Massachusetts Institute of Technology
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Unified Engineering
Fall 2004

Problem Set #4

Due Date: Tuesday, October 5, 2004 at 5pm

	Time Spent (minutes)
M7	
S1	
S2	
S3	
C8	
C9	
C10	
Study Time	

Name: ______________

Unified Engineering I **Fall 2004**

Problem S1 (Signals and Systems)

1. Consider the system of equations

$$\begin{array}{rcrcrcr} 3x & + & 5y & + & 4z & = & -3 \\ 6x & + & 2y & + & 1z & = & 3 \\ 3x & + & 2y & + & 1z & = & 0 \end{array}$$

   Solve for x, y, and z, in three separate ways. The goal of part (1) is to practice solving systems of equations, so that when you get to part (2), you will have a fair basis of comparison.

   (a) Determine x, y, and z using (symbolic) elimination of variables.

   (b) Determine x, y, and z by Gaussian reduction.

   (c) Determine x, y, and z using Cramer's rule.

2. Consider the system of equations

$$\begin{array}{rcrcrcr} 2 & + & 1 & + & 4 & = & 4 \\ 3 & + & 1 & + & 3 & = & 4 \\ 1 & + & 1 & + & 4 & = & 3 \end{array}$$

   Again, solve for x, y, and z, in three separate ways. This time, please time each part (a), (b), (c) below.

   (a) Determine x, y, and z using (symbolic) elimination of variables.

   (b) Determine x, y, and z by Gaussian reduction.

   (c) Determine x, y, and z using Cramer's rule.

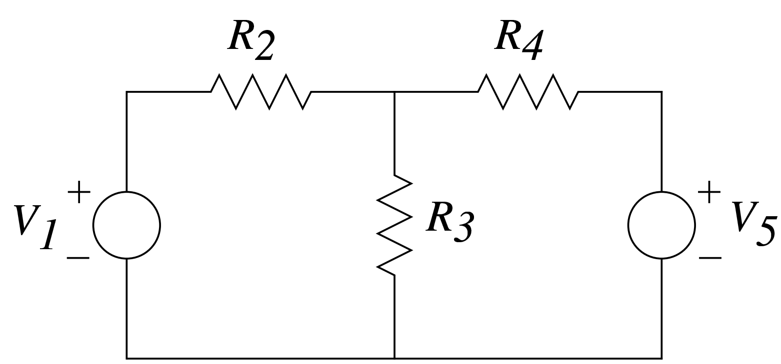
   (d) How much time did each method take?

   (e) Which method do you prefer? When answering this question, think about how much time might be required for a larger system, say, one that is 5×5.

Problem S2 (Signals and Systems)

For the circuit below, solve for all the branch currents and branch voltages, using the following steps. (Note: This problem will be easier once you learn the node method and the loop method. You should do just this one problem the long way.)

1. Label each circuit element with a branch voltage and branch current.
2. Write down Kirchhoff's voltage law for each loop in the circuit.
3. Write down Kirchoff's current law for all the nodes, except one.
4. Write down the constitutive relation for each circuit element.
5. Verify that there are as many equations as unknowns, and solve for all the unknowns. Hint: You should do this in an organized way, as there are a large number of variables.



$V_1 = 7$ V, $R_2 = 1$ Ω, $R_3 = 2$ Ω, $R_4 = 2$ Ω, $V_5 = 2$ V

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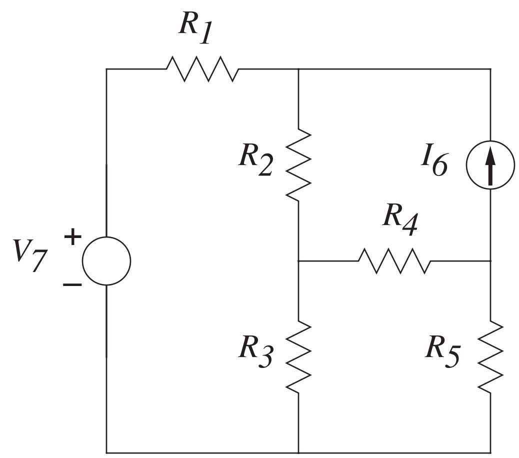
Problem S3 (Signals and Systems)



1. For the circuit above, find the branch voltages and branch currents using the node method. The component values are:

$$\begin{aligned} R_1 &= 1\ \Omega \\ R_2 &= 2\ \Omega \\ R_3 &= 4\ \Omega \\ R_4 &= 6\ \Omega \\ R_5 &= 1\ \Omega \\ I_8 &= 3\ \text{A} \\ V_7 &= 5\ \text{V} \end{aligned}$$

2. Verify that the net power dissipation of the circuit is zero, that is, that

$$\sum_{n=1}^{7} i_n v_n = 0 \tag{1}$$

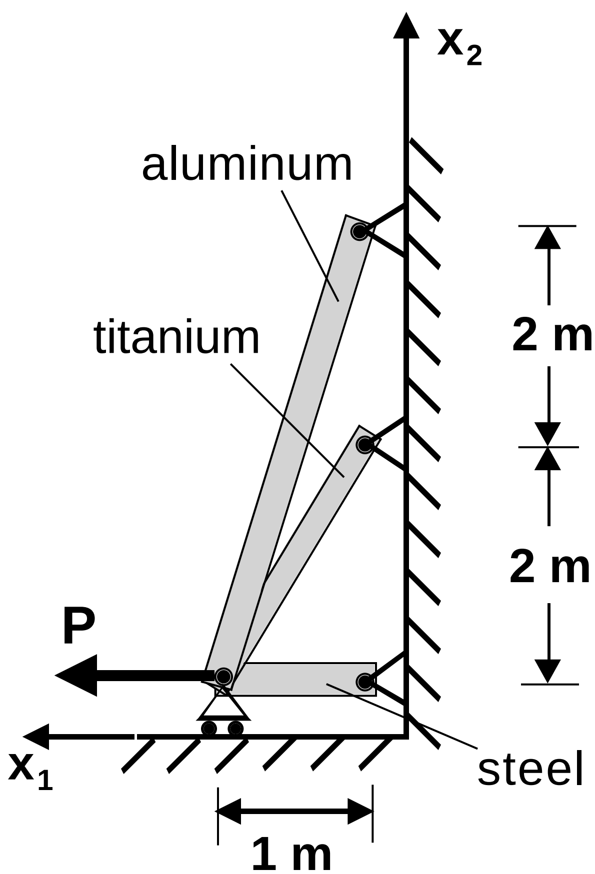
The net power dissipation for *every* circuit is zero, no matter what the circuit elements are, so long as Kirchhoff's laws are satisfied. This result can be viewed as a consequence of the first law of thermodynamics, applied to circuits.

Unified Engineering Problem Set #4 **Unit M1.5**
Fall, 2004

M7. A three-member truss arrangement in a corner is used to resist a horizontal load applied to a roller assembly. The steel member is pinned against the vertical wall such that it is horizontal and 1 meter in length. A titanium member is pinned 2 meters up the vertical wall while an aluminum member is pinned 4 meters up the vertical wall. All members have a square cross-sectional area, 10 mm to a side, with the overall configuration shown in the accompanying illustration.

Each material has a different stiffness (known as "modulus of elasticity") causing each of these bars to behave differently despite having the same cross-sectional area. The different lengths further contribute to this. Modeling these bars as effective springs, the spring constants are:

Aluminum	1.70×10^6 (N / m)
Titanium	4.69×10^6 (N / m)
Steel	21.0×10^6 (N / m)



(a) Draw the free body diagram for this situation. (Consider the overall system and any appropriate subsystems.)

(b) Determine whether this structural configuration is statically determinate or statically indeterminate and clearly explain your reasoning.

(c) Determine the bar loads and the reaction forces as a function of the applied load P.

(d) Determine the deflection of the roller support and the associated deflections of each bar as a function of the applied load P.

(e) If the deflection of the roller support were to become “large”, are there any adjustments which would need to be made in the analysis? If so, describe these adjustments and give your reasoning.

Problem Set 4

C8.

a. Write an algorithm to implement My_Type’Predecessor and My_Type’Successor as follows:

- The enumeration type is cyclic, i.e.
  - My_Type’Predecessor(My_Type’First) = My_Type’Last
  - My_Type’Successor(My_Type’Last) = My_Type’First
- My_Type’Successor skips the next element and returns the following element.
- My_Type’Predecessor skips the preceding element and returns the element that precedes it.

Turn in a hard copy of your algorithm in the **analysis format** as discussed in the recitation.
For example:

```
type Days is (Monday, Tuesday, Wednesday, Thursday,
              Friday, Saturday, Sunday);

package Days_Io is new Ada.Text_Io.Enumeration_Io (Enum => Days);

My_Day : Days; := Wednesday

--Days'Predecessor(My_Day) returns Monday

--Days'Successor(My_Day) returns Friday

--Days'Predecessor(Days'First) returns Days'Last

--Days'Successor(Days'Last) returns Days'First
```

b. Implement your new type as a package. Your package should contain
- The type definition
- The new predecessor and successor operations as functions.

Turn in a hard copy of your package code listing and an electronic copy of your code.

c. Implement a test program that prompts the user for input, gets user input, and demonstrates all four key operations as follows:
- Display My_Type’Predecessor(My_Type’First)
- Display My_Type’Successor(My_Type’Last)
- Display My_Type’Predecessor(User_Input)
- Display My_Type’Successor(User_Input)

Turn in a hard copy of your code listing and an electronic copy of your code.

C9.

a) Write an algorithm to check if a user input string is a palindrome. If the string is not a palindrome, reverse the string and display the reversed string to the user. Turn in a hard copy of your algorithm in the analysis format.

A palindrome is a string that is read the same whether you read it from left to right or right to left. For example: ABBA

b) Implement your algorithm as an Ada95 program. Your program should:
- Prompt the user for an input string (assume a maximum string length of 80)
- Read in the input
- Determine if it is a palindrome
- If it is not a palindrome, reverse the string
- Display the string to the user.

Turn in a hard copy of your code listing and an electronic copy of your code.

C10. Convert the following:

a) 1.7 into 8-bit floating point notation. Is there a loss of precision?

b) -113.3125 into 32-bit floating point notation

c) 00100110_2 into decimal (assume 8-bit floating point representation)

d) $B3983AB1_{16}$ into decimal (assume 32 bit floating point representation)