ES 202 Exam 3 Mayhew/Richards
14 Feberuary Sections E F G

Name:____ Campus Mail Box ____________

Section:____________________________

Problem 1 : __________ /60

Problem 2 : __________ /40

TOTAL ________________ /100

NOTE FOR FULL CREDIT: If you apply the conservation of energy, conservation of mass, or the entropy balance in solving a problem, you must clearly indicate how you used the information in the problem statement to simplify the general equations for the specific conditions of the problem

Useful information:

R_u = 8.314 kJ/(kmol·K) = 1545 ft·lbf/(lbmol·^{o}R)

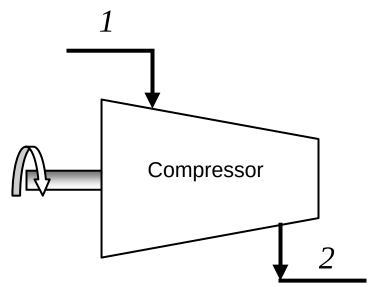
M_{air} = 28.97 kg/kmol

R_{air} = 0.287 kJ/(kg·K)

Problem 2 (40 points)

An adiabatic, steady-state air compressor is shown below. At the inlet, the pressure is 68 kPa, the temperature is 7 ^{o}C, and the volumetric flow rate is 95 m^3/s. At the compressor exit, the pressure is 820 kPa. The adiabatic efficiency of the compressor is 0.85.

Assume air behaves as an ideal gas *and* changes in gravitational potential energy and kinetic energy are negligible.



(a) Determine the mass flow rate of the air, in kg/s.

(b) Determine the power required to operate the air compressor, in kilowatts.

(c) Determine the temperature of the air as it leaves the compressor, in ^{o}C.

NOTE: Interpolation in the property tables is <u>not</u> necessary. If interpolation would normally be required to find the answer, use the closest tabulated value in the table.

Problem 1 (60 points)

As part of a compressed air system, the compressed air must be cooled before it can be supplied to the plant. This is accomplished using a steady-state device called an intercooler -- a two-fluid heat exchanger without mixing.

Air side: The air enters the heat exchanger at 450 K and 400 kPa with a velocity of 20 m/s. It leaves the heat exchanger at 310 K and 390 kPa with a velocity of 14 m/s. Changes in gravitational potential energy are negligible for the air stream. *Do not neglect kinetic energy effects.* The mass flow rate of air through the heat exchanger is 0.3 kg/s. Assume air can be modeled as an ideal gas.

Water side: The cooling water enters the heat exchanger at 10^{o}C and 100 kPa and exits the heat exchanger at 20^{o}C and 100 kPa. Changes in both kinetic and gravitational potential energy are negligible for the water stream. Water under these conditions is NOT an ideal gas.

(a) Determine the direction and magnitude of the heat transfer rate for the air stream, in kilowatts.

(b) Determine the mass flow rate of the water through the heat exchanger, in kg/s.

(c) Determine the entropy generation rate *within the air side of the heat exchanger*, in kW/K, assuming that the heat transfer occurs at an average surface temperature of 15^{o}C.