

GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER-IV • EXAMINATION – SUMMER 2013

Subject Code: 140102**Date: 14-06-2013****Subject Name: Aerodynamics I****Time: 10:30am – 01:00pm****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

- Q.1** (a) What is Potential flow? Prove that scalar function velocity potential exist only for potential flow. **07**
- (b) Prove that $\tan q = 2 \cot b \frac{M_1^2 \sin^2 b - 1}{M_1^2 (g + \cos 2b) + 2}$ and plot β - M relationship. **07**
- Q.2** (a) Explain basic elementary flow in terms of stream function and potential function. **07**
- (b) Four singularities are arranged in a line as shown in Figure 1. They include a source, a vortex with counter-clockwise circulation, then a sink and another vortex. The singularities are equally spaced, each a distance dx from its neighbors. Find (a) circulation around a large circle of radius R and (b) the total force on the system of singularities and indicate its direction. **07**

OR

- (b) Using the principle of momentum and mass conservation, derive a formula for the drag of a wing in a wind tunnel as shown in Figure 2 in terms of the measured velocity components $u(y,z)$, $v(y,z)$, $w(y,z)$ near the back of the test section as shown in Assume inviscid, incompressible flow where the pressures and velocities are related by the Bernoulli equation: $P + \frac{1}{2} \rho v^2 = P_s$ **07**
- Q.3** (a) The Rankine body is 1m thick has its source and sink each located at a distance of 0.75m from the origin and is exposed to an upstream velocity of 25 m/s. what is the equivalent source strength? **07**
- (b) Show that part of the flow given by the complex potential function $w = \cosh^{-1} \left(\frac{z}{c} \right)$ can represent irrotational flow in a converging diverging channel of constant depth. **07**

OR

- Q.3** (a) A sink of strength $120 \text{ m}^2/\text{s}$ is situated 2 m downstream from a source of equal strength in an irrotational uniform stream of 30 m/s. Find the fineness ratio of the oval formed by the streamline $\psi = 0$ **07**
- (b) Derive algebraic form of fundamental lift equation using potential flow theory and show that lift is directly proportional to circulation **07**
- Q.4** (a) Derive Rankine Hugoniot Relations and prove that density down stream the shock is 6 times the upstream density. **07**
- (b) Prove that shock is irreversible in nature. **07**

OR

- Q.4** (a) Explain with the help of diagram shockwave interaction and reflection. **07**
- (b) Calorically perfect, ideal air with $P_1 = 100 \text{ kPa}$, $T_1 = 300 \text{ K}$, $u_1 = 500 \text{ m/s}$, turned through a 30° , expansion corner. Find: Fluid properties after the expansion **07**

- Q.5 (a)** Explain airspeed measurement in supersonic aircraft. Derive equation for airspeed in supersonic flow **07**
- (b)** What is Transonic Transition? Explain transition from Subsonic to Transonic to Supersonic Flow over a wedge as shown in Figure 3. **07**

OR

- Q.5 (a)** The pressure and Mach number at the upstream are 2 bar and 1.5 respectively. Find the rise in static pressure through shock and the total pressure loss across the shock for (a) Normal Shockwave and (b) when flow past a wedge having angle $\theta = 10^\circ$. Give your comments and conclusion on rise in static pressure and loss in total pressure by comparing both the case. **07**
- (b)** Air flowing over a wedge, $\theta = 20^\circ$, $P_1 = 100$ kPa, $T_1 = 300$ K, $M_1 = 3.0$. Find: Shock angle β and downstream pressure and temperature P_2, T_2 . Consider weak shock wave. **07**

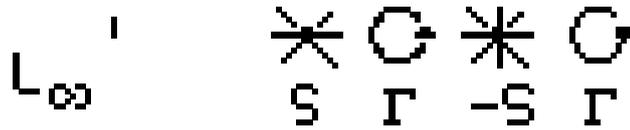


Figure 1. Four singularities

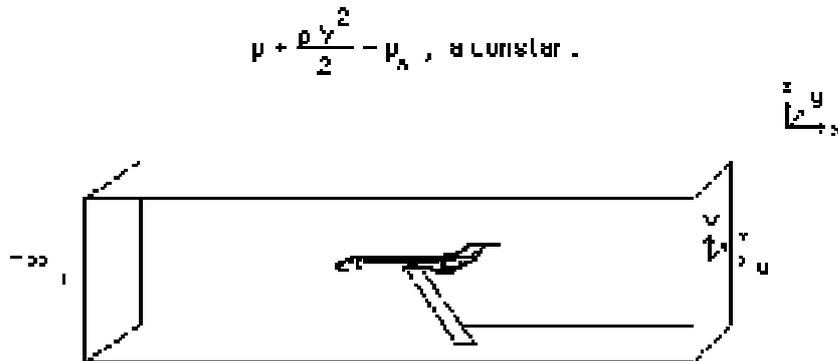


Figure 2. Test Section of Wind Tunnel



Figure 3. Wedge