CE 3305 Fluid Mechanics
Spring 2014 Quiz 13

1. Figure 1 is a balloon suspended from a taut wire by a hollow tube and string. The nozzle is a 0.8-cm-diameter tube, and an air jet exits the nozzle with speed of 45 m/s, and density of 1.2 kg/m^3. Find the force **F** needed to hold the baloon stationary.

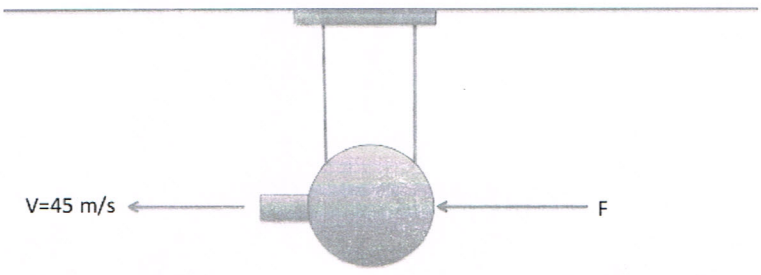


Figure 1: Balloon Rocket Schematic

KNOWN

$V = 45 m/s$

$\rho = 1.2 kg/m^3$

$d = 0.8 cm$

GOVERNING EQN(S)

CONTINUITY

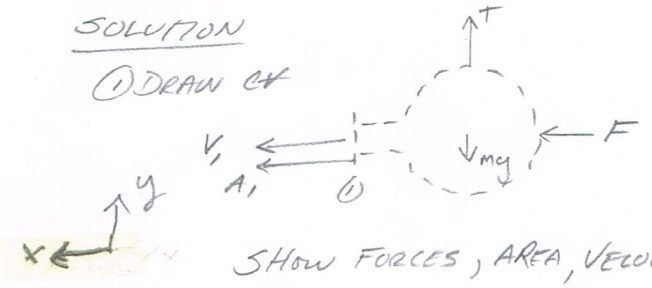
MOMENTUM

FIND

F REQUIRED TO HOLD BALLOON STATIONARY

SOLUTION

① DRAW CV



SHOW FORCES, AREA, VELOCITIES

② MOMENTUM

$$\Sigma F_x = \frac{d}{dt}\int_{CV} \rho v \, d\forall + \int_{CS} \rho v (v \cdot dA)$$

(NOT STRICTLY TRUE HERE, BUT FOR AN INSTANT ...)

$$\rightarrow F = -\rho V_1 \cdot V_1 \cdot A_1$$

$$= (1.2 kg/m^3)(45 m/s)(45 m/s)\left(\pi \frac{(0.008 m)^2}{4}\right)$$

$$= 0.122 \, kg \frac{m^4}{s^2 m^3} = 0.122 \frac{kg\,m}{s^2} = 0.122 N$$

DISCUSSION

① NOTE COORDINATE DIRECTIONS CHOSEN TO ELIMINATE "−" SIGNS IF CHOOSE $\rightarrow x$, THEN $-F = -\rho V^2 A$

② $\frac{d}{dt}\int_{CV} \rho v \cdot d\forall$ IS NOT STRICTLY 0. AS GAS EXITS BALOON, $\forall$ CHANGES BUT SO DOES ρ, AT ABOUT SAME RATE (IF ρ = CONST.) SO THE TIME VARIATION IS NEARLY ZERO UNTIL BALLOON GOES LIMP.