INSTRUCTIONS

• This is a closed book and closed notes exam. Answer as many questions as you can in the allotted time. Do not hesitate to ask questions if you do not understand a problem statement. For your own benefit, please write clearly and legibly. Maximum credit for each problem is indicated below. To receive full credit for a problem, you must follow instructions, show all work, and write the answers in the appropriate boxes.

• For Problems 2, 3, and 4, significant credit will be given if you start with the basic equation(s), list all assumption(s), and illustrate the method by which you propose to solve the problem correctly.

• Do not write on the back of any page. Material on the back of a page may not be graded. If additional pages are needed, ask for additional pages. Insert the extra pages in their proper order and staple them to the exam.

• The use of PDAs, Blackberry-type devices, cell phones, laptop computers, or any other sources of communication (wireless or otherwise) are strictly prohibited during examinations. Doing so is cheating. If you bring a cell phone or other communication devices to the examination, they must be turned off prior to the start of the exam, placed in your backpack, and the backpack stored below your seat, and only picked up as you leave the examination room for the final time. They are not to be turned on again until after you have exited the examination room. Otherwise it will be considered a form of cheating and treated as such.

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Problem 1: (30 points)

(a) Under what assumptions, does the equation \( \frac{ds}{dt} = \sum q_j + \left( s_1 - s_2 \right) + \sigma \) reduce to \( \sigma = c \ln \left( \frac{T_2}{T_1} \right) \)? Circle all that apply. (10 points)

- Closed System
- Insulated System
- Incompressible
- No Change in KE
- Constant Specific Heats
- Uniform Flow

(b) An irreversible process in a closed system can never be isentropic. Identify by circling one answer whether the above statement is true or false. You must provide justification with an appropriate equation to receive full credit. (10 points)

(b) True  False
(c) Consider two Carnot refrigerators removing heat from a cold space maintained at -23°C and rejecting heat to the ambient. Refrigerator A operates in summer and refrigerator B operates in winter at the same geographic location. Identify the correct statement by circling one answer. You must provide justification with an appropriate equation to receive full credit. (10 points)

| COP of refrigerator A is higher than that of refrigerator B |
| COP of refrigerator B is higher than that of refrigerator A |
| COP of refrigerator A is equal to that of refrigerator B |
Problem 2: (45 points)

**Given:**
An ideal reheat Rankine cycle operates between pressure limits of 8 MPa and 10 kPa with reheating occurring at 4 MPa. Steam enters both turbine stages (states 1 and 3) at 500°C. At the exit of the high-pressure turbine (state 2), enthalpy of steam is 3183.45 kJ/kg; while at the exit of the low-pressure turbine (state 4), enthalpy of steam is 2246.45 kJ/kg. Water enters and leaves the pump at states 5 and 6, respectively.

**Find:**
(a) Draw a schematic component diagram of the system. Clearly label all the components and show the known values of properties at appropriate states within the system. (10 points)

(b) Show the reheat cycle on the T-s diagram. Clearly label all the states and show appropriate lines of constant pressure. (10 points)
(c) The pump work in the Rankine cycle can usually be neglected. Identify the equation by circling one of the answers below which justifies neglecting the pump work. (6 points)

\[
\begin{align*}
\frac{\int P\,dv}{5} & \quad \frac{-\int v\,dP}{5} \\
\eta_{\text{pump}} & = \frac{w_{\text{isentropic}}}{w_{\text{actual}}} \\
BWR & = \frac{w_{\text{pump}}}{w_{\text{turbine}}}
\end{align*}
\]

(d) Neglecting the pump work, what is the thermal efficiency (%) of the cycle? Write any necessary assumptions, equations, and show your solution in the spaces provided. (10 points)

(d) Thermal efficiency of the cycle = \% 

Assumptions: (3 points)

Basic Equations: (6 points)

Solution:
Problem 2 Solution (contd.):
Problem 3: (45 points)

Given:
Consider an air-standard Otto cycle with a compression ratio of 6.98. The pressure and temperature of air at the beginning of compression is 90 kPa and 290 K, respectively. The maximum temperature in the cycle is 1300 K. You must consider variable specific heats for air. No credit will be given for analysis using constant specific heats.

Find:
(a) Show the cycle on T-s diagram. (4 points)

(b) What is the thermal efficiency (%) of the cycle? Write any necessary assumptions, equations, and show your solution in the spaces provided. (30 points)

Assumptions: (3 points)

Basic Equations: (8 points)
Name: __________________________________   Thermo No: _____________________

(Last)                          (First)

Solution:
Problem 4: (30 points)

A rigid tank (Volume = 0.3 m$^3$) is perfectly insulated and initially contains steam at 400 kPa and quality of 60%. The valve at the bottom of the tank is opened and steam flows out of the tank until pressure inside the tank drops to 150 kPa. Assume that steam undergoes a reversible, adiabatic process.

(a) Calculate the amount of steam (kg) leaving from the tank. Write any necessary assumptions, equations, and show your solution in the spaces provided. (18 points)

\[
\text{(a) Amount of steam leaving from the tank } = \text{ kg}
\]

(b) What is the final temperature ($^\circ\text{C}$) of steam in the tank? Write any necessary assumptions, equations, and show your solution in the spaces provided. (4 points)

\[
\text{(b) Final temperature of steam in the tank } = \text{ } ^\circ\text{C}
\]

Assumptions: (2 points)

Basic Equations: (6 points)
Name: ______________________  Thermo No: _____________________
  (Last)  (First)

Solution: