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B.E. DEGREE EXAMINATIONS: APRIL / MAY 2010

Fourth Semester

AERONAUTICAL ENGINEERING

U07AR401: Aerodynamics I

Time: Three Hours **Maximum Marks: 100**

Answer ALL the Questions:-

PART A (10 x 1 = 10 Marks)

1. Continuity equation $\frac{\partial}{\partial s}(\rho AV)+\frac{\partial}{\partial t}(\rho A)=0$ is for

   a) Compressible steady flow b) Incompressible unsteady flow

   c) Compressible unsteady flow d) Incompressible steady flow.

2. A fluid flow is considered incompressible when

   a) Mach number of the flow is moderate below one.

   b) Mach number of the flow is large above one

   c) Mach number of the flow is less than 0.3

   d) Mach number of the flow is equal to one.

3. Choose correct set of result

   a) $v_r = \frac{1}{r}\frac{\partial \phi}{\partial \theta}; v_\theta = \frac{\partial \phi}{\partial r}$

   b) $v_r = \frac{\partial \phi}{\partial \theta}; v_\theta = \frac{1}{r}\frac{\partial \phi}{\partial r}$

   c) $v_r = \frac{\partial \phi}{\partial r}; v_\theta = \frac{1}{r}\frac{\partial \phi}{\partial \theta}$

   d) $v_r = \frac{1}{r}\frac{\partial \phi}{\partial r}; v_\theta = \frac{\partial \phi}{\partial \theta}$

4. For same velocity at free stream and at point on an aerofoil the pressure coefficient is

   a) 0 b) ∞ c) 1 d) -1

5. Maximum thickess chord ratio of NACA 23012 aerofoil is

   a) 0.01 b) 0.12 c) 0.23 d) 0.30

6. According to Kutta condition the circulation at the trailing edge of the aerofoil should be

   a) 0 b) 1 c) -1 d) ∞

7. Joukowski aerofoils are modified
   a) because it cannot be used in air craft
   b) to make its geometry simple
   c) as it has some draw back at the trailing edge
   d) because the lift curve slope is very low
8. Down wash component along the span of an untwisted wing of an elliptical plan form has
   a) sinusoidal variation b) parabolic variation
   c) elliptical variation d) no variation
9. For two dimensional boundary layer over a flat plate
   a) $\frac{\partial u}{\partial x} > \frac{\partial v}{\partial y}$ b) $\frac{\partial u}{\partial x} < \frac{\partial v}{\partial y}$ c) $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ d) $\frac{\partial u}{\partial x} = -\frac{\partial v}{\partial y}$
10. The nominal boundary thickness for a laminar boundary layer varies as
   a) distance from the leading edge
   b) square of the distance from the leading edge
   c) square root of the distance from the leading edge
   d) inverse of the distance from the leading edge

PART B (10 x 2 = 20 Marks)

11. State the condition for irrotation in 2D flow.
12. Why Bernoulli's equation is not applicable to flow within boundary layer ?
13. If flow exists $\phi = kx^2 y - y^3$ evaluate k.
14. Show that circulation for a free vortex is constant.
15. Sketch zero lift lines of symmetric and cambered aerofoils.
16. What is meant by bound vortex and horseshoe vertex with reference to an aeroplane.
17. State Prandtl's lifting line theory with its limitations.
18. What are the advantages of Karman-Trefftz profiles over Joukowski profile?
19. Give physical interpretation of displacement thickness of boundary layer.
20. Why the variation of pressure across boundary layer is neglected and variation along the boundary layer is considered?

PART C (5 x 14 = 70 Marks)

21. (a) (i) Derive equation of motion of the particle moving along a stream line.

(ii) Show how this can be used to derive Bernoulli's equation along a stream line.

(OR)

(b) (i) Derive equation of continuity in terms of 2D potential functions.

(ii) In a flow field radial component of velocity is $-\mu \cos\theta / r^2$ determine tangential component of velocity and resultant velocity.

22. (a) (i) Show that the combination of doublet with an uniform flow will represent a flow past a circular cylinder. How much is the radial component of velocity on the surface of the cylinder?

(ii) Plot the variation of the pressure coefficient on the surface of the above cylinder and explain why there is no aerodynamic force?

(OR)

(b) For a lifting flow over a circular cylinder the lift coefficient is 5

(i) Calculate the negative peak pressure coefficient.

(ii) Calculate the location of the stagnation point/s on the cylinder where the pressure is equal to free stream pressure.

23. (a) Obtain an expression for the thickness ratio of a symmetrical aerofoil section transformed from a circle by adopting Joukowski conformal transformation.

(OR)

(b) (i) How circulation is limited in real fluid flows past an aerofoil.

(ii) State Blasius theorem and its importance in aerodynamics.

24. (a) Consider an aerofoil with mean camber line

$$Z = 4\left[\frac{x}{c} - \left(\frac{x}{c}\right)^2\right]$$

Find

1. Zero lift angle 2. Ideal angle of attack

(OR)

(b) (i) An aeroplane wing with an elliptical plan form and lift distribution, is having an aspect ratio of 6 and span of 12m. For a wing loading 900N/m^2 and for a speed of 150 kmph at sea level compute the induced drag.

(ii) State Biot Savart's law.

25. (a) (i) Find out displacement and momentum thickness of boundary layer for a velocity distribution $\frac{u}{U} = \left(\frac{y}{\delta}\right)^{1/7}$ in the boundary layer.

(ii) Sketch and explain the variation of velocity across the laminar and turbulent boundary layers

(OR)

(b) (i) Using momentum integral equation for zero pressure gradient evaluate an expression for nominal thickness in terms of Reynolds number along a flat plate for the velocity distribution within boundary layer $\frac{u}{U} = \left(\frac{y}{\delta}\right)$

(ii) Sketch and explain the structure and growth of boundary layer along a flat plate at zero incidence.

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