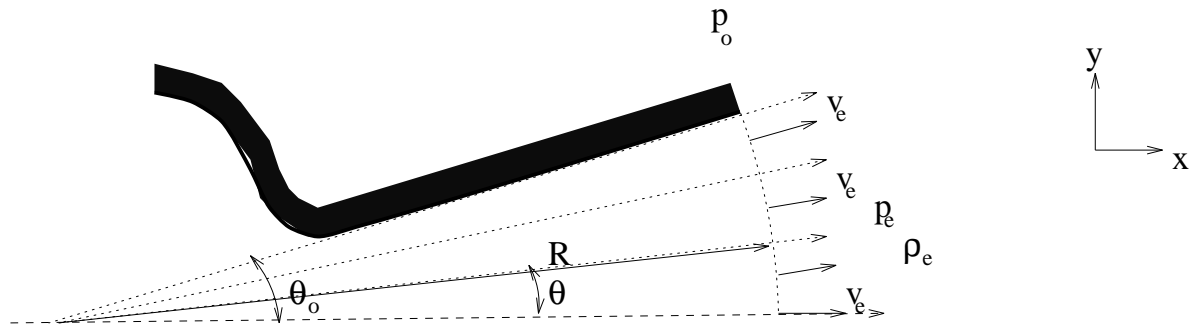


MAE 150R
 Rocket Propulsion Systems
 Assignment 2: Due Wednesday, April 26, 2000
 A. R. Karagozian

1. The **two-dimensional** exit nozzle for a rocket engine has **radial flow** along the dotted lines in the schematic shown below. The schematic is essentially constant as one moves in and out of the page. **Assume** that $p_e = p_o$.

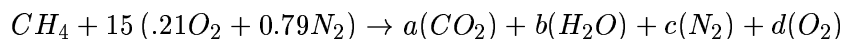


- a) Approximating the nozzle and flowfield as being roughly two-dimensional (**not conical**), find the thrust associated with this nozzle and express it in the form

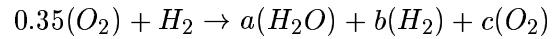
$$T = \dot{m}_e v_e f(\theta_o)$$

HINT: integrate over the surface area of the exit shown.

- b) What is the limiting value of thrust for a **horizontal** exit (i.e., as $\theta_o \rightarrow 0$)?
2. (Same as problem 10.1 in Hill and Peterson) Find the ratio of the velocities of two vehicles, $V_1/V_2 = \Delta u_1/\Delta u_2$, if vehicle 1 is powered by a liquid chemical rocket and vehicle 2 is powered by a solid chemical rocket, each used to accelerate a 10,000 kg payload in a **zero** gravity field. Both vehicles have a total initial mass of 510,000 kg. The liquid propellant rocket (1) has 60% greater specific impulse and 30% greater mass of the empty vehicle (without propellant and payload), and the solid propellant rocket (2) has an inert mass fraction $m_i/(m_p + m_i) = 0.08$.
3. Assuming no dissociation of the product species, determine the adiabatic flame temperature T_f and product molar concentrations (a, b, c, d values) for the reaction of methane (CH_4) and air which are introduced at 298K and 1 atm pressure:



4. Gaseous hydrogen and oxygen are burned in a rocket combustion chamber at 15 atm under the “rich” conditions designated by the following combustion reaction:



The gases enter the combustion chamber at 298K. Calculate the adiabatic flame temperature and the product composition (a, b, c values).

5. Air enters a length of constant cross section area pipe with $p_1 = 200$ kPa(abs), $T_1 = 500$ K, and $u_1 = 400$ m/s. If 500 kJ/kg of energy is removed from the air by frictionless heat transfer between sections (1) and (2), determine p_2 , T_2 , and u_2 .