

Time spent on problems:

Problem 1:

Problem 2:

Problem 3:

Problem 4:

Problem 5:

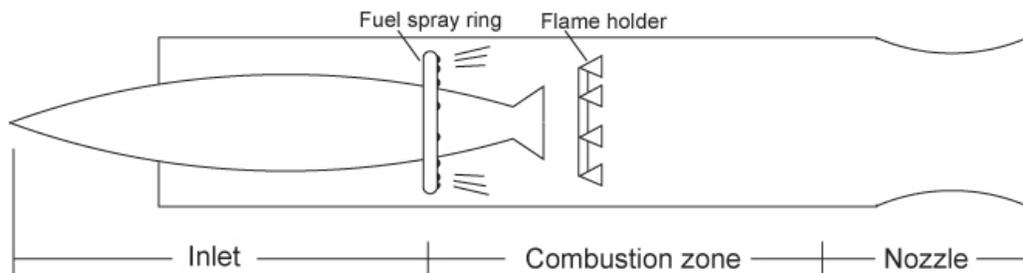
Problem 6:

16.050 Thermal Energy

Problem Set #6 – Fall 2002

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

1. An Otto cycle with a compression ratio of 7.5 operates from the suction conditions of 100 kPa, 30°C. Find the pressure and temperature at the end of the compression **(a)** if cold air ($k=1.4$) is the working substance, **(b)** if hot air ($k=1.32$) is the working substance. Compare answers. **(c)** Solve for the ideal thermal efficiency based upon the conditions given in **(a)** and **(b)**.
2. For an ideal Otto engine operating with $c_p=1$ kJ/kgK, the temperature at the end of isentropic compression is 450°C and at the end of expansion is 1400°C. The compression ratio is $r=7.5$. Find the work and the efficiency.
3. An ideal Diesel engine operates on 0.01 m³ (measured at state 1) of air. Let $P_1=100$ kPa, $T_1=60^\circ\text{C}$, $r=14$, and let the cutoff be at 6% of the stroke (where cutoff is V_3-V_2). Draw the P - V and T - s diagrams, use $c_p=1$ kJ/kgK, and find **(a)** T_2 , P_2 , V_2 , T_3 , V_3 , P_4 and T_4 ; **(b)** Q_{in} and Q_{out} ; **(c)** W and η .
4. Reynolds and Perkins, Engineering Thermodynamics, 2nd Ed. Problem 9.61, pp.371
5. Reynolds and Perkins, Problem 9.67, pp. 372
6. Scramjets or ramjets are candidate flight vehicles for high-speed flight (Mach numbers greater than 3, say, i.e. speed greater than 1 km/s). A schematic of a ramjet is given below. The flow enters at supersonic conditions and is decelerated to a combustor inlet Mach number of 0.2. In contrast, the flow in the combustion chamber of the scramjet is supersonic; the term stands for "supersonic combustion ramjet". Suppose the flight Mach number is $M_0 = 10$ and the altitude is 20km.
 - a) If there were no shock waves in the inlet, what would be the temperature rise from the inlet to the combustor for a ramjet?
 - b) If the combustor inlet Mach number were equal to 5 in the scramjet, what would be the temperature rise, from the vehicle inlet to the combustor inlet?
 - c) Suppose the walls of the inlet duct were uncooled (adiabatic), would they be able to survive in the ramjet? In the scramjet?



In all of the calculations, assume that air is a perfect gas with constant specific heats.