



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

16.01/16.02 Unified Engineering I, II
Fall 2003

Problem Set #2

Name: _____

Due Date: 9/16/03

Problems: T2, T3, T4, T5, C2, C3, C4

	Time Spent (min)
T2	
T3	
T4	
T5	
C2	
C3	
C4	
Study Time	

Announcements:

Problem T2. (Unified Thermodynamics)

Consider the helium tank from the gas-pressurized, bipropellant, 4th-stage rocket engine from homework T1.

Assume the initial conditions at launch in the helium tank are $p_i = 100\text{MPa}$ and $T_i = 300\text{K}$.

- a) As the vehicle passes into the upper atmosphere at high speed (using stages 1-3) it heats up due to friction from the surrounding atmosphere. Assume the helium tank is rigid. Prior to igniting the 4th stage, the temperature of the helium has risen to 400K. What is the pressure in the tank at this condition?
- b) How much work was done during the heating process in part a)?
- c) Now assume that the tank is not rigid, but expands quasi-statically a small amount as the pressure is increased such that $dp/dv = 1e05 \text{MPa}\cdot\text{kg}/\text{m}^3$. If the helium reaches the same final temperature before igniting the 4th stage (400K), what is the final pressure?
- d) How much work was done during the heating process in part c)?
- e) Sketch processes a) and c) on a p-v diagram. To make the sketch clearer you may want to accentuate the changes in volume with pressure for the second process. Also, include a series of isotherms in the background as a reference.

(LO#4, LO#5)

Problem T3. (Unified Thermodynamics)

Consider two quasi-static expansion processes, one adiabatic, the second isothermal for a closed system containing air at $T_1 = 300\text{K}$, $v_1 = 1 \text{ m}^3/\text{kg}$. At the end of both expansion processes, the specific volume, $v_2 = 10 \text{ m}^3/\text{kg}$. Assume that $c_p = 1.0035 \text{ kJ/kg-K}$, $c_v = 0.7165 \text{ kJ/kg-K}$, and $R = 0.287 \text{ kJ/kg-K}$.

- a) Sketch both processes on p-v and T-v diagrams.
- b) For each process determine p_2 and T_2 .
- c) For each process, determine the work done by the system and the heat transferred to the system.
- d) For each process calculate the change in enthalpy of the air.
- e) What is the difference between heat and temperature?

(LO#4, LO#5)

Problem T4. (Unified Thermodynamics)

A thermally-insulated piston-cylinder arrangement holds a thermally perfect gas at $p_1 = 100\text{kPa}$ and $T_1 = 300\text{K}$. Assume that $c_p = 1.0035\text{ kJ/kg-K}$, $c_v = 0.7165\text{ kJ/kg-K}$, and $R = 0.287\text{ kJ/kg-K}$. You are to compare two processes.

- a) The first process is an adiabatic, quasi-static compression from $p_1 = 100\text{kPa}$ to $p_2 = 500\text{kPa}$. What are T_2 and v_2 , and how much work was done by the system during this process?
- b) For the second process, an external pressure of $p=500\text{kPa}$ is instantaneously applied to the gas in the cylinder. What is the final state of the gas in the cylinder (T_2 , v_2), and how much work was done by the system during the process?
- c) Sketch both processes on a $p_{\text{ext}}-v$ diagram. Which process is a more efficient means of compressing the gas to 500kPa and why?

(LO#4, LO#5)

Problem T5. (Unified Thermodynamics)

a) Draw a thermodynamic cycle on p-v and T- v diagrams consisting of

- Leg 1-2: adiabatic expansion
- Leg 2-3: constant volume heat addition
- Leg 3-4: constant pressure expansion
- Leg 4-1: isothermal compression

Assume that all processes are quasi-static and involve an ideal gas. On the p-v diagram, include lines of constant temperature in the background. On the T-v diagram, include lines of constant pressure in the background.

- b) For each leg, determine if the heat and work transfers are (+), (-), or zero.
- c) Is the net work for this cycle positive or negative?
- d) What common purpose might you use a cycle like this for and why?

(LO#3, LO#4, LO#5, LO#6)

Problem C2. (Unified Computers and programming)

Start with downloading 2 files from the CP web page: **screen.ads** and **screen.adb**.

1. Modify the “Hello” program shown in class (Lecture C2) to display the following text on the screen

```
Hello World
My name is Your Name
```

Ensure that the output of your program occurs on two separate lines as shown above. Turn in a hard copy of your code listing and an electronic copy of your code.

2. Compile `Spider_Crash` (Program 2.10, Page 56, Feldman Koffman). Redirect the output of your program into a file (In AdaGIDE, use menu Run → Run Options). What is the output of running the program? (It is sufficient to print the contents of the output file)
3. Write an algorithm to use the Feldman “spider package” to draw an inverted triangle as shown below. Turn in a hard copy of your code listing and an electronic copy of your code.

```
RRRRRRR
 R   R
  R  R
   R
```

Hint: Start the spider facing west; draw the top line and so on. The spider can draw a blank by changing the color to ‘None’. Read Program 2.5 (Page 47, Feldman Koffman) and Program 2.6 (Page 50, Feldman Koffman).

Problem C3. (Unified Computers and programming)

1. Compile Program 3.8 (Distance_With_Errors.adb, Feldman-Koffman, Page 107) into a listing file. Turn in a hard copy of the listing file.
2. Correct the errors in Program 3.8. Turn in a hard copy of the listing of the modified program and an electronic copy of your code.
3. Write an algorithm to
 - a. Accept the weight of the user (in kilograms)
 - b. Compute the equivalent weight in pounds
 - c. Display

`weight_in_kg` kg = `weight_in_pounds` lb

where `weight_in_kg` is the entered value and `weight_in_pounds` is the computed value.

Hint:

- I. Write down the mathematical formula that you would use. The algorithm will flow from that.
 - II. Identify inputs and outputs
 - III. 1 pound = 0.453592 kilograms.
4. Write an Ada95 program to implement your algorithm from question 3 above. Turn in a hard copy of your program listing and an electronic copy of your code.

Problem C4. (Unified Computers and programming)

3. Encode the following statement in ASCII notation:

$$2 + 3 = 5$$

4. Convert the following bit patterns into hexadecimal notation
- 0000111100001111
 - 001100110000000010000000
 - 0000101010100000