Homework #3 (group) – Tuesday, February 13 by 4:00 pm

5290 exercises (individual) – Thursday, February 15 by 4:00 pm

extra credit (individual) – Thursday, February 15 by 4:00 pm

Readings for this homework assignment and upcoming lectures

1. Read Chapter 1 of Textbook (Weston)
2. Read Chapter 2 of Textbook (Weston)
3. Review lecture notes:
   - Part 5. The Rise of Heat Engines
   - Part 6. Review of Engineering Thermodynamics, Parts A and B
4. Review Thermodynamics textbook as needed

Homework Submission

For this assignment, the homework is to be worked as a group assignment and submitted as a group in class or by dropping off at my office (room 905).

PLEASE include the course number (MEEM4200 -or- MEEM5290) in the subject line of any email correspondence.

MEEM 5290 problems are always to be worked and submitted individually.

Extra credit are always to be worked and submitted individually.

Homework #3 - due Tuesday, February 13 by 4:00 pm

1. Weston 1.11

2. A 10-m^2 rigid tank contains steam at 30 bar and 400 °C. It is left to cool down until its pressure drops to 5 bar. Find (a) the final condition of the steam and (b) the heat transfer in kilojoules.

3. A 1.2 kW_e compressor moves R134a through a residential heat pump at a rate of 0.018 kg/s. The refrigerant enters the heat pump condenser at 800 kPa and 35 °C and exits at 800 kPa as saturated liquid. Determine (a) the COP of the heat pump, and (b) the rate of heat absorption from the outside air.

4. Liquid ammonia at 87 °F and 250 psia is throttled to 100 psia into a flash tank. The flow rate into the flash tank is 100 lbm/hr. Ammonia vapor is drawn off of the top of the flash tank and liquid ammonia is discharged at the bottom. Determine the temperature [°F] in the tank and the mass and volume flow rates [lbm/hr, ft^3/hr] of the two exit streams. (good problem to use EES)

5. Air expands from 10 bar and 1000 °C to 1 bar and 500 °C in an insulated turbine. Calculate
   (a) the isentropic turbine efficiency,
   (b) the change in entropy during expansion, in kJ/kg K,
   (c) the specific work output of the turbine, in kJ/kg, and
   (d) the polytropic exponent.

   Assume a constant specific heat of 1.005 kJ/kg K.

6. Helium is compressed from 15 psia and 40 °F to 60 psia. The isentropic compressor efficiency is 0.70. Determine (a) the helium exit temperature, in °F, (b) the specific work of the compressor, in Btu/lbm, and (c) the change in entropy, in Btu/lbm °R.

7. 10^6 lbm/hr of steam at 250 psia and 1000 °F expands in a turbine to 1 psia. The turbine has isentropic and mechanical efficiencies of 0.90 and 0.95, respectively. The turbine drives an electric generator that has an efficiency of 0.96. What is the output power of the generator, in MW_e?

8. An ideal gas cycle is composed of four processes with air as the working fluid:

   1-2: Isentropic compression from 100 kPa and 27 °C to 1 MPa.
   2-3: Isobaric heat addition of 2800 kJ/kg.
   3-4: Isochoric heat rejection to 100 kPa.
   4-1: Isobaric heat rejection to state (1).

   (a) Show the cycle on a P-v and T-s diagram.

   (b) Calculate the maximum temperature in the cycle.

   (c) Calculate the thermal efficiency.

   Assume the specific heats are constant at the room temperature value.

9. A new inert gas appears to be well-suited for converting thermal energy from the exhaust heat of an engine manifold into mechanical energy via an Erickson engine. In order to design the cycle you need to determine the specific heats, the ideal gas constant and the entropy (all as a function of temperature) of this gas. The gas can be assumed to behave as an ideal gas. Design a simple experiment which will, with accompanying analysis, provide the necessary property data.

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10. Air at 800 kPa and 27 °C enters a steady-flow nozzle with a very low velocity and leaves at 100 kPa. If the air undergoes an adiabatic expansion process through the nozzle, what is the maximum velocity of the air at the nozzle exit, in m/s?

11. Weston 1.24

12. A gas has a molecular mass of 30 and a specific heat at constant pressure of 0.25 Btu/lbm-R. The gas undergoes a non-flow polytropic compression during which its temperature increases from 100 to 200 °F. The polytropic exponent is 1.3. Calculate the work done and the heat transfer in Btus per hour.

extra credit (individual) – Thursday, February 15 by 4:00 pm

13. Air at 140 °F and 100 psia is confined in an uninsulated 10 ft^3 vessel. A propeller is driven inside the vessel by a 50-W electric motor. After a period of 1 hour the air temperature dropped to 100 °F. Find the heat transfer in Btu per hour.

14. A 10-m^2 rigid tank contains steam at 30 bar and 400 °C. It is left to cool down until its pressure drops to 5 bar. Find (a) the final condition of the steam and (b) the heat transfer in kilojoules.

15. An inventor claims to have built an engine that operates on a cycle, receives 1000 kJ at 500 °C, produces work, and rejects 350 kJ at 50 °C. Is this claim valid? Why or Why not?

16. A long roll of 2-m-wide and 0.5-cm-thick manganese steel plate ($\rho = 7854$ kg/m^3 and $c_p =$ 0.434 kJ/kg°C)coming off a furnace at 820 °C is to be quenched in an oil bath at 45 °C to a temperature of 51.1 °C. If the metal sheet is moving at a steady velocity of 10 m/min, determine the required rate of heat removal from the oil to keep its temperature constant at 45 °C.