ME40 – QUIZ 2
Fall 2010

Last Name: ______________

First Name: ______________

Circle the section you attend:
M 4-5
T 10-11
T 1-2

Student ID #:____________

ABSOLUTELY NO QUESTIONS WILL BE ANSWERED DURING THE TEST. IF YOU ARE UNSURE ABOUT SOMETHING, MAKE AND STATE AN ASSUMPTION AND COMPLETE THE PROBLEM.

Complete as many problems as you can.

Problems 1-4 are multiple-choice or matching, only the final answer will be graded.

For Problems 5-8:

Show all work on the pages provided and cite assumptions made.

Box all answers. Answers without proper units will be considered incomplete.

Partial credit will be given.

1. (8 pts.) From a work-production perspective, which is more valuable:

a. thermal energy reservoirs at 600K and 250K

b. thermal energy reservoirs at 700K and 335K

2. (8 pts.) A perfect Carnot heat pump is used to maintain a house at 25 deg. C when the temperature outside is 4 deg. C. The house is losing heat through the walls and the windows at a rate of 14.07 kJ/s, and the heat generation rate within the house from people, lights, and appliances amounts to 1.77 kJ/s. Determine the minimum power input required for this heating system.

a. 0.932 kW

b. 1.12 kW

c. 0.482 kW

d. .866 kW

3. (8 pts) What is the thermal efficiency of an ideal Otto cycle, based on the following characteristics?
q_{in}= 20kJ, T_{min}=20°C, T_{max}=35°C, V_{min}=2m^3, V_{max}=4m^3, Cp=3 kJ/kg.K, Cv=1.5kJ/kg.K.

a. $\eta_{th} = 40\%$

b. $\eta_{th} = 75\%$

c. $\eta_{th} = 50\%$ d

d. $\eta_{th} = 24.5\%$

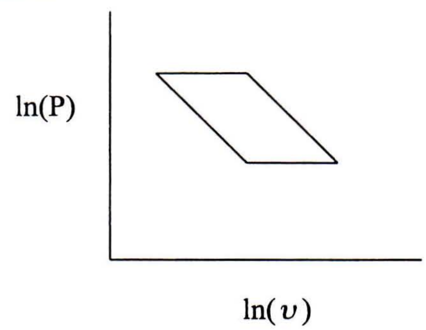
4. (6 pts.) Match the following graphs of $\ln(P)$ vs. $\ln(\upsilon)$ to their corresponding cycle from the choices given below. Mark the letter of the cycle in the blank above the graph. Assume all cycles flow in the clockwise direction.

A. Brayton Cycle

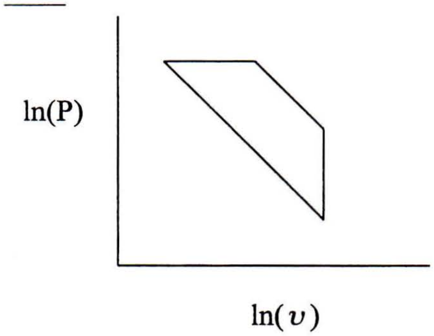
B. Otto Cycle

C. Diesel Cycle

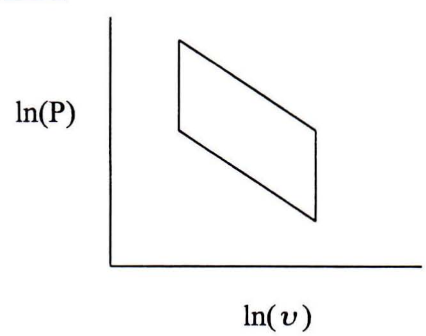
4.1) ____



4.2) ____



4.3) ____



5. (19 pts.) In class we discussed a method of distributing power using high-pressure air lines. The stages involved in such a system are as follows:

1-2 Air is isentropically compressed at the power plant.

2-3 The compressed air is transported at constant pressure to the end use site. Along the way, heat is lost to the surroundings through the pipe walls.

3-4 At the end use site, the air is isentropically expanded through a turbine producing electricity.

4-1 The air is exhausted from the turbine to the atmosphere. This stage can be modeled as a constant pressure addition of heat that returns the working fluid to stage 1.

Using constant c_p=1.005 kJ/kgK and k =1.4:

a) Draw the *P*- and *T-s* diagrams for this cycle. Label the states with numbers and indicate the direction of flow with arrows.

b) Given

- T_1= 20 deg. C
- compression ratio $r = 5$
- $\dot{Q}_{out,2\rightarrow 3} = 180.86$ kW
- $T_4 = 0$ deg. C
- $\dot{m} = 2$ kg/s

Find the thermal efficiency of the cycle (hint $\eta_{th} = \dot{W}_{turbine} / \dot{W}_{compressor}$).

6. (16 pts.) Liquid water at 100kPa and 20°C is heated in an adiabatic chamber by mixing it with superheated steam at 300kPa and 150°C.

Liquid water enters the mixing chamber at a rate of 3kg/s. If the mixture leaves the mixing chamber at 300kPa and 60°C, determine

(a) the mass flow rate of the superheated steam

(b) the rate of entropy generation during this mixing process.

Hint: Assume subcooled properties are the same as saturated liquid properties at a given temperature.

7. (16 pts.) Helium enters a steady-flow adiabatic compressor at 0.5kg/s, 100kPa and 27°C, with at a height of 7m and is compressed to 350kPa. The inlet and outlet velocities are neglected.
Properties: c_p = 5.1926 kJ/kg·K and k = 1.667, g=9.8 m/s^2

(a) Determine the exit temperature to make the work input and kinetic energy at the compressor exit have the minimum values.

(b) If the rate of work input into the compressor is measured to be a minimum with a value of 500 kW, determine the compressor exit height in m.

8. (19 pts.) We want to use a really hot rock with an initial temperature T1 =1000K to heat a building (see figure below). The building is large enough that it can be considered to be at a constant T2 = 300K.

a) Assuming that we just put the rock in the building and let it come to thermal equilibrium, determine the heat transfer to the building.

b) If we use a Carnot heat pump to transfer the equivalent energy found in **(a)** from the ground to the building, calculate the work input required.

c) If we run a Carnot heat engine between the ground and the rock as the rock cools to T3, calculate the work produced. What is the ratio of work required in part **(b)** to the work of the heat engine?