

Massachusetts Institute of Technology
Department of Aeronautics and
Astronautics
Cambridge, MA 02139

16.01/16.02 Unified Engineering I, II
Fall 2003

Problem Set #4

Name: _____

Due Date: 9/30/03

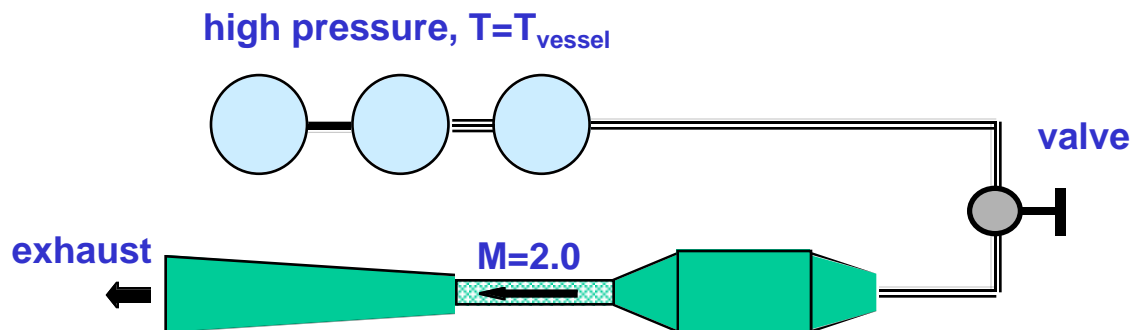
	Time Spent (min)
T10	
T11	
T12	
C8	
C9	
C10	
S1	
Study Time	

Announcements:

Problem T10 (Unified Thermodynamics)

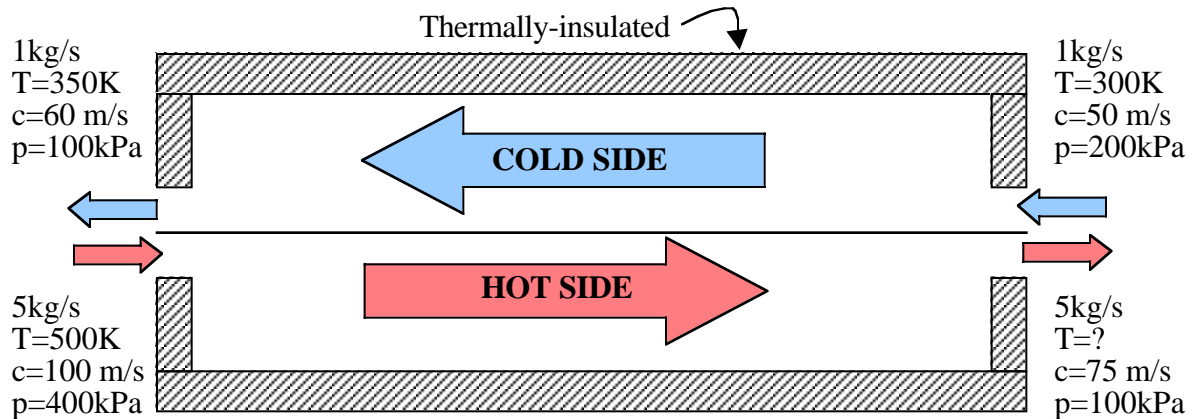
An aircraft is flying at $M=2.0$ at 11km ($T_{\text{atm}} = 217\text{K}$, $p_{\text{atm}} = 22.6\text{kPa}$, $\gamma = 1.4$). (LO# 4)

- In the reference frame of the airplane, what are the static and stagnation (or total) temperatures, and static and stagnation (or total) pressures?
- In the inlet of the engine, the flow is decelerated (adiabatically and quasi-statically) to about $M=0.7$ before passing into the compressor. Again in the reference frame of the airplane, what are the stagnation and static pressures and temperatures at the entrance to the compressor?
- The fan tip speed is Mach 1.7 relative to the engine. In the reference frame of the fan tip, what are the stagnation and static pressures and temperatures at the entrance to the compressor?
- A wind-tunnel is being designed to test the engine of this aircraft. The tunnel will be a blowdown facility like that shown below. High pressure air will be metered through a valve so that it flows through the wind-tunnel test section at Mach = 2 relative to the stationary lab frame. If the high pressure air were to start at room temperature and be accelerated adiabatically with no external work enroute to the test section, what would the static temperature of the flow in the wind-tunnel be? What temperature would it be necessary to set the pressure vessels to so that the static temperature in the test section matched those experienced in flight?



Problem T11 (Unified Thermodynamics)

A device called a heat exchanger is shown below. Assume that both the hot side flow and the cold side flow behave as ideal gases with $R=287 \text{ J/kg-K}$, $c_p=1003.5 \text{ J/kg-K}$, and $c_v = 716.5 \text{ J/kg-K}$.



- What is the temperature at the exit of the hot side flow? (LO# 4)
- This is a quote from *Thermodynamics for Engineers* by Wong, ©2000 by CRC Press. "No work is done in a heat exchanger." Do you agree or disagree and why? Please substantiate your argument with a calculation. (LO# 4)
- Is the process in this device reversible or irreversible and why? (Do not do a calculation; answer with a few sentences) (LO# 5)
- Describe the energy exchange processes in the device in terms of various forms of energy, heat and work. (LO# 2)

Problem T12 (Unified Thermodynamics) (LO#5)

- a) In problem T3 you evaluated the work for two different adiabatic processes. Calculate the change in entropy for those same two processes. What is the relationship between entropy change, work and irreversibility for these two processes?
- b) In problem T7 part (d) you were asked to compare measured values for the compressor for MIT's ABB Cogeneration Plant to an ideal quasi-static, adiabatic compression process. Calculate the change in entropy for these two processes and plot them on a T-s diagram (include constant pressure lines in the background of the plot).
- c) Write a paragraph that explains the concepts of reversibility and irreversibility of various thermodynamic processes. Cite examples of how irreversibility would impact the performance of aerospace power and propulsion systems.

Problem C8. (Unified Computers and programming)

1. Write an Ada95 program to accept a date in the **Date/Month/Year** format. Accept each of the inputs separately. Display the date in all three formats as shown below. Turn in the hard copy of your algorithm and code listing, and an electronic copy of your code.

- i. 19/9/2003 (Date, Month, Year)
- ii. 19 September 2003
- iii. 19.IX.2003

Hint: Use Enumerations to represent the month.

2. What are the First and Last values of the following data types
 - a. Integer
 - b. Float
 - c. Character
 - d. Boolean

Problem C9. (Unified Computers and programming)

1. Write a simple package that contains
 - a. A type definition
 - b. Two functions called `Successor` and `Predecessor` that work exactly like `Type'Succ` and `Type'Pred`. The only difference being:
 - i. `Successor(Type'Last) = Type'First`
 - ii. `Predecessor(Type'First) = Type'Last`

For example:

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

```
Successor(Sunday) = Monday  
Predecessor(Monday) = Sunday
```

Turn in a hard copy of your algorithm and code listing (package specification and package body), and an electronic copy of your code.

2. Write an Ada95 program that demonstrates the functionality of your package from question 1 above. Turn a hard copy of your code listing and an electronic copy of your code.

Problem C10. (Unified Computers and programming)

1. Explain the difference between the statements on the left and the statements on the right below. For each of them, what is the final value of X if the initial value of X is 3?

```
IF x >= 0 THEN
    x := x+1;
ELSIF x >=1 THEN
    x := x + 2;
END IF;
```

```
IF x >= 0 THEN
    x := x + 1;
END IF;
IF x >= 1 THEN
    x := x + 2;
END IF;
```

2. Write a simple package that contains
 - a. A function to add two integers.
 - b. A procedure to multiply two integers.

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

3. Write an Ada95 program that uses the package defined in Problem 2. Your program should:
 - a. Display a menu to the user as shown in Figure 1, and prompt him/her for a choice.
 - b. Accept a choice
 - c. Prompt the user for the inputs.
 - d. Clear the screen and display the result as shown below in Figure 2.

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

Hint: Use a case statement to select the required function/ procedure from the package.

Your Name's Program to Implement Simple Math Functions

1. Add Two Numbers
2. Multiply Two Integers
3. Quit

Please Enter Your Choice (1-3):

Figure 1: Menu Display

If the numbers are `First_Number` and `Second_Number`,

If the User Selects 1, the output should be:

```
Adding First_Number and Second_Number:  
First_number + Second_Number = Sum
```

If the User Selects 2, the output should be

```
Multiplying First_Number and Second_Number:  
First_number * Second_Number = Sum
```

Figure 2: Displaying Outputs

Problem S1 (Signals and Systems)

1. Consider the system of equations

$$\begin{aligned}x + y - 2z &= -1 \\x + 4y + 2z &= 5 \\x + y - z &= 0\end{aligned}$$

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

$$\begin{aligned}4x + 2y + 2z &= 7 \\3x + y + 2z &= 5 \\x + 3y - z &= 4\end{aligned}$$

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 .