GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2004

THERMODYNAMICS

EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

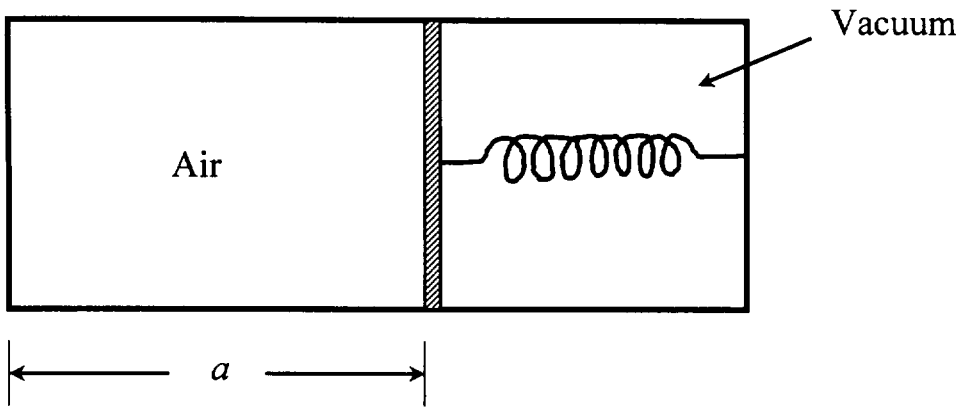
* Please sign your **name** on the back of this page —

G. W. Woodruff School of Mechanical Engineering
Ph.D. Qualifying Exam, Fall 2004
Thermodynamics

Problem 1

Consider the piston-cylinder systems shown below. Given the following

- Piston area = 4 cm^2
- Vacuum in the spring chamber
- Spring force, $F = ka$ where $k = 50$ kN/m



The cylinder initially contains air ($c_p = 1.004$ kJ/kg·K ; $c_v = 0.717$ kJ/kg·K ; and $R = 0.287$ kJ/kg·K) at 25 °C, and a is initially at 5 cm. The cylinder walls are then slowly cooled and the piston moves to the left until $a = a_2 = 4$ cm. Compute the energy transfer as heat from the gas for this process.

Problem 2

Steam at $P_1 = 150$ kPa and $T_1 = 200$ °C enters a diffuser with a velocity of V_1, and leaves the diffuser with a negligible velocity. The surroundings are at $T_0 = 25$ °C. The information provided by the manufacturer indicates that, with these inlet conditions, the steam exit pressure must be $P_{2s} = 700$ kPa if the process is isentropic. A test is performed, and it is reported that during the test heat is lost to the surroundings at the rate of 73.1 kJ/kg, and the steam leaves at a temperature of 380 °C.

a) Determine the inlet steam velocity, V_1.

b) Find the steam pressure at exit, P_2, during the test.

c) Is the reported test process possible? Justify your answer.

Problem 3

A turbo-charger is to be utilized to boost the inlet air pressure to an automobile engine. This device consists of an exhaust gas-driven turbine directly connected to an air compressor feeding combustion air to a truck diesel engine, as shown below. The steady state conditions are as shown in the figure. It may be assumed that the exhaust gas properties are the same as those of air with constant specific heats at the average temperature. The turbine and compressor are adiabatic. The isentropic efficiency of the compressor and turbine is 85%.

a) Calculate the turbine exit temperature at 4.

b) Calculate the compressor exit pressure and temperature at 2.