

Department of Aerospace Engineering  
IIT Kharagpur

Mid Semester Exams (Autumn 2002-2003)

INTRODUCTION TO AERODYNAMICS (AE 21001)

Course: B.Tech. (2nd year)

Max Marks: 40.

Time: 2 hrs.

Answer all the FOUR Questions

- Q1. (a) Derive the hydrostatic Equation. What do you mean by buoyancy force? Explain.  
(b) Assuming adiabatic process, determine the pressure and density of air at an elevation of 500m above sea level given that the atmospheric pressure and density at an elevation of 3000m are 70.107 kPa and 0.9092 kg/m<sup>3</sup> respectively. Assume  $\gamma = 1.4$ . (4+6)

Q2. (a) Derive the relation:  
$$\rho \frac{Du}{Dt} = -\frac{\partial p}{\partial x} + \rho f_x + (F_x)_{\text{viscous}}$$

- (b) Distinguish between  
(i) Rotational and Irrotational flow  
(ii) Stream function and Velocity Potential function (6+4)

- Q3. (a) Derive Bernoulli's equation clearly stating conditions under which the equation apply.  
(b) A 20 cm diameter jet of oil (RD = 0.9) strikes a flat plate at an angle of 25° to the normal. The plate is moving at a velocity of 3 cm/s in the direction of the jet. Calculate absolute velocity of the jet if the resultant force on the plate is 2500 N. (5+5)

Q4. (a) What do you mean by vorticity? Show that vorticity  $\xi = \nabla \times \vec{v}$ .

(b) Calculate the unknown velocity component in the following so that continuity equation is satisfied:-

(i)  $u = \frac{2}{3}xy^3 - x^2y$   
 $v = ?$

(ii)  $u = Aye^x$   
 $v = ?$

(c) Verify whether the following velocity fields are rotational? If so, determine the component of rotation.

(i)  $u = xyz$   
 $v = zx$   
 $w = \frac{1}{2}yz^2 - xy$

(ii)  $u = xy$   
 $v = \frac{1}{2}(x^2 - y^2)$  (4+3+3)