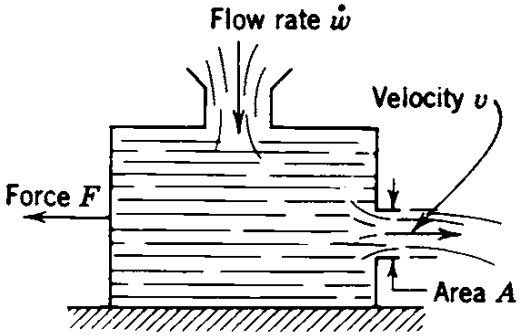
AUBURN UNIVERSITY
SAMUEL GINN
COLLEGE OF ENGINEERING
AEROSPACE

AERO 4970/7970 **Rocket Propulsion I** **SET I**

Definitions and Fundamentals

1. Prove that the value of the reaction thrust F equals twice the total dynamic pressure across the area A for an incompressible fluid as shown below.



2. The following data are given for a certain rocket unit: thrust, 8,896 N; propellant consumption, 3.867 kg/s; velocity of vehicle, 400 m/s; energy content of propellant, 6.911 MJ/kg. Assume 100% combustion efficiency. Determine (a) the effective velocity; (b) the kinetic jet energy rate per unit mass flow rate of propellant; (c) the internal efficiency; (d) the propulsive efficiency;(e) the overall efficiency; (f) the specific impulse; (g) the specific propellant consumption.
   Answers: (a) 2300 m/s; (b) 2.645 MJ/kg (power per mass flowrate); (c) 38.3%; (d) 33.7%; (e) 13.3%; (f) 234.7 sec; (g) 0.00426 s^{-1}.

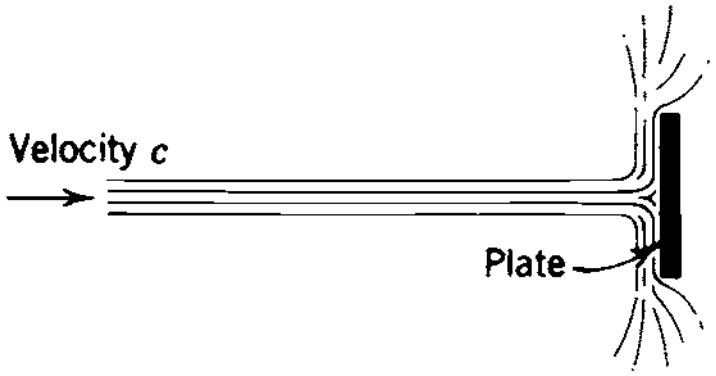
3. A certain rocket has an effective exhaust velocity of 7000 ft/sec; it consumes 280 lbm/sec of propellant mass, each of which liberates 2,400 Btu/lbm. The unit operates for 65 sec. Construct a set of curves plotting the propulsive, internal, and overall efficiencies versus the velocity ratio u/c $(0 < u/c < 1.0)$. The rated flight velocity equals 5,000 ft/sec. Calculate (a) the specific impulse; (b) the total impulse; (c) the mass propellants required; (d) the volume that the propellants occupy if their average specific gravity is 0.925.
   Answers: (a) 217.5 sec; (b) 3,960,000 lbf-sec; (c) 18,200 lbm; (d) 315 ft^3.

4. For the rocket in Problem 2, calculate the specific power, assuming a propulsion system dry mass of 80 kg and a duration of 3 min. *Answer*: 1.31×10^4 W/kg.

5. A jet of fluid hits a stationary flat plate in the manner shown below.

   (a) If we have 50 kg of fluid flowing per minute at an absolute velocity of 200 m/s, what will be the force on the plate? *Answer*: 167 N.

   (b) What will this force be when the plate moves to the right, in the direction of flow at u = 50 km/h? *Answer*: 144 N.



6. Derive an equation relating the mass ratio MR and the propellant mass fractio ζ .
   Answer: $\mathrm{MR} = 1 - \zeta$.