Practice Problems  **23-1:** R-134a as saturated liquid flows through an expansion valve. It enters the valve at  
 100 F and exits the valve at 0 F. Assuming isenthalpic conditions, calculate:  
 (a) the quality downstream of the valve  
 (b) the specific entropy upstream and downstream of the valve  
 (c) the specific entropy production

**23-2:** Saturated liquid water enters a commercial boiler at 1 atm and leaves as saturated vapor.  
 If the mass flow rate of fluid is 3 kg/min, find the   
 (a) boiler duty (aka heat transfer rate) and  
 (b) the entropy production rate given boundary temperature of 100 °C   
 (c) the entropy production rate given boundary temperature of 200 °C

## Preparatory Reading Questions

1. What steam engine innovation was introduced by James Watt? Why was this effective in increasing steam engine efficiency? What new applications for steam power emerged after Watt’s innovation? (pages 453-454, page 466)
2. What is a steam engine indicator? What thermodynamic information is obtained through its use? (pages 455-457)
3. Sketch a simple Rankine cycle on Ts and Pv diagrams. Show the location of the liquid-vapor dome on both diagrams. Relate state points on each diagram to the hardware in a Rankine cycle. (page 458)
4. Derive equation 13.3 by applying the 1st law for open systems to each hardware component in a Rankine cycle. (pages 458-459)
5. Compare the efficiency of a Rankine cycle with a Carnot cycle operating between the same maximum and minimum cycle temperatures shown on your Ts diagram.  
   (pages 462-465)
6. What is meant by ‘superheat’ in a Rankine cycle. How is this implemented and how does this impact cycle efficiency? (pages 466-468)

Answers1) R134a Valve

1. x\_2 ~ 0.36
2. Entropy values depend on your source (tables vs. EES)
3. Entropy values depend on your source (tables vs. EES)
4. Entropy production is ~ 0.0075 Btu/lbm-°F

2) Boiler

1. Boiler duty ~ 6800 kJ/min
2. If Tb = 100 °C, entropy production rate ~ 0 kJ/min-K
3. If Tb = 200 °C, entropy production rate ~ 3.83 kJ/min-K