ME 200 Thermodynamics – Spring 2023
PREPARING FOR FINAL EXAM

I. Class Notes, Examples, and Quizzes

Review all class notes, examples, and quizzes**.** Do you understand all the concepts presented and discussed? Could you solve the examples and quizzes without looking at the solutions?

II. Homework Problems

Be able to solve all the homework problems without having to look at the solutions!

III. Previous Exam

One previous exam has been posted on your Brightspace site or your course site. Try to solve this exam in the time allotted for this 2-hour exam.

IV. Some Additional Coceptual Practice Problems

1. Each equation below is obtained from one or more equations from the ME-200 equation sheet. List the required basic equation(s) from the ME-200 equation sheet and identify the assumption(s) by letter from the list below that lead to the simplified equation. If necessary, apply the assumptions and perform any algebra needed to obtain the result. Think about examples where each equation is applied.

   Assumptions: (a) closed system, (b) open system, (c) steady state, (d) steady flow, (e) adiabatic, (f) no work, (g) negligible changes in potential energy, (h) neglible changes in kinetic energy, (i) isothermal, (j) constant pressure, (k) internally reversible, (l) externally reversible, (m) incompressible, (n) ideal gas, (o) constant specific heats

   ______________ $q = \int_1^2 T ds$

   ______________ $w = -\int_1^2 v dP$

   ______________ $\Delta h = \Delta u + v \Delta p$

   ______________ $\frac{p_{r2}}{p_{r1}} = \frac{p_2}{p_1}$

   ______________ $\frac{v_{r2}}{v_{r1}} = \frac{v_2}{v_1}$

   ______________ $\eta_{turbine} = \frac{h_2 - h_1}{h_{2s} - h_1}$

______________ $\frac{\dot{\sigma}}{\dot{m}} = s_2 - s_1$

______________ $\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{(k-1)/k}$

______________ $\dot{\sigma} = -\sum \frac{\dot{Q}_j}{T_j}$

______________ $Pv^k = \text{constant}$

______________ $W = P\Delta V$

______________ $\Delta s = c_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1}$

______________ $\Delta s = s_2^o - s_1^o - R\ln(P_2 / P_1)$

______________ $\Delta s = c\ln\frac{T_2}{T_1}$

______________ $Q = \Delta H$

______________ $w = -RT\ln\left(\frac{P_2}{P_1}\right)$

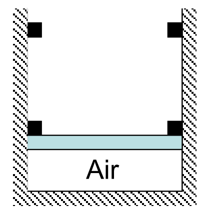
______________ $\eta_{th} = 1 - \frac{T_C}{T_H}$

______________ $COP_{HP} = \left|\frac{Q_H}{W_{net}}\right|$

2. Air is contained in a sealed tank of fixed volume. Air in the tank is initially at 20°C and 1 atm. It is heated to 250°C. Indicate how properties of air change compared to their initial values during the process. <u>In each case, justify using equations and/or property relations.</u>

a. Mass of air in the tank	increases	decreases	same
b. Density of air in the tank	increases	decreases	same
c. Pressure of air in the tank	increases	decreases	same
d. Specific internal energy of air in the tank	increases	decreases	same
e. Specific entropy of air in the tank	increases	decreases	same

3. Air at high pressure and ambient temperature is contained in a well-insulated piston-cylinder device. A set of stops prevent the piston from moving up. The stops are removed and the piston quickly rises until it encounters a second stop that prevents it from leaving the cylinder. Indicate how properties of air change compared to their initial values during the process. <u>In each case, justify using equations and/or property relations.</u>



a. Internal energy of air in the tank	increases	decreases	same
b. Temperature of air in the cylinder	increases	decreases	same
c. Density of air in the tank	increases	decreases	same
d. Pressure of air in the cylinder	increases	decreases	same
e. Specific entropy of air in the tank	increases	decreases	same

4. A rigid tank contains a saturated liquid-vapor mixture. Energy is added to the tank until all the fluid in the tank is single phase. What is the state at the end of the process if:

a) the initial specific volume is higher than the specific volume at the critical point.
i) sat. liquid, ii) sat. vapor, iii) can't tell

b) the initial specific volume is lower than the specific volume at the critical point.
i) sat. liquid, ii) sat. vapor, iii) can't tell

5. Liquid water treated as an incompressible fluid is flowing through a horizontal, adiabatic, and internally reversible diffuser. What happens to the following quantities as the water flows through the device? <u>In each case, justify using equations and/or property relations.</u>

Velocity:	increases	decreases	constant
Enthalpy:	increases	decreases	constant
Entropy:	increases	decreases	constant
Temperature:	increases	decreases	constant
Pressure:	increases	decreases	constant

6. Does entropy increase, decrease, or remain constant for each case? <u>In each case, justify using entropy balance or property relations.</u>

Ideal gas with constant P and increasing v	increases	decreases	same
Incomp. liquid with constant T and decreasing P	increases	decreases	same
Incomp. liquid with constant h and decreasing P	increases	decreases	same
Ideal gas with constant h and decreasing P	increases	decreases	same
2-phase mixture with constant h and decreasing P	increases	decreases	same
Ideal gas undergoing an isothermal compression	increases	decreases	same
2-phase substance condensed at constant pressure	increases	decreases	same
Closed system undergoing a rev. adiabatic process	increases	decreases	same
Closed reversible system undergoing heat rejection	increases	decreases	same
Adiabatic, irreversible process	increases	decreases	same

7. Circle the correct answer (True or False)

a. Properties of sub-cooled liquid can be approximated by the properties of saturated liquid at the given pressure.	True	False
b. A closed system containing an ideal gas undergoing a quasi-equilibrium and isothermal process where the volume decreases must receive energy by heat transfer from the surroundings.	True	False
c. In a steady state, steady flow process properties cannot change with position.	True	False
d. Heating of water using an electric resistance heater is an irreversible process.	True	False
e. Coefficient of performance of an air-conditioner or heat pump increases when the temperature difference between the hot reservoir and cold reservoir increases.	True	False
f. There is work associated with mass flow entering an open system.	True	False
g. An internally reversible, SSSF water pump operating between two fixed pressures requires more specific work than an internally reversible, SSSF steam compressor operating between the same two pressures. Neglect changes in KE and PE in both cases.	True	False
h. The enthalpy of an incompressible fluid flowing steadily through a well-insulated, horizontal, rigid duct of constant area is always constant.	True	False
i. All reversible heat pumps operating between the same two reservoirs have the same coefficient of performance.	True	False
j. A heat engine for which all the processes are internally reversible is a Carnot heat engine.	True	False
k. Temperature of an incompressible substance undergoing an irreversible and adiabatic process cannot decrease.	True	False

8. You are in the business of melting ice. As a gift, someone gives you a hot rock at 2000°C and another person gives you two rocks each at 1000°C. All the rocks are of the same size. Which gift will melt more ice?

   a) Single rock at 2000°C, b) Two rocks at 1000°C, c) Same for both cases

9. A bright ME student tells you that since you are melting ice with hot rocks, you should try to extract some mechanical work from the melting process to run your ice conveyors. He reminds you that mechanical work is "more valuable" than the heat. Which gift can lift more ice?

   a) Single rock at 2000°C, b) Two rocks at 1000°C, c) Same for both cases

10. An electric water heater consists of a perfectly insulated tank filled with water that is fitted with an electric heating element. Water enters the tank at 10°C and exits at 50°C at a pressure higher than 100 atm. The efficiency of the water heating process is defined as the energy provided to the water divided by the electrical energy provided to the heating element. The efficiency of the water heating process is:

    a) much higher than 100%, b) about equal to 100%, c) much lower than 100%

11. Air is compressed in a reversible, isothermal, SSSF process with negligible changes in kinetic and potential energy. Which of the following are valid for calculating the specific work input (per unit of mass flow)?

    a) $w = h_2 - h_1$, b) $w = \int_1^2 P\,dv$, c) $w = -\int_1^2 v\,dP$, d) a and b, e) a and c, f) none of the above

12. An engineer claims that thermal efficiency of a steam power plant changes between seasons. Considering an ideal Rankine cycle, does the thermal efficiency increase, decrease, or remain the same in winter as compared to summer? Assume that condensing temperature is maintained just above the ambient temperature.

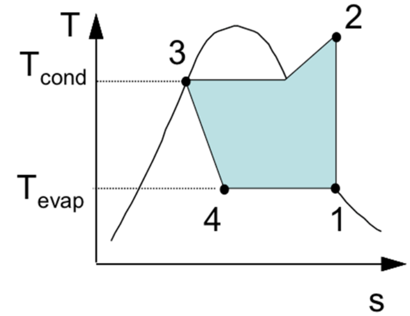
    a) increases, b) decreases, c) remains the same

13. In an ideal Rankine cycle, what happens to the specific pump work (per unit mass of flow) as the condensing temperature is lowered with everything else the same?

    a) increases, b) decreases, c) remains the same, d) can't tell

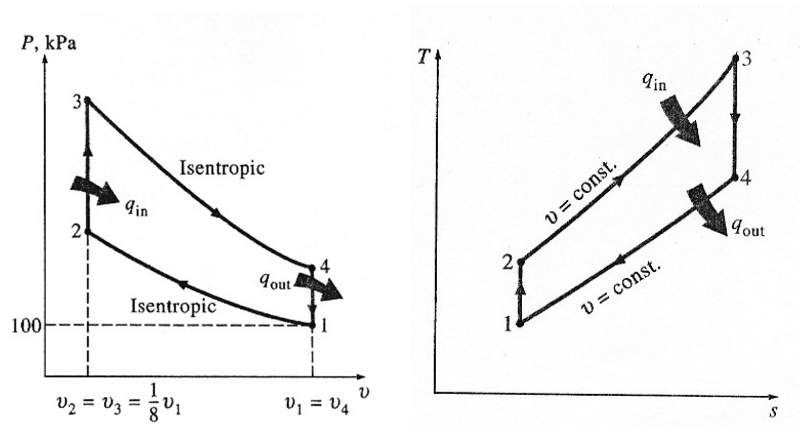
14. An ideal vapor compression refrigeration cycle is shown on a *T*-*s* diagram below. What does the area enclosed by the four processes of the the cycle represent?

a) Heat addition per unit mass flow
b) Heat rejection per unit mass flow
c) Work input per unit mass flow
d) Work output per unit mass flow
e) None of the above



15. Which ideal cycle is depicted on the *P*-*v* and *T*-*s* diagrams?

a) Carnot cycle
b) Otto cycle
c) Diesel cycle
d) None of above



16. Which ideal cycle has higher thermal efficiency for the same maximum and minimum cycle temperatures? Justify your answer.

a) Carnot cycle, b) Otto cycle, c) the same for Carnot and Otto cycles

17. Which of the Brayton cycles shown on the *T*-*s* diagram has higher thermal efficiency?

a) $r_p = 2$
b) $r_p = 8.2$
c) $r_p = 15$
d) Same efficiency