Roll No .....

MMTP-104

M.E./M.Tech., I Semester

Examination, June-2013

Advanced Fluid Mechanics

Time : Three Hours

Maximum Marks : 70

Note: *Attempt any five questions.*
Assume suitable missing data if any.

1. a) The velocity profile in laminar flow through a round pipe is expressed as

$$u = 2u\left(1 - r^2/r_0^2\right)$$

Where U is the average velocity, r is the radial distance from the centre line of the pipe, and r_0 is the pipe radius.

Draw the dimensionless shear stress profile τ/τ_0 against r/r_0, where τ_0 - is wall shear stress. Find the value of τ_0 when fuel oil having an absolute viscosity μ=0.4 poise flows with an average velocity of 4 m/s in a pipe of diameter 150mm.

b) A cylinder of 0.12m radius rotates concentrically inside a fixed hollow cylinder of 0.13m radius. Both the cylinders are 0.3m long. Determine the viscosity of the liquid which fills the space between the cylinders if a torque of 0.88 Nm is required to maintain an angular velocity of 2π rad/s.

2. a) Given a velocity field

$$V = (4 + xy + 2t)\hat{i} + 6x^3\hat{j} + (2xt^2 + z)\hat{k}$$

Find the acceleration of a fluid particle at (2,4,-4) and time t = 3.

b) Find the vorticity components at a point (1,1,1) for the following flow field:

$u = 2x^2 + 3y$; $v = -2xy + 3y^2 + 3zy$; $w = \frac{3}{2}z^2 - 2xz - 9y^2z$

3. State the Reynolds transport theorem (RTT). Derive RTT for a system and control volume configuration, and apply the derived RTT for the conservation of mass.

4. a) A line source discharging a flow at 0.6m²/s per unit length is located at (-1,0) and a sink of volume flow rate 1.2 m²/s per unit length is located at (2,0). for a dynamic pressure of 10 N/m² at the origin. Determine the velocity and dynamic pressure at (1,1).

b) Write a brief note on Naiver-Stokes equation for steady in compressible flows.

5. a) Discuss the implication of an inflection point in a boundary layer profile. Specifically, does the existence of an inflection point infer a favourable or adverse pressure gradient? Explain.

b) Write a brief note on drag and lift.

6. a) Water flows over a flat plate at a free stream velocity of 0.15 m/s. There is no pressure gradient and laminar boundary layer is 6mm thick. Assume a sinusoidal velocity profile.

$$\frac{u}{U} = \sin\frac{\pi}{2}(y/\delta)$$

For the flow conditions stated above, calculate the local wall shear stress and skin friction coefficient.

Take $\mu = 1.02 \times 10^{-3}$ Kg/ms, $\rho = 1000$ Kg/m³

b) A radial flow hydraulic turbine is required to be designed to produce 20MW under a head of 16 m at a speed of 90 rpm. A geometrically similar model with an output of 30 KW and a head of 4 m is to be tested under dynamically similar conditions. At what speed must the model be run?

7. a) An air plane travels at 800 km/h at sea level where the temperature is 15°C. How fast would the air plane be flying at the same Mach number at an altitude where the temperature is -40°C?

b) Derive the relation

$$\frac{dA}{A} = \frac{dV}{V}(M^2 - 1)$$

Where each term has usual meaning. Also discuss this relation for nozzle and diffuser.

8. a) An impeller with an eye radius of 51mm and an outside diameter of 406 mm rotates at 900 rpm. The inlet and outlet blade angles measured from the radial flow direction are 75° and 83° respectively, while the depth of blade is 64 mm.

Assuming zero inlet whirl, zero slip and an hydraulic efficiency of 89%.

Calculate :

i) The volume flow rate through the impeller and

ii) Power input to the impeller

b) Why is Pelton Turbine not suitable for low heads?