

AREN 2110: Thermodynamics
Spring 2011

HOMEWORK 8: Due Friday, April 1, 6 PM (7 problems, 25 points possible)

1. (3 points) An automobile engine consumes fuel at a rate of 28 liters/hour and produces 60 kw of power at the wheels. The fuel has a heat value of 44,000 kJ/kg and a density of 0.8 kg/liter. What is the efficiency of the car's engine?
2. (3 points) Are the efficiencies of all work-producing devices, including hydroelectric power plants, limited by the Kelvin-Planck statement of the second law? Explain.
3. (4 points, 2 per part) A heat engine using steam as the working fluid with a thermal efficiency of 40 percent rejects heat at the rate of 1,000 kJ/kg.
 - a. How much heat does it receive
 - b. If a 50 MW power plant is to be designed, what is the mass flow rate of steam required?
4. (3 points) A food refrigerator provides 15,000 kJ/hr cooling while rejecting 22,000 kJ/hr heat. Calculate the COP.
5. (4 points, 2 per part) R-134a enters the condenser (heat exchanger for rejection) of a heat pump at 800 kPa and 40 °C and a mass flow rate of 0.018 kg/s. It leaves the condenser as saturated liquid at the same pressure. The compressor consumes 1.2 kw power.
 - a. What is the COP of the heat pump?
 - b. At what rate is heat transferred from the outside air?
6. (4 points, 2 per part) A heat-engine cycle uses steam as the working fluid. The maximum possible efficiency of the cycle is 30 percent. During the heat addition process, steam changes from a saturated liquid to a saturated vapor at a constant temperature of 275 °C.
 - a. If the mass flow rate of steam is 3 kg/s, what is the net power output in kw?
 - b. What is the temperature at which heat is rejected?
7. (4 points, 2 per part) A Carnot heat engine receives heat at 750K and rejects the waste heat at 300K. The entire work output from the heat engine is used to power a Carnot refrigerator that removes heat from the -15 °C cold space at a rate of 400 kJ/min and rejects heat to the same reservoir as the heat engine, at 300K.
 - a. At what rate is heat supplied to the heat engine?
 - b. What is the total rate of heat rejected to the 300K environment?