AML160
Major Examination Part II

2841-2006

Please answer the questions in this part on the answer book. ν for water = 10^{-6} m^2/s, ν for air = 10^{-5} m^2/s, g = 10 m/s^2, ρ for air = 1.25 kg / m^3, ρ for water = 1000 kg / m^3. Each question is worth 20 marks

Q1 We wish to estimate the total drag on a ship. For the calculations the ship is treated like a flat plate with one side in contact with water. The total drag on the ship is a sum of of two components: wave drag and skin friction drag. On performing dimensional analysis it is found that total drag (non-dimensionalized) is a function of Reynolds number and Froude number{ $(V^2/gL)^{0.5}$}. The analysis is simplified by assuming the coefficient of wave drag to be a function only of Froude number and that of skin friction drag to be a function of Reynolds number alone. The coefficient of skin friction for a flat plate is given by C_d skin friction = $0.0742 / (Re_L)^{0.2}$. All drag coefficients are based on the wetted area for this problem.

Consider the actual ship to be a plate of 10m (Length) X 1m (Width) in contact with water. We wish to use a 1:9 scale model.

a) If the Froude numbers are matched for the model and the prototype and the actual ships moves with a speed of 20m/s, what should be the velocity at which the model should be towed.

b) If the model is towed with velocity determined in a) above, it is observed that the total drag on the model is 20N. What is the estimate for the total drag force on the ship?

Q2 Consider the potential flow from the superposition of a clockwise vortex located at (x,y) = (-a,0) adjacent to a wall given by the y axis (x=0) and a uniform stream with velocity = Uj.

a) Find the stream function, velocity potential and the velocity field for this flow.

b) Also find the pressure distribution on the y axis.

ψ for a counter clockwise vortex at origin = $- K \ln r / (2\pi)$

ψ for a source flow at origin = $q \theta / (2\pi)$

ψ for a uniform flow parallel to x axis (+ i direction) = $U y$.

Q3 A centrifugal pump operates at 1750 rpm. The impeller has backward curved vanes with = 30^0 and blade width b_1 = 2 cm (at entrance) and $\beta_2 = 60^0$ and blade width b_2 = 1 cm (at exit). At a flow rate of 1200 litre per minute the radial outlet velocity is 4 m/s. Assuming radial flow at the inlet.

a) Estimate the Head generated by the pump.

b) Assuming that the pump is running at high enough RPM so that Reynolds number effects can be neglected, estimate the Head developed by the pump at 1200 RPM.

It is a law of life that all good things in life come to an end and so has this course. It was a pleasure teaching you and hope to see some of you later. I was particularly impressed by the students who have taken this course as an elective.