Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: AERODYNAMICS [AAE 2201]

REVISED CREDIT SYSTEM
(17/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. Explain the followings: **(4)**
(a) Steady and unsteady flows
(b) Laminar and turbulent flows
(c) Source and sink flows
(d) Vortex sheet

1B. If for a two-dimensional potential flow, the velocity potential is given by $\phi = x\,(2y - 1)$. Determine the velocity at the point P (4,5), determine also the value of stream function Ψ at the point P. **(3)**

1C. Consider an aircraft that has a wing span of 15m, a wing area of 37.5m^2, and a gross weight of 88000N. In level flight the lift equals the weight. The aircraft is flying at 102.88 m/s at an altitude of 10 km. Also, the Oswald's efficiency factor is 0.9 and the zero lift drag coefficient is 0.022. Determine the following a) Lift coefficient b) induced drag coefficient c) Total drag coefficient d) Induced drag e) Zero lift drag f) Total drag g) Lift to drag ratio. **(3)**

2A. Sketch and explain the flow pattern of an ideal fluid flow past a circular cylinder with circulation. **(2)**

2B. Explain what doublet flow is and derive the equation for stream function and velocity potential of doublet flow. **(4)**

2C. A uniform flow with a 3 m/s is flowing over a plane source of strength 30m^2/s. The uniform flow and the source flow are in the same plane. A point P situated in the flow field. The distance of the point P from the source is 0.5m and it is at an angle of 30^o to the uniform flow. Determine the (a) stream function at point P (ii) resultant velocity of flow at P and (iii) location of stagnation point from the source. **(4)**

3A. Differentiate between the Source panel and Vortex panel methods. **(2)**

3B. Explain the functions and components of open and closed circuit wind tunnels, Mention their advantages and disadvantages as well. **(4)**

3C. Consider a low speed subsonic wind tunnel designed with a reservoir cross sectional area $A_1=2m^2$ and test section cross section area $A_2=0.5m^2$. The pressure in the test section is p_2= 1atm. Assume sea level constant density. **(4)**

(a) Calculate the pressure required in the reservoir p_1, necessary to achieve a flow velocity V_2=40m/s in the test section

(b) Calculate the mass flow through the wind tunnel.

4A. Equation for local vortex sheet strength on thin symmetric airfoil is **(4)**

$$\gamma(\theta) = 2\alpha V_\infty \frac{(1+\cos\theta)}{\sin\theta}$$

Derive an equation for circulation and deduce lift coefficient equation.

4B. Consider a NACA 23012 airfoil. The mean camber line for this airfoil is given by **(6)**

$$\frac{z}{c} = 2.6595\left[\left(\frac{x}{c}\right)^3 - 0.6075\left(\frac{x}{c}\right)^2 + 0.1147\left(\frac{x}{c}\right)\right] \qquad \text{for } 0 \le \frac{x}{c} \le 0.2025$$

$$\text{and} \qquad \frac{z}{c} = 0.02208\left(1-\frac{x}{c}\right) \qquad \text{for } 0.2025 \le \frac{x}{c} \le 1.0$$

Use thin airfoil theory to calculate (a) the angle of attack at zero lift (b) lift coefficient when $\alpha=4^o$ (c) the moment of coefficient about quarter chord point (d) the location of center of pressure in terms of x_{cp}/c, when $\alpha=4^o$

5A. Write down differences between aerodynamic center and center of pressure and their importance's in aerodynamics. **(2)**

5B. A wing is designed using elliptical circulation distribution **(4)**

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

Prove that the induced angle is directly proportional to the coefficient of lift and inversely proportional to the aspect ratio.

5C. Explain the followings: **(4)**

(a) Biot-Savart law

(b) Helmholtz's theorem

(c) Horse shoe vortex

(d) Circulation