

(Following Paper ID and Roll No. to be filled in your Answer Book)

**PAPER ID : 4061**

Roll No.

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B.TECH

EIGHTH SEMESTER EXAMINATION, 2004-2005

ADVANCED FLUID MECHANICS

Time : 3 Hours

Total Marks : 100

Note : (i) Attempt ALL questions.

(ii) All questions carry equal marks.

1. Attempt *any four* parts of the following : (5x4=20)

(a) An idealised flow is given by -

$$\vec{V} = 2x^3j - 3x^2yj$$

Is it two or three dimensional? Make calculation for convective acceleration of a fluid particle in this flow field at point P (2, 1, 3).

(b) Describe the various types of motion of a fluid particle in brief.

(c) Differentiate between steady and unsteady flow.

(d) Briefly explain the reasons why the velocity distribution  $U(r)$  in a turbulent pipe flow is more flattened than that in a laminar pipe flow.

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- (e) What is vorticity ? How it is related to rotation ?  
In what situation fluid motion is described irrotational ?
- (f) Does the one dimensional incompressible flow given by -
- $$U(y) = AY^2 + BY + C, V = W = 0$$
- where A, B and C are constants, satisfy the continuity equation ?

2. Attempt **any four** parts of the following : (5x4=20)

- (a) For a doublet of strength  $20\text{m}^2/\text{s}$  calculate the velocity at point P (1, 2) and the value of stream function passing through it.
- (b) From Euler's equation of motion derive Bernoulli's equation, state the assumptions made.
- (c) A kite weighs 11N and has an area of  $0.75\text{m}^2$ . The tension in the kite string is 30N when the string makes an angle of  $45^\circ$  with the horizontal. For a wind of  $9\text{m/s}$  derive the coefficients of lift and drag if the kite assumes an angle of  $8^\circ$  with the horizontal. Consider kite essentially a flat plate and  $e_{\text{air}}g = 11.8\text{N/m}^3$ .
- (d) Explain magnus effect in brief.
- (e) Explain circulation and derive it's theorem.
- (f) What is an airfoil ? On what factors will the total drag on airfoil depends. Draw pressure distribution over an airfoil.

- (a) Write the general momentum balance equation in one dimension and explain the terms.
- (b) Why is it very important to decide the boundaries correctly for the momentum balance ?
- (c) What is the importance of the 'Navier Stokes' equation in solving fluid mechanics problems ?

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4. Attempt *any two* parts of the following : (10x2=20)

- (a) From the first principles, prove that for an adiabatic flow in a constant area duct, a subsonic flow can never become supersonic one.
- (b) For the steady compressible flow, prove that -

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

A = Area of the duct

V = Velocity, and

m = Mach number

Hence deduce the necessary shape of a nozzle to obtain supersonic flow.

- (c) A converging diverging nozzle is designed to operate with an exit mach number of 1.75. The nozzle is supplied from an air reservoir at  $68 \times 10^5 \text{ N/m}^2$ . Assuming one dimensional flow, calculate :

- (i) Maximum back pressure to choke the nozzle

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- (ii) Range of back pressure for super sonic flow at the nozzle exit plane.

5. Attempt *any two* parts of the following : (10x2=20)

- (a) Show that in flow through a tube of constant area with heat addition, (i) the mach number at the point of maximum temperature is equal to  $1/\gamma$  and (ii) the mach number at the point of maximum entropy is equal to unity.
- (b) A normal shock moves in a constant area tube. The velocity of shock with respect to fixed co-ordinate system is  $600\text{m/s}$  whereas velocity of fluid ( $V_1$ ) is  $100\text{m/s}$ . The static temperature ( $T_1$ ) before shock is  $30^\circ\text{C}$  and static pressure ( $P_1$ ) is  $0.7\text{ bar}$ . Find the fluid properties after shock wave.
- (c) A straight pipe of  $0.05\text{m}$  diameter is attached to a large air reservoir at pressure  $13.8 \times 10^5\text{N/m}^2$  and temperature  $310\text{K}$ . The exit of the pipe is open to atmosphere. Assuming adiabatic flow with an average friction coefficient of  $0.005$ , calculate the pipe length required to obtain a mass flow rate of  $2.25\text{ kg/s}$ .