

AREN 2110
Sections 001 and 002
Fall 2007

Homework # 8: Due Thursday, Nov. 1

1. What are the characteristics of all heat engines?
2. What is the Kelvin Planck expression of the 2nd Law of Thermodynamics?
3. A household refrigerator with a COP of 1.5 removes heat from the refrigerated space at a rate of 60 KJ/min. Determine the electric power consumed by the refrigerator and the rate of heat transfer to the kitchen air.
4. A heat pump is used to maintain a house at a constant temperature of 23 C. The house is losing heat to the outside air through the walls and windows at a rate of 60 MJ/hr, while the energy generated within the house from people, lights and appliances is 4000 kJ/hr. For a COP of 2.5 determine the required power input to the heat pump.
5. Consider a building whose annual air conditioning load is estimated to be 120,000 kW- hours, where the unit cost of electricity is \$0.10 / kW-hr. Two air conditioners are considered for the building. Air conditioner A has a seasonal average COP of 3.2 and costs \$5500 to purchase and install. Air conditioner B has a seasonal average COP of 5 and costs \$7000 to purchase and install. All else considered equal, determine which air conditioner is a better buy.
6. What are the four processes that make up the Carnot cycle?
7. Consider two power plants operating on solar energy. Energy is supplied to one plant from an 80 C reservoir, and the other from a 600 C reservoir. Which will have a higher efficiency and why?
8. A Carnot heat engine operates between a source at 1000K and a sink at 300K. If the heat engine is supplied with heat at a rate of 800 kJ/min, determine the thermal efficiency and the power output of this heat engine.
9. A Carnot heat engine receives 650 kJ of heat of heat from a source of unknown temperature and rejects 200 kJ of it to a sink at 17 C. Determine the temperature of the source and the thermal efficiency of the heat engine.
10. Consider a Carnot heat engine cycle executed in a steady-flow system using steam as the working fluid. The cycle has a thermal efficiency of 30 percent, and steam changes from saturated liquid to saturated vapor at 275 C during the heat addition process. If the mass flow rate of the steam is 3 kg/s, determine the net power output of this engine, in kw.
11. A Carnot heat engine receives heat at 750 K and rejects the waste heat to the environment at 300 K. The entire work output of the heat engine is used to drive a Carnot refrigerator that removes heat from a cooled space at - 15 C (258 K) at a rate of 400 kJ/min and rejects it to the same environment at 300 K. Determine (a) the rate of heat supplied to the heat engine and (b) the total rate of heat rejection to the environment by the two cycles.