2 \Rightarrow v_2 = 2v_1$$

$$\frac{v_2}{2} + \frac{v_0}{2} = 0 \Rightarrow v_0 = -v_2$$

$$\Rightarrow v_0 = -2v_1 \quad \text{OR} \quad v_1 = -\frac{v_0}{2}$$

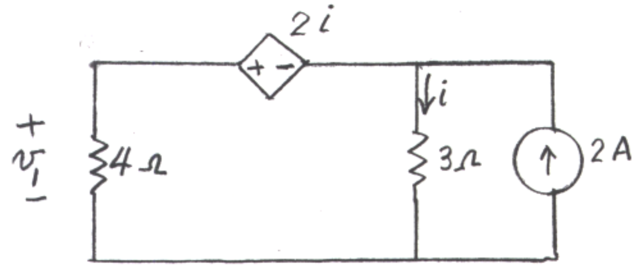
$$4 + v_1 + v_0 = 0$$

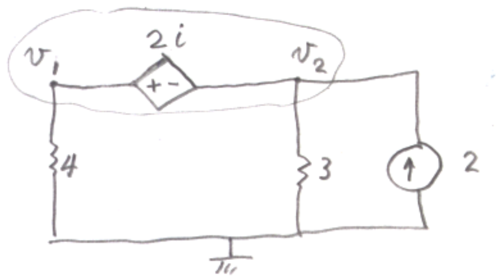
$$4 - \frac{v_0}{2} + v_0 = 0$$

$$v_0 = -8$$

Prob. 2:

Find the voltage v_1 in the following circuit. Use a nodal analysis.





INSIDE BALLOON: $v_1 - v_2 = 2i = 2\,\frac{v_2}{3} \Rightarrow 3v_1 - 5v_2 = 0$

ON BALLOON: $\frac{v_1}{4} + \frac{v_2}{3} - 2 = 0 \Rightarrow 3v_1 + 4v_2 = 24$

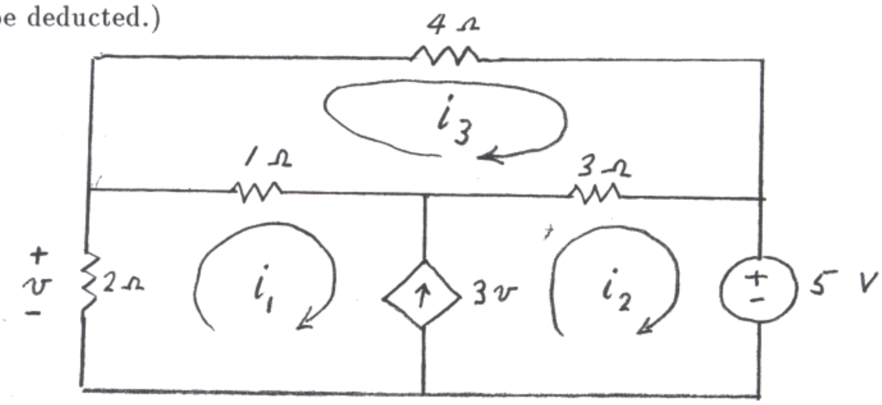
SUBTRACT FIRST EQUATION FROM THE SECOND EQUATION:

$$9v_2 = 24 \quad \text{OR} \quad v_2 = \frac{8}{3}$$

THUS, $v_1 = \frac{5}{3} v_2 = \frac{40}{9} = \underline{\underline{4.44}}$

Prob. 3:

Using the mesh currents shown, find i_2 by using Cramer's rule. Write your answer as a 3-by-3 determinant over a 3-by-3 determinant occurring when all three mesh currents are used as unknowns. That is, do not eliminate one of the unknowns to get 2-by-2 determinants. (You do not have to get i_2 as a single number. Write your answer neatly—otherwise points will be deducted.)



FROM DEPENDENT CURRENT SOURCE:

$$i_2 - i_1 = 3v = 3(-2i_1) = -6i_1 \quad \Rightarrow \quad 5i_1 + i_2 = 0$$

AROUND LOWER LOOP, AVOIDING THE CURRENT SOURCE:

$$2i_1 + i_1 - i_3 + 3i_2 - 3i_3 + 5 = 0 \quad \Rightarrow \quad 3i_1 + 3i_2 - 4i_3 = -5$$

AROUND TOP LOOP:

$$4i_3 + 3i_3 - 3i_2 + i_3 - i_1 = 0 \quad \Rightarrow \quad -i_1 - 3i_2 + 8i_3 = 0$$

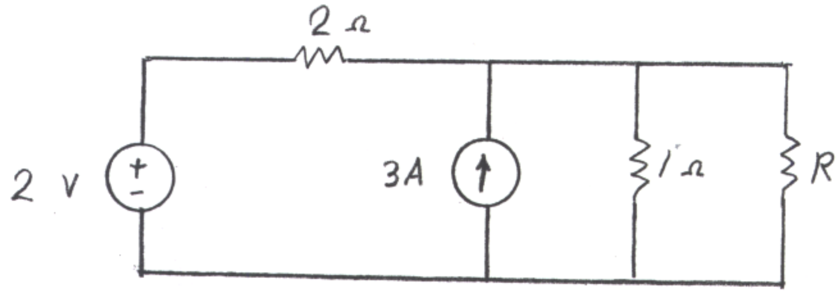
So,

$$i_2 = \frac{\begin{vmatrix} 5 & 0 & 0 \\ 3 & -5 & -4 \\ -1 & 0 & 8 \end{vmatrix}}{\begin{vmatrix} 5 & 1 & 0 \\ 3 & 3 & -4 \\ -1 & -3 & 8 \end{vmatrix}}$$

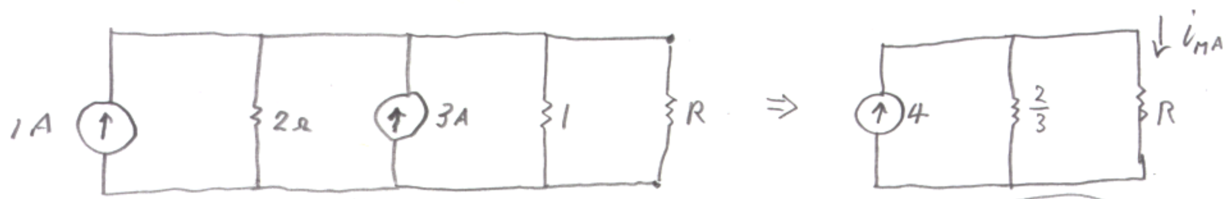
NOTE: REARRANGEMENTS OF THESE EQUATIONS WOULD YIELD OTHER CORRECT ANSWERS.

Prob. 4:

For what value of R will the power in R be a maximum? Also, find the value of that maximum power.



ONE SOLUTION: MAKE A THEVENIN TO NORTON TRANSFORMATION ON THE LEFT:



$$\frac{1\times 2}{1+2} = \frac{2}{3}$$

So, FOR MAX. POWER INTO R:

$$R = \frac{2}{3}\ \Omega$$

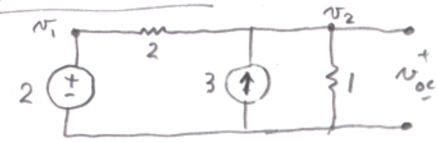
THUS

$$i_{MAX} = \frac{\frac{2}{3}}{\frac{2}{3}+\frac{2}{3}}\, 4 = 2\ A$$

So,

$$P_{MAX} = 2^2 \times \frac{2}{3} = \frac{8}{3}\ W = 2.66\ W.$$

ANOTHER SOLUTION: GET AN OVER-ALL THEVENIN CIRCUIT:

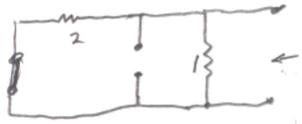


$v_2 = v_{OC}$

$v_1 = 2$

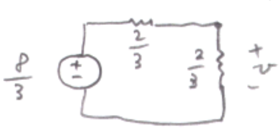
$$\frac{v_2 - 2}{2} - 3 + \frac{v_2}{1} = 0$$

$3 v_2 = 8$, $v_2 = \frac{8}{3}$



$$\leftarrow R_{TH} = \frac{2\times 1}{2+1} = \frac{2}{3}$$

So FOR MAX $R = \frac{2}{3}\ \Omega$



$$v = \frac{\frac{2}{3}}{\frac{2}{3}+\frac{2}{3}} \times \frac{8}{3} = \frac{4}{3}$$

$$P_{MAX} = \frac{\left(\frac{4}{3}\right)^2}{\frac{2}{3}} = \frac{8}{3}\ W$$