GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Semester 2001

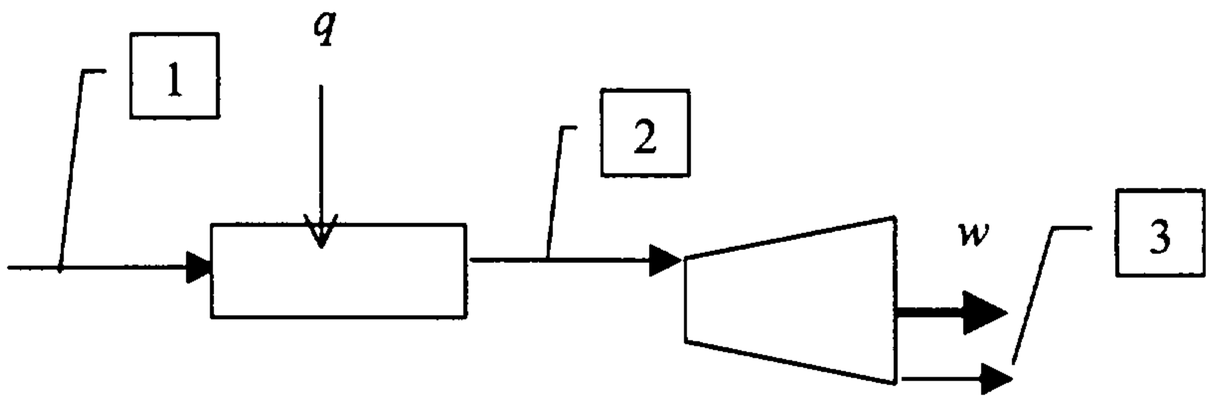
Thermodynamics
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

- **Please sign your name on the back of this page—**

Problem 1.

A proposed energy system is a heat exchanger followed by an adiabatic turbine. Air, an ideal gas with $k = 1.4$ and $M = 29$ kg/kmole, is the working fluid. Air enters the exchanger at 300 K and 5 bar and leaves at 500 K and 4.9 bar. The air expands through the turbine and leaves at ambient conditions, 298 K and 1 bar.



The work input to the exchanger _____ kJ/kg.

The work output from the turbine _____ kJ/kg.

Comment on the general feasibility of this proposed system.

Problem 2.

Comment on the properties of air with a small amount of water vapor in it. Assume that no rain droplets are present. In particular explain how the volume, internal energy, enthaply, and entropy can be evaluated.

Problem 3.

One kg of air, an ideal gas with $k = 1.4$ and $M = 29$ kg/kmole, is contained in an adiabatic and friction free piston cylinder assembly. Initially the air is at $T_1 = 300$ K and $P_1 = 3$ bar. The piston weighs $F_g = 100,000$ N and has an area of $A = 1$ m^3. The ambient atmosphere is at $T_0 = 298$ K and $P_0 = 1$ bar.

To start the process, the pin restraining the cylinder is removed, and the air expands reversibly against the piston. The state when the volume is a **maximum** is P_2 , T_2 and V_2 . First, find an **analytical** expression that relates the temperature at the maximum volume, T_2 , to the initial temperature T_1 in terms of the ambient pressure, P_0 , the weight of the piston, F_g , the area of the piston, A, and the specific heat ratio, k. It is **not** necessary that the result be an explicit formula for T_2 such as $T_2 = f(T_1, P_0, F_g, k, A)$; an implicit formula such as

$$f_1 (T_1 , T_2) = f_2 (P_0 , F_g , k, A)$$

is entirely adequate. Then address the following questions

. Explain how you would find the numerical value for T_2 .

2. In symbols show how much work is done by the air during the process.

3. Discuss how P_2 compares with P_0 .

4. Explain what happens to the piston after the maximum volume is reached.

Problem 4.

A tank (designated "A") is connected via a pipeline with a valve to a piston-cylinder (designated as "B"). The tank has a volume of 1.0 cubic meter. Initially the tank contains saturated water vapor at 100 kPa. The piston–cylinder initially contains water vapor at 400 C, 300 kPa, and 1.0 cubic meter total volume. The valve is now opened which results in the tank and piston-cylinder coming into equilibrium. Assuming that the final temperature is 200 C, please compute:

1. The initial mass in "A."

2. The initial mass in "B."

3. The final mass in "A."

4. The final mass in "B"

5. The heat transfer to or from the system.

6. The work into or out of the system.

7. The entropy generation.