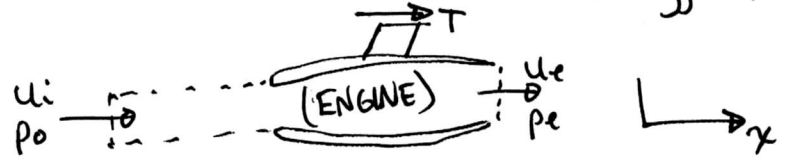
PROPULSION PI SOLUTIONS

WAITZ

INTEGRAL MOMENTUM EQN.: $\Sigma F_x = \int \rho u_x (\vec{u}\cdot\vec{n}) dA$



$$T + (p_o - p_e)A_e = \dot{m} u_e - \dot{m} u_o$$

a) MOM. FLUX INTO ENGINE
= mass flow rate * momentum per unit mass (i.e. velocity)
= $\dot{m}$ (velocity)

OR FROM THE INTEGRAL

$$= \int \rho u_x (\vec{u}\cdot\vec{n}) dA = \dot{m}(-u_{in}) = 50\frac{kg}{s}\cdot(-400 m/s)$$

(negative because u_{in} is (+) an outward normal is (−))

$$= -20 kN$$

b) MOM. FLUX OUT – SAME AS ABOVE EXCEPT $\vec{n}$ & $\vec{u}_e$ ARE IN SAME DIRECTION SO $\vec{u}\cdot\vec{n}$ IS (+)

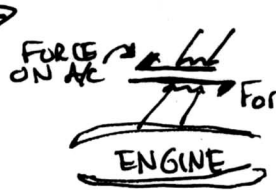
$$= 50\frac{kg}{s}\cdot 700 m/s = 35 kN$$

c) NET MOM FLUX = 15 kN

d) NET PRESSURE FORCE
$= (p_o - p_e)A_e = (30kPa - 25kPa)(1m^2) = 5 kN$

e) NET FORCE ON MASS IN C.V.
$T = \dot{m}u_e - \dot{m}u_o - A_e(p_o - p_e) = 35kN - 20kN - 5kN = 10kN$

f) THIS FORCE ACTS IN THE POSITIVE X-DIRECTION ON THE MASS IN THE C.V. →



g) SINCE THE AIRCRAFT IS IN STEADY LEVEL FLIGHT, THE FORCES MUST BALANCE. THEREFORE THE (VECTOR) SUM OF ALL OTHER FORCES (LIFT, DRAG, WEIGHT) MUST = 10 kN +x DIR