AE 234/711 Aircraft Propulsion
Tutorial 5 - Thermodynamics

1. Show that $c_p - c_v = \mathcal{R}_g$.

2. Derive the expressions that relate $T - s$ and $p - v$ for `isobaric`, `isochoric`, `isothermal` and `isentropic` processes. Use these expressions to represent them on $T - s$ and $p - v$ axes.

3. Consider the compression of a system from a volume of $\mathcal{V}_i$ to a smaller volume $\mathcal{V}_f$. Compare the change in internal energy, pressure gain, work and heat interactions with surroundings `isobaric`, `isothermal` and `isentropic` processes. Which of these is the most efficient way to compress a gas?
   Isentropic compression is the most efficient

4. Derive the expression for the ideal efficiency of an Otto Cycle. Plot the dependence of this efficiency as a function of the compression ratio.

5. Derive the expressions for the efficiencies of Carnot and Diesel cycles.

6. The temperature at the beginning of the compression process of an air-standard Otto cycle with a compression ratio of 8 is 300 K, the pressure is 1 bar, and the cylinder volume is 560 cm^3. The maximum temperature during the cycle is 2000 K. Determine (a) the temperature and pressure at the end of each process of the cycle, and (b) the thermal efficiency.
   Stage 1 (100 kPa, 560 cc, 300 K, 0 J/kg-K) $\rightarrow$ Stage 2 (1837.9 kPa, 70 cc, 689.2 K, 0 J/K) $\rightarrow$ Stage 3 (5333.3 kPa, 70 cc, 2000 K, 8.9 J/K) $\rightarrow$ Stage 4 (290.2 kPa, 560 cc, 870.6 K, 8.9 J/K), Efficiency is 56.5 %
   How would these change if there was a energy loss of 1% during compression and expansion? Assume that the compression ratio and maximum temperature are maintained as before.
   Stage 1 (100 kPa, 560 cc, 300 K, 0 J/K) $\rightarrow$ Stage 2 (1853.3 kPa, 70 cc, 695 K, 0.1 J/K) $\rightarrow$ Stage 3 (5333.3 kPa, 70 cc, 2000 K, 8.9 J/K) $\rightarrow$ Stage 4 (290.2 kPa, 560 cc, 863.6 K, 8.8 J/K), Efficiency is 55.7 %