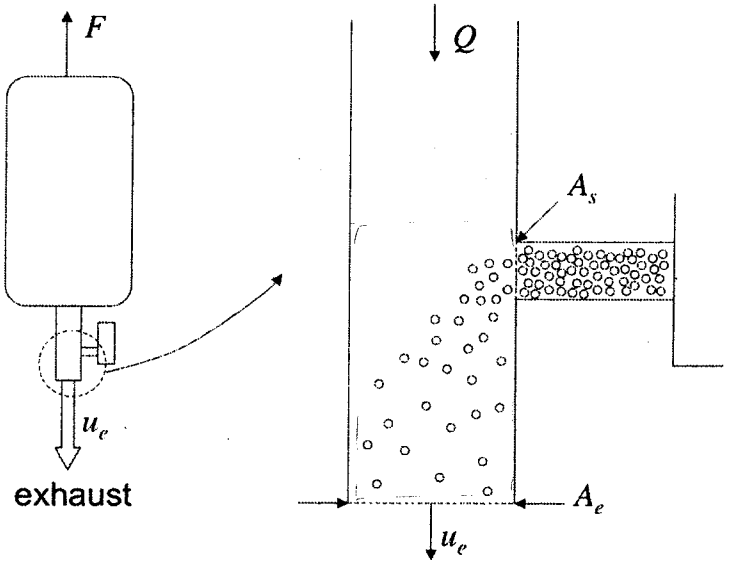
Unified Engineering Name: _____
Fluids Quiz 2 October 15, 2008

Suppose you have a water rocket similar to the one you are working on in your lab. The "engine" is modified as shown in the schematic to include a T connection from which solid spherical particles of radius R and mass density ρ_s are injected into the incoming water flow Q (m^3s^{-1}) at a rate of $\dot{N}$ particles per second. Water cannot go into the conduit containing the injected particles. The particles mix and accelerate until they flow with the same velocity as the water. The velocity of the exhaust is uniform at the nozzle exit. The rocket operates in steady state conditions. Neglect gravity effects.



(a) Find an expression for the mass *flux* of particles at the exit plane of the T injection conduit in terms of ρ_s and R.

(b) Prove that the exhaust velocity is given by:

$$u_e = \frac{4\pi R^3 \dot{N} + 3Q}{3A_e}$$

Note: *Here is important to identify the concepts and equations that lead to this result. Random manipulation of expressions without a clear explanation is not acceptable.*

(c) Find an expression for the mass density of the exhaust.

(d) Select an adequate control volume and evaluate the momentum equation to find the thrust F produced by this rocket.