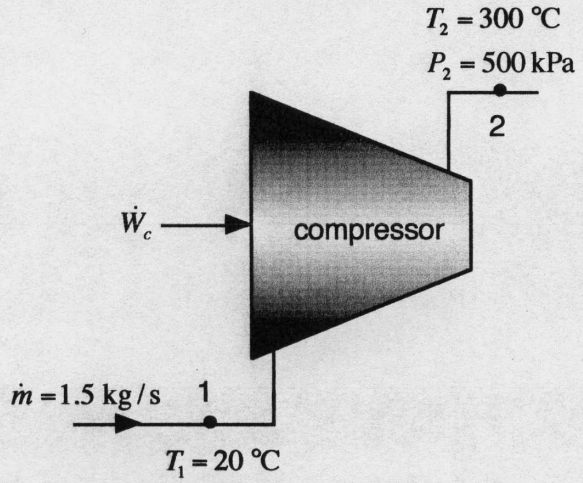
Mechanical Engineering Department
University of California at Berkeley

Midterm II

Name: w/soln

Instructions: Do all four problems. Each problem is worth 25 points. Show all work and make sure that your final answers are clearly distinguishable *with proper units.*



1. Air flows at a steady rate of 1.5 kg/s through a compressor. The inlet temperature at 1 is 20 °C. At the exit location 2, the temperature is 300 °C and the pressure is 500 kPa. The pressure at 1 is unknown, due to an instrumentation failure. The compressor operates adiabatically and has an efficiency of 0.8. In analyzing this system, treat air as an ideal gas with constant specific heats: $c_p = 1.005$ kJ/kgK, $c_v = 0.780$ kJ/kgK.

(a) What is the input power to the compressor?
(b) What would the temperature at 2 be if the compressor were reversible and adiabatic?
(c) What is the inlet pressure at 1?

(a) SSSF: $\dot{W}_c = \dot{m}(h_1 - h_2) = \dot{m} c_p (T_1 - T_2) = 1.5(1.005)(20 - 300)$

$\dot{W}_c = -422.1$ kW

(b) $\eta = \dfrac{\dot{W}_{c,i}}{\dot{W}_c} = \dfrac{\dot{m} c_p (T_1 - T_{2,i})}{\dot{m} c_p (T_1 - T_2)} \rightarrow \eta(T_1 - T_2) = T_1 - T_{2,i}$

$\rightarrow T_{2,i} = T_1 - \eta(T_1 - T_2) = 20 - .8(20 - 300) = 244$ °C

(c) $P_1 = P_2 \left(\dfrac{T_1}{T_{2,i}}\right)^{k/(k-1)} = 500 \left(\dfrac{293}{244+273}\right)^{1.29/.29} = 39.4$ kPa.