Registration No : | | | | | | | | | | |

Total Number of Pages : 03 **B.Tech.**
PAE4I101

4th Semester Regular Examination 2017-18
AERODYNAMICS – I
BRANCH : AERO
Time : 3 Hours
Max Marks : 100
Q.CODE : C658
Answer Part-A which is compulsory and any four from Part-B.
The figures in the right hand margin indicate marks.
Answer all parts of a question at a place.

Part – A (Answer all the questions)

Q1 **Answer the following questions: *multiple type or dash fill up type:*** **(2 x 10)**

a) At higher altitudes as altitude increases, pressure _______________
a. decreases at constant rate.
b. decreases exponentially.
c. increases exponentially.

b) Bernoulli's equation cannot be applied when the flow is
a. rotational
b. turbulent
c. unsteady
d. all of the above

c) Streamline and equipotential lines in a flow field
a. are parallel to each other
b. are identical to each other
c. are perpendicular to each other
d. intersect at acute angles

d) When a velocity distribution is uniform over the cross-section, the correction factor for momentum is:
a. 0
b. 1
c. 4/3
d. 2

e) The Reynolds number, R_e is defined as $\frac{U_\infty L}{v}$ where L is the length scale for a flow, $U\infty$ is its reference velocity and v is the coefficient of kinematic viscosity. In the laminar boundary layer approximation, comparison of the dimensions of the convection term $u\frac{\partial u}{\partial x}$ and the viscous term $v\frac{\partial^2 u}{\partial x}$ leads to the following relation between the boundary layer thickness δ and R_e
a. $\delta \propto \sqrt{R_e}$
b. $\delta \propto \frac{1}{\sqrt{R_e}}$
c. $\delta \propto R_e$
d. $\delta \propto \frac{1}{R_e}$

f) In a forced vortex motion, the velocity of flow is
   a. Directly proportional to its radial distance from axis of rotation
   b. Inversely proportional to its radial distance from the axis of rotation
   c. Inversely proportional to the square of its radial distance from the axis of rotation
   d. Directly proportional to the square of its radial distance from the axis of rotation

g) If stream function (Ψ) satisfies the Laplace equation, it is a possible case of _____________
   a. circular flow
   b. a rotational flow
   c. an irrotational flow
   d. none of the above

h) The Joukowskii airfoil is studied in aerodynamics because
   a. It is used in many aircraft
   b. It is easily transformed into a circle, mathematically
   c. It has a simple geometry
   d. It has the highest lift curve slope among all airfoils

i) In a 2-D, steady, fully developed, laminar boundary layer over a flat plate, if x is the stream-wise coordinate, y is the wall normal coordinate and u is the stream-wise velocity component, which of the following is true.
   a. $\frac{\partial u}{\partial x} >> \frac{\partial u}{\partial y}$
   b. $\frac{\partial u}{\partial y} >> \frac{\partial u}{\partial x}$
   c. $\frac{\partial u}{\partial x} = \frac{\partial u}{\partial y}$
   d. $\frac{\partial u}{\partial x} = -\frac{\partial u}{\partial y}$

j) Boundary layer thickness is the distance from the boundary to the point where velocity of the fluid is :
   a. equal to 10% of free stream velocity
   b. equal to 50% of free stream velocity
   c. equal to 90% of free stream velocity
   d. equal to 99% of free stream velocity

Q2 **Answer the following questions:** ***Short answer type:*** **(2 x 10)**

a) State the continuity equation for compressible flow.
b) Write the assumptions and application of Kutta-Jonkowski's theorem.
c) Write energy equation for a steady incompressible flow and name the terms involved in the equation.
d) What are the limitations of lifting line theory?
e) Discuss about complex potential.
f) What is the application of Joukowshi's transformation to flow problems with respect to airfoil?
g) State Biot-Savarts law and its application.
h) How is horse shoe vortex formed? Explain.
i) Schematically explain the boundary layer.
j) Give an explanation on conformal transformation.

Part – B (Answer any four questions)

Q3 **a)** Derive the general x-momentum equation for an unsteady 3-D inviscid flow in partial differential form using a control volume approach. **(10)**

b) Explain about stream function and velocity potential function. **(5)**

Q4 **a)** Explain source, sink, free and forced vortex with neat sketches. **(10)**

b) Explain Blasius theorem for a steady 2-D irrotational flow **(5)**

Q5 **a)** The NACA 4412 airfoil has a mean chamber line given by **(10)**

$$\frac{y}{c} = 0.25\left[0.8\frac{x}{c} - \left(\frac{x}{c}\right)^2\right]$$ for 0≤ x/c ≤ 0.4 and

$$\frac{y}{c} = 0.111\left[0.2 + 0.8\frac{x}{c} - \left(\frac{x}{c}\right)^2\right]$$ for 0.4 ≤ x/c ≤ 1.0

Where c is chord of the airfoil, x and y are the axis parallel and perpendicular to the chord respectively.Based on thin airfoil theory calculate (a)αL at zero lift andmoment coefficient at quarter chord point.

b) Explain 'ideal' and 'perfect' fluid. **(5)**

Q6 **a)** Prove that for an elliptical wing loading the induced drag is minimum. **(10)**

b) Explain the terms 'Bound vortex', 'Starting vortex' and 'Horse shoe vortex'. **(5)**

Q7 **a)** What do you mean by vortex sheet? Find out a theoretical solution for low speed flow over an airfoil using vortex sheet method. **(10)**

b) Why is it so important to make a distinction between rotational and irrotationalflows? **(5)**

Q8 **a)** Explain the effect of low Reynold Number to high Reynold number on boundary layer structure with suitable illustrations. **(10)**

b) What do you mean by infinite boundary conditions? **(5)**

Q9 **a)** Any irrotational, incompressible flow has a velocity potential and stream function on2-D that both satisfy Laplace's equation, justify. **(10)**

b) Show that the combination of doublet flow and the uniform flow is equivalent to a non-lifting flow over a cylinder. **(5)**