Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL

A Constituent Institution of Manipal University

IV SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL/MAY 2017

SUBJECT: AERODYNAMICS [AAE 2201]

REVISED CREDIT SYSTEM
(19/04/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Explain the followings **(04)**
  a) Horseshoe vortex
  b) Aero dynamical twist
  c) Biot-Savart law
  d) Aerodynamic similarity parameters

1B. Derive the stream function and velocity potential equations for Doublet flow of the elementary flows. **(04)**

1C. Explain the difference between finite volume approach and finite element approach in aero dynamic problems. **(02)**

2A. Consider the lifting flow over a circular cylinder and the lift coefficient is 3.5. Calculate the location of the stagnation points and the points on the cylinder where pressure equals freestream static pressure. **(03)**

2B. Derive the fundamental equation for numerical vortex panel method with its boundary conditions as normal component of velocity at its control point is equal to zero. **(04)**

2C. What is the major difference in aerodynamic properties for an airfoil when it turn into a wing? To match the wing property with airfoil properties to close approximations, what are the choices & options we need to consider? **(03)**

3A. The NACA 4412 airfoil has a mean camber line given by **(05)**

$$\frac{z}{c} = 0.25\left[0.8\frac{x}{c} - \left(\frac{x}{c}\right)^2\right] \; for \; 0 \le \frac{x}{c} \le 0.4$$

$$\frac{z}{c} = 0.111\left[0.2 + 0.8\frac{x}{c} - \left(\frac{x}{c}\right)^2\right] \; for \; 0.4 \le \frac{x}{c} \le 1$$

Use thin airfoil theory, calculate

a) $\alpha_{L=0}$ b) c_l c) $c_{m,\,c/4}$ d) x_{cp}/c

Consider angle of attack is equal to 3 deg for suitable cases.

3B. Explain the steps & procedures for numerical non-linear lifting line methods. **(3)**

3C. Why do we prefer thicker airfoil in civil aviation? Write down the effect of $C_{L.max}$ on thicker and thinner airfoils. **(2)**

4A. Derive and prove that the elliptical lift distribution is ideal case for the wing design and also derive the equations for induced drag coefficient and induced angle of attack with the same elliptical lift distribution. **(4)**

4B. Consider the flow over a flat plate and estimate the followings from Figure-1 **(3)**

Case-1: Where $Re=4x10^6$, if then calculate,

a) The laminar boundary layer thickness at the trailing edge for a chord of 1.5m and the net laminar skin friction drag coefficient for the plate. (assume complete laminar flow over the plate)

b) The turbulent boundary layer thickness at the trailing edge for chord length of 1.5m and the net turbulent skin friction drag coefficient for the plate (assume complete turbulent flow over the plate)

Case-2: Consider the following figure and calculate the net skin friction drag coefficient by assuming that the critical Reynolds number is 500000.

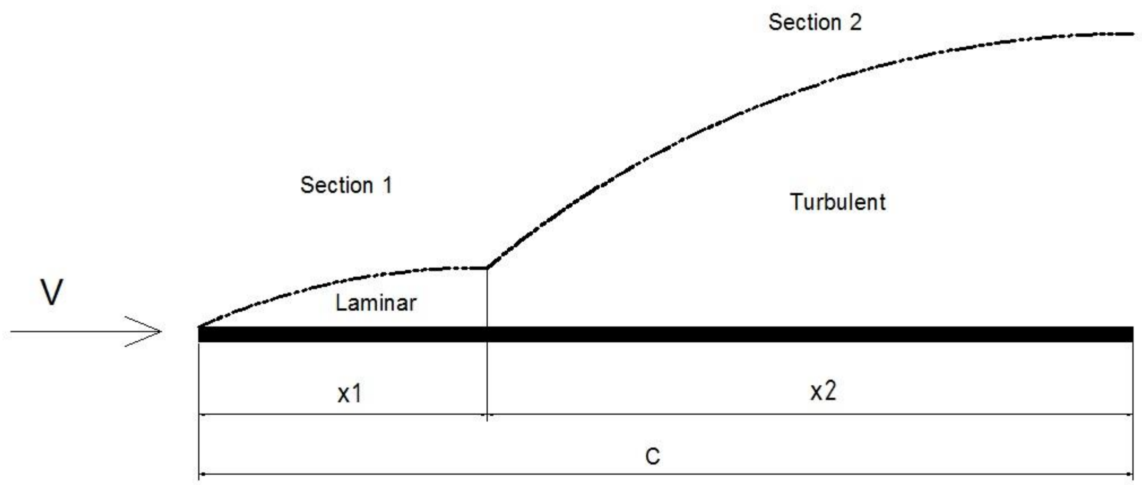

Figure - 1

4C. How many types of drag components we deal with an airplane when it flying at subsonic speed? Also explain these drag component differences too **(03)**

5A Consider a rectangular wing with aspect ratio of 5.5 and induced drag factor δ=0.06 and zero lift angle of attack of -1.8^0. At an angle of attack of 3^0, the induced drag coefficient for this wing is 0.015. Calculate the induced drag coefficients for a similar wing (a rectangular wing with the same airfoil section) at the same angle of attack, but with aspect ratios of 8, 10 and 12. Assume that $\delta=\tau$. Also for AR=8, 10 and 12, δ=0.108. At last compare the results. **(04)**

5B. Derive the fundamental equation of Prandtl's classical thin airfoil theory and also compare the major results of symmetric and cambered airfoil with the application of classical thin airfoil theory. **(04)**

5C. What are the differences between center of pressure and aerodynamic center in wing design? **(02)**