

UNIFIED PROPULSION PR SOLUTIONS (WATZ)

USE INTEGRAL MOMENTUM THEOREM IN VEHICLE REFERENCE FRAME.

VELOCITY OF REFERENCE FRAME = V (VELOCITY OF VEHICLE).

ALL OTHER VELOCITIES ARE RELATIVE TO V AND ARE LABELED

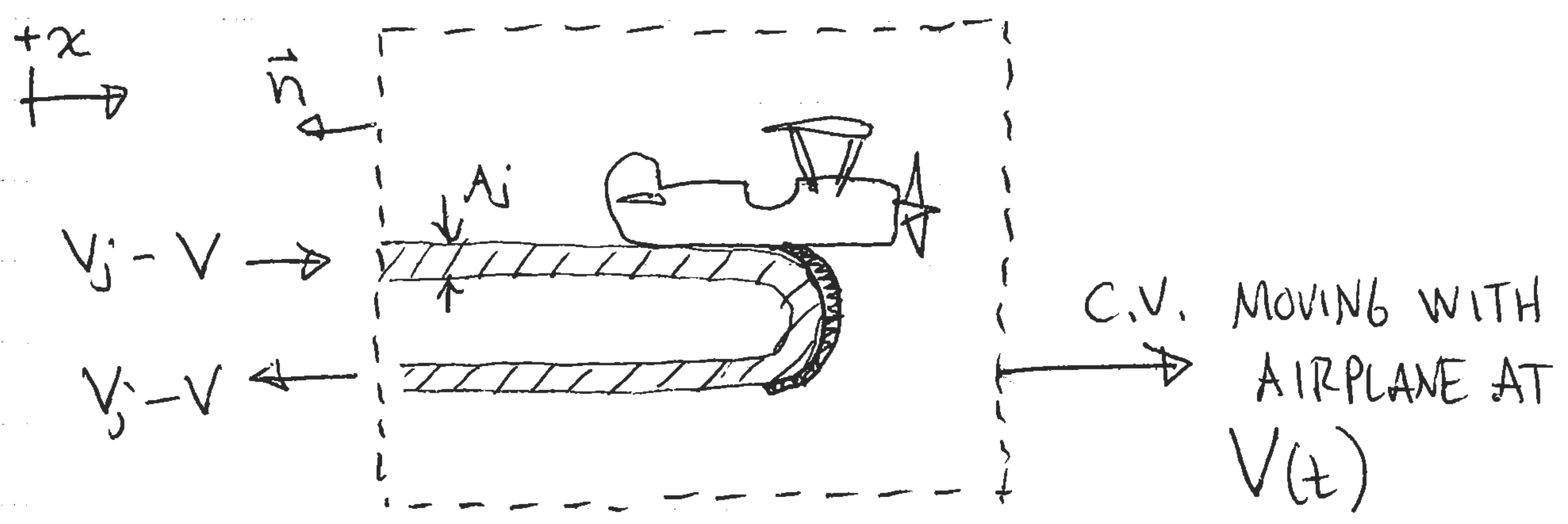
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a)
$$\sum F_x = \underbrace{\frac{dV}{dt} \int_{Vol} \rho dVol}_{\text{ACCELERATION RELATIVE TO INERTIAL REF. FRAME}} + \underbrace{\int_{Vol} \frac{d(\rho u_x)}{dt} dVol}_{\text{CHANGE IN MOM. OF MASS WITHIN C.V. RELATIVE TO C.V. REF. FRAME}} + \underbrace{\int_S u_x (\rho \vec{u}) \cdot \vec{n} dS}_{\text{NET FLUX OF MOM. ACROSS BOUNDARIES OF C.V.}}$$

SUM OF EXTERNAL FORCES = 0 SINCE PROBLEM SAYS TO NEGLECT DRAG

= $M \frac{dV}{dt}$

= 0 SINCE MASS OF VEHICLE NOT CHANGING AND CAN NEGLECT ANY UNSTEADY CHANGES IN MOMENTUM OF WATER PER PROBLEM STATEMENT



$$0 = M \frac{dV}{dt} + \int_S u_x (\rho \vec{u}) \cdot \vec{n} dS$$

(2 OF 2)

$$b) \quad -M \frac{dV}{dt} = \underbrace{-A_j \rho_j (v_j - V)(v_j - V)}_{\substack{\text{flow in} \\ \text{OPPOSITE} \\ \text{TO NORMAL}}} - \underbrace{A_j \rho_j (V - v_j)(V - v_j)}_{\substack{\text{flow out} \\ \text{NEGATIVE} \\ \text{X-DIRECTION}}}$$

NOTE THE SIGNS ARE BOTH NEGATIVE BUT FOR DIFFERENT REASONS!

EQNS OF MOTION:

$$\frac{dV}{dt} = \frac{2A_j \rho_j}{M} (v_j - V)^2 \quad v_j > V$$

$$\frac{dV}{dt} = 0 \quad v_j < V$$

$$c) \quad F = -2\rho_j A_j (v_j - V)^2$$

$$T = -F = 2\rho_j A_j (v_j - V)^2$$