

2011 IIA Paper 3A3 (Fluid Mechanics II) Answers

Q1:

a) $\frac{p_s}{p_\infty} = 4.382 \quad \frac{p_{0s}}{p_{0\infty}} = 0.8856$

Q2:

b) $\tan \theta = \frac{\sin 2\beta}{(\gamma + 1) - 2 \sin^2 \beta}$

c) $\beta = 67.8^\circ$

d) $M_2 = 0.9622$ and $M_2 = 0.8829$ (both subsonic)

Q3:

b)ii) $\frac{V_p}{a_1} = -0.670$ iii) $p_2 = 41.87 \text{ kPa}$

Q4:

a)i) $\frac{A_N}{A} = 0.6257$ ii) $\frac{F}{\dot{m}} = 776.4 \text{ Ns/kg}$

b)i) $T_{02} = 861.1 \text{ K}$ ii) $\frac{F}{\dot{m}} = 930.1 \text{ Ns/kg}$ iii) $p_3 = 1.536 \text{ bar}$

Q5:

b) $h_2 = 1.147 \text{ m}$ $v_2 = 3.419 \text{ m/s}$

c) $x_{full} = 413.6 \text{ m}$

Q6:

a) $U \left(\frac{u_{i+1,j} - u_{i,j}}{\Delta x} \right) = \mu \left(\frac{u_{i,j-1} - 2u_{i,j} + u_{i,j+1}}{(\Delta y)^2} \right)$

b) $\Delta x \leq \frac{U(\Delta y)^2}{2\mu}$ and $\frac{\Delta x}{U} \geq 0$ (i.e. true forward difference in flow direction)

Q7:

a)i) $A = 14 \times 10^{-6} \text{ m}^2$ ii) $\text{flux} = -21.6 \times 10^{-3} \text{ kg/ms}$ iii) $\frac{\partial \rho}{\partial t} = 1543 \text{ kg/m}^3\text{s}$

c) $Y_p = 0.103$

Q8:

a) $u_1 = 136.7 \text{ m/s}$ $\Omega = 759.3 \text{ rad/s}$

b) $v_2 = 102.5 \text{ m/s}$ $\alpha_2 = 36.9^\circ$ $T_{02} = 323.2 \text{ K}$

c) $P_{02} = 1.276 \text{ bar}$

d) $\dot{m} = 36.11 \text{ kg/s}$

f) $\alpha_2^{rel,hub} = -22.9^\circ$ $\alpha_2^{rel,mid} = -42.5^\circ$ $\alpha_2^{rel,tip} = -53.5^\circ$