Time spent on problems:

Problem 1:

Problem 2:

Problem 3:

Problem 4:

Problem 5:

Problem 6:

16.050 Thermal Energy

Do all problems. Please use a separate sheet of paper for each problem.

1. Two different fuels can be used in a heat engine, operating between the fuel-burning temperature and a low temperature of 350 K. Fuel A burns at 2500 K delivering 52,000 kJ/kg and costs $1.75 per kilogram. Fuel B burns at 1700 K, delivering 40,000 kJ/kg and costs $1.50 per kilogram. Which fuel would you buy and why?

2. Two heat reservoirs (500 K and 300 K) operate a Carnot engine between them. (**a**) If the engine receives 1000 J from the 500 K reservoir, what heat is rejected to the 300 K reservoir? (**b**) If the engine were operated in reverse as a refrigerator and received 1000 J from the 300 K reservoir, what heat is delivered to the 500 K reservoir? (**c**) What is the mechanical work required to operate the refrigerator in (b)?

3. Problem 7.90. VW, S&B. pp. 247.

4. **a**) A simple engine uses a perfect gas as the working fluid in a piston-cylinder system. The gas is first heated at constant pressure from state 1 to state 2, then cooled at constant volume to state 3 where $T_3=T_1$, and then cooled at constant temperature, thereby returning to state 1. Derive expressions for the amounts of energy transfer as work and heat (per kg of gas) for each process in terms of the temperatures and pressures at each state and the constants of the gas. Suppose $T_1=$ 300 K, $P_1=$ 0.2 MPa, $T_2=$ 800 K, and $k\equiv c_p/c_v=$ 1.4. Calculate the cycle efficiency (*net* work output/energy *input* as heat).

   b) When the engine of part (a) is reversed, it becomes a refrigeration device. Calculate the amount of energy transfer as heat from the cold space for this cycle (per kg of gas), and the cycle COP (energy transfer as heat from cold space/net work input). You can assume air for the working fluid.

5. There are 528 kJ/min of heat removed from a body by a refrigerator operating between the limits of 244.5 K and 305.5 K. If its coefficient of performance is three fourths of that of a Carnot refrigerator working between the same temperature limits, find (**a**) the heat rejected and (**b**) the work input, kW. (**c**) What are the COP and the heat if this device is used to deliver heat?