

ME 456

Prof. J. M. Powers

Homework 10

Due: Monday 26 April 1999

Consider the reactive Euler equations for a calorically perfect ideal gas as developed in class with $\gamma = \frac{7}{5}$, $q = 1.0 \times 10^6 \frac{J}{kg}$, $R = 287 \frac{J}{kg \cdot K}$, $P_o = 1 \times 10^5 Pa$, $T_o = 300 K$, $E = 1.0 \times 10^6 \frac{J}{kg}$.

- If $D = 3000 \frac{m}{s}$, find the pressure at N , S , and W .
- Find D_{CJ} , P_{CJ} , ρ_{CJ} , and T_{CJ} for both Chapman-Jouguet detonation and deflagration.
- Give a computer-generated plot of the complete reaction Hugoniot, the inert Hugoniot, and Rayleigh lines for $D = D_{CJ}$ and $D = 3000 \frac{m}{s}$
- Give a computer generated plot of the wave speed D as a function of the laboratory frame complete reaction velocity $u(\lambda = 1)$.
- Plot $P(\xi)$, $u(\xi)$, and $M(\xi)$ for two wavespeeds: $D = D_{CJ}$ (detonation branch) and $D = 3000 \frac{m}{s}$. For the Mach number plots, take the Mach number to be defined in the steady wave frame. Take as a kinetics model

$$\hat{u} \frac{d\lambda}{d\xi} = k(1 - \lambda) \exp\left(-\frac{E}{RT}\right)$$

with $k = 1 \times 10^8 s^{-1}$.

Give all supporting analysis. You may use any point in the course notes as a starting point, or you may want to give a complete development for your own benefit. You will likely need to use either a Fortran or Maple/Mathematica program to complete the analysis.