Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI • EXAMINATION – SUMMER 2013

Subject Code: 160101 Date: 24-05-2013

Subject Name: Aerodynamics - II

Time: 10.30 am - 01.00 pm 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)** Attempt all. **07**

1) In NACA 4-digit airfoils, what are the meanings of these digits?
2) *'In a flow field streamlines can't intersect each other.'* True or False? Why?
3) What is the difference between Joukowski Transformation and modified Joukowski Transformation?
4) What is induced drag?
5) What is the valid range of linearized velocity potential equation?
6) What is the physical meaning of vortex sheet strength?
7) In finite wing theory, why wing is replaced by horse shoe vortex instead of piece of vortex filament along the span.

(b) Define mean camber line and chord line; represent it on neat sketch of airfoil. Explain basic aerodynamics characteristics of airfoil, center of pressure and aerodynamics center. **07**

Q.2 **(a)** Derive velocity potential equation for inviscid, compressible subsonic flow over a body immersed in a uniform flow. **07**

(b) Explain vortex panel numerical method for airfoil. **07**

OR

(b) Explain vortex lattice numerical method for finite wing. **07**

Q.3 **(a)** Derive equation of coefficient of lift and lift slop for symmetrical airfoil from fundamental equation of thin airfoil theory **07**

$$\frac{1}{2\pi}\int_0^c \frac{\gamma(\xi)d\xi}{x-\xi} = V_\infty\left(\alpha - \frac{dy}{dx}\right)$$

(b) Consider elliptical span wise lift distribution represented by **07**

$$\Gamma(y) = \Gamma_0\sqrt{1-\left(\frac{2y}{b}\right)^2}$$

Obtain downwash, induced angle of attack and induced drag coefficient by using equations of finite wing theory.

OR

Q.3 **(a)** Give statements of Kutta condition & Explain it. Also relate it with lift generation in inviscid flow. **07**

(b) Consider a flat plate placed in the uniform flow at zero angle of attack. Reynolds number at the trailing edge is 3.1×10^5. If critical Reynolds number of the flow is 2×10^5 then calculate the net skin friction drag co-efficient. **07**

Q.4 **(a)** What is supersonic area rule? Explain it with suitable example. **07**

(b) Using *Kutta Joukowski* function, derive equations to transform circle in to cambered airfoil. **07**

OR

Q.4 **(a)** What is critical mach number and drag divergence mach number? What are the characteristics of super critical airfoil? **07**

(b) Consider a finite wing with an aspect ratio of 6. Assume an elliptical lift distribution. The lift slope for the airfoil section is 0.12 degree^{-1}. Calculate and compare the lift slops for **07**

(1) A straight wing

(2) Swept back wing with a half chord line sweep of 30º

Q.5 **(a)** Derive equation for pressure coefficient in linearized form for supersonic flow. **07**

(b) Consider an aircraft in steady level flight at mach2 at 11km altitude. Weight of the aircraft is 9400kgf. Assume all lift of the aircraft comes from the lift on the wing of area 18.21m^2 and mean chord length 2.2m. Calculate angle of attack of the wing relative to free stream, airfoil wave drag coefficient and skin friction drag coefficient. (Consider fully turbulent flow on the wing and viscosity of air is1.4226×10^5 kg/ms, ρ_D=0.3648kg/m^3, and T_D=216.78K) **07**

OR

Q.5 **(a)** Derive *Prandtl-Glauert rule* for compressibility correction. **07**

(b) Consider a subsonic compressible flow in Cartesian coordinates where the velocity potential is given by **07**

$$\phi(x, y) = V_\infty x + \frac{70}{\sqrt{1-M_\infty^2}} e^{-2\pi\sqrt{1-M_\infty^2}\,y} \sin 2\pi x$$

If the free stream properties are given by V_∞ =700ft/s, p_∞ = 1 atm, and T_∞ =519R, calculate the following properties at location (0.2ft,0.2ft): M, p and T

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