Fifth Semester B.Tech Degree Examination

(2013 scheme)

Branch: Aeronautical Engineering

MODEL QUESTION PAPER

13.506.3 : ADVANCED FLUID MECHANICS (S)

(SEMESTER-5)

Time: Three hours ***Maximum Marks: 100***

(a) Use of electronic calculators is permitted
*(b) This question paper contains **3** pages*
(c) Any missing data can be assumed suitably
(d) Answers should be brief and to the point

PART-A

*Answer all the questions, Each question carries **2** Marks*

1. To what equation does the principle of *conservation of mass* lead to? Write down the vector form of this equation.
2. Briefly explain the notion of a *Newtonian fluid*.
3. Discuss the *boundary conditions* that are imposed at a solid (wall) surface, while solving the (a) Navier Stokes equations (b) the Euler equations
4. A small thermocouple probe measures the temperature of a flow field whose *temperature field* is given by the relation

   $$T(x,y,z,t) = 2x^2 + yz + t .$$

   Find the rate of change of temperature at the point P (3,1,3) at 1 sec.
5. Explain *the principle of similarity solu*tions of boundary layer equations.
6. A 1m x 1m square plate is towed in its own plane in air at a speed of 2 m/s. Discuss whether the flow is *laminar or turbulent*.
7. Briefly explain the concept of *mixing length* in the context of turbulent flows.
8. Write down the expressions for the stream function and velocity potential for *a source-sink* combination separated by a distance ‘ d ‘ and explain the nature of the resulting flow field.
9. Discuss the differences between *rotational and irrotational* flows.
10. What is *Reynolds stress* and write down the expression for the same.

10 x 2 = 20 marks

PART-B

*Answer one full question from each module, Each question carries **20** Marks*

Module -I

11)

(a) In two dimensional flows, the continuity and x-momentum equations can be written as

$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}=0$$

$$\frac{\partial(\rho u)}{\partial t}+\frac{\partial(\rho u u)}{\partial x}+\frac{\partial(\rho v u)}{\partial y}=-\frac{\partial p}{\partial x}+\mu\nabla^2 u$$

Write down the above equations in non-conservative form, using the material derivative defined by

$$\frac{D}{Dt}=\frac{\partial}{\partial t}+u\frac{\partial(\ )}{\partial x}+v\frac{\partial(\ )}{\partial y}$$

(b) Show that for incompressible flows, (ρ = const) the z-momentum equation can be written in terms of the piezo-metric pressure defined as $p + \rho gz$

OR

12)

(a) Explain the concept of continuum in the study of fluid mechanics

(b) Briefly explain the Lagrangian and Eulerian methods of describing fluid flows.

Module II

(13)

Show that the power dissipated in a journal bearing of diameter 'D' and length 'L' is given by

$$P=\frac{\pi\mu\Omega^2\,DL^3}{4t}$$

where ' μ ' is the viscosity of the lubricant and ' Ω ' is the rotational speed and ' t ' is thickness of the oil film.

OR

(14) Derive the Von-Karman Integral momentum equation and reduce it to the case of flow over a flat plate.

Module III

(15)

Write short notes on

a) Control of separation of boundary layer by wall suction
b) Displacement thickness and Momentum thickness

OR

(16)

Find the terminal velocity of fall of a thin square plate of mass 300 grams and side 0.2 m when it is dropped in water vertically (with opposite sides vertical) Assume that the boundary layer is turbulent from the leading edge of the plate.

Module IV

(17)

The momentum thickness for a flat plate boundary layer using Blasius solution profile is given by

$$\theta = \frac{0.664\,x}{\sqrt{(Re_x)}}$$

and the transition Reynolds number using Michel's correlation is given by

$$Re_\theta = 2.9\,Re_x^{\,0.4}$$

Estimate the distance from the leading edge, at which transition can occur, using these data when air flows over a flat plate at 1 m /s and at 25 deg C and at atmospheric pressure.

OR

(18)

(a) For turbulent flows, the velocity profile in the boundary layer can be approximated as a power-law profile given by

$$\frac{u}{u_e} = \left(\frac{y}{\delta}\right)^{\frac{1}{n}}$$

Show that for this assumed profile, the shape factor is given by $H = \frac{N+2}{N}$

(b) A sail-boat 35m long, has a streamlined shape and a wetted area of 200 sq. m. Estimate the maximum velocity, if the boat is fitted with engines having a net power output of 400 KW. State all modelling assumptions and the data that are used in the calculations.

4 x 20 = 80marks