## Practice Problems

1. A thermoelectric generator (TEG) consists of a series of semiconductor elements. When heat passes across the TEG (one side accepts heat from a hot source, and one side rejects heat to a cold sink) some of the heat energy is converted to electricity. A TEG is a type of thermal engine, except that the output is electrical rather than mechanical work. Electric current (DC) output is produced as a result of heat input.   
     
   In a particular experiment, the steady state DC output is measured to be 0.500 A at 0.800 V. The rate of heat flow on the hot side is 5.50 W. Find the following:
   1. The rate of heat transfer to the cold side [W]
   2. The efficiency of the device [%] in converting heat power to electrical power.
2. The mechanical equivalent of heat (i.e., the number of ft\*lbf per Btu) was first established accurately by James Prescott Joule (1818 –1889) in a long series of experiments carried out between 1849 and 1878. In one of his first experiments, the work done by falling weights caused the rotation of a paddle wheel immersed in water. The weights had a mass of 57.8 lbm and fell 105 ft. The resulting paddle wheel motion caused an increase in temperature of 0.563°F in 13.9 lbm of water in an insulated container. Use a specific heat of c = 1.00 Btu/(lbm\*R). Calculate the mechanical equivalent of heat from this early experiment   
   [1 Btu = \_\_\_\_\_ ft\*lbf]. How does this compare to the correct value, and where do you expect the errors were?

## Problems continued on next page

1. A pulse jet engine can be modeled by an ideal gas undergoing the following closed cycle.  
   Note that P2>P1 and V3>V1. *1-2: Isochoric combustion from P1 to P2  
   2-3: Adiabatic, polytropic expansion from P2 back to P1   
   3-1: Isobaric compression back to state 1*
   1. Draw a P-V diagram to support your answers to the next questions.
   2. In the table below, give correct sign (+, -, or 0) for work transfer, heat transfer, and change in internal energy. You may want to include a note that explains your rationale for a few of the boxes.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Work Transfer** | **Heat Transfer** | **Change in Internal Energy** |
| **Process 1-2** |  |  |  |
| **Process 2-3** |  | **Example**: Q=0 Adiabatic process |  |
| **Process 3-1** |  |  |  |
| **Net for Entire Cycle** |  |  |  |

1. 5 lbm of water goes through two processes in a piston-cylinder assembly as shown below. The water is initially at 240°F and it is a saturated liquid. Heat is then transferred to the contents, and the volume increases (while pressure remains constant) until the piston reaches a set of stops. At this point the volume is 5.0 ft3. Heat continues to be transferred to the contents (while volume remains constant) until the water is a saturated vapor. Sketch this 2-step process on a P-v diagram. Determine the work and heat transfer for this overall process. Use EES to verify your solution.



## Answers

1. Efficiency is ~ 7%, and heat transferred from the cold side is about -5 [W]
2. Late 1800’s conversion: 1 Btu =~774.85 ft\*lbf
3. For each process 1st Law still applies (Q – W = Delta\_U)  
   But for each process you also have some other relationships that also apply, such as:
   1. W = integral of P dV
   2. Delta\_U = mass \* specific heat capacity \* Delta\_T
4. You’re supposed to find total work and total heat transfer for this process. Here are some intermediate answers:  
   Specific Work from 1🡪3 is 4.545 Btu/lbm  
   Specific Heat Transfer from 1🡪3 is 915.3 Btu/lbm