Hall Ticket No | | | | | | | | | | | Question Paper Code: AAEB10

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER

B. Tech IV Semester End Examinations (Regular), May – 2020

Regulations: IARE - R18

AERODYNAMICS

(AERONAUTICAL ENGINEERING)

Time: 3 hours **Max. Marks: 70**

Answer ONE Question from each Unit

All Questions Carry Equal Marks

All parts of the question must be answered in one place only

UNIT – I

1. a) Explain in detail how combination of a uniform flow and doublet flow produces non-lifting flow over a cylinder. **[7M]**

   b) Determine the flow field governed by the stream function (units: m^2/s) defined by the expression: $\Psi = 6x + 12y$ **[7M]**

2. a) Explain in detail how combination of uniform flow, doublet flow and vortex flow produces lifting flow over a cylinder. **[7M]**

   b) Consider a circular cylinder in a hypersonic flow, with its axis perpendicular to the flow. **[7M]**

   Let ϕ be the angle measured between radii drawn to the leading edge (the stagnation point) and to any arbitrary point on the cylinder. The pressure coefficient distribution along the cylindrical surface is given by $C_p = 2\cos^2\phi$ for $0 \le \phi \le \pi/2$ and $3\pi/2 \le \phi \le 2\pi$, and $C_p = 0$ for $\pi/2 \le \phi \le 3\pi/2$. Calculate the drag coefficient for the cylinder, based on projected frontal area of the cylinder.

UNIT – II

3. a) Describe the stalling of an airfoil and the related aerodynamic phenomena that result in the process of stall. **[7M]**

   b) For a particular airfoil section, the pitching moment coefficient about an axis located at one-third of the chord behind the leading edge, varies with the lift coefficient in the following manner: **[7M]**

C_l	0.2	0.4	0.6	0.8
C_m	-0.02	0.00	+0.02	+0.04

   Calculate the location of aerodynamic center, and the value of the pitching moment coefficient at zero left, C_{m0}.

4. a) Analyze the steady-state flow velocities at the trailing edge (T.E.) of an airfoil when (i) having a finite angle at the T.E. and (ii) having a cusped T.E. Also, evaluate the vorticity at the T.E. in the above cases. **[7M]**

   b) Consider a thin, symmetric airfoil at 1.5° angle of attack. From the results of thin airfoil theory, calculate the lift coefficient C_l, and the moment coefficient about the leading edge, $C_{m,LE}$. **[7M]**

UNIT – III

5. a) Explain the process of vortex formation on wings including starting, bound and trailing vortices of wings. **[7M]**

   b) The Piper Cherokee (a light, single-engine general aviation aircraft) has a wing area of 170 ft^2 and a wing span of 32 ft. Its maximum gross weight is 2450 lb. The wing uses an NACA 65-415 airfoil, which has a lift slope of 0.1033 $degree^{-1}$ and $\alpha_{L=0}$ = -3°. Assume τ = 0.12. If the airplane is cruising at 120 mi/h at standard sea level at its maximum gross weight and is in straight-and-level flight, calculate the geometric angle of attack of the wing. **[7M]**

6. a) Explain Helmholtz's vortex theorems using the concept of an infinite vortex filament along with diagrams. **[7M]**

   b) The measured lift slope for the NACA 23012 airfoil is 0.108 $degree^{-1}$, and α_{L0}= -1.3°. Consider a finite wing using this airfoil, with AR = 8 and taper ratio = 0.8. Assume that $\delta = \tau$. Calculate the lift and induced drag coefficients for this wing at a geometric angle of attack = 7°. **[7M]**

UNIT – IV

7. a) Explain the meaning of wing-fuselage interference. Give a brief mention of the effect of propeller slipstream on the wing. **[7M]**

   b) An aircraft weighing 40,000 lbs, has a wing area of 350 ft^2 and a wing span of 50 ft. At sea-level, the aircraft flies at (i) 200ft/sec (ii) 600ft/sec. For the entire aircraft, determine the estimated values of the induced drag and the associated drag coefficients for the two cases? Note that lift = weight in level flight. Also, assume Oswald efficiency factor of 0.85. **[7M]**

8. a) Explain non-lifting and lifting bodies and give examples while giving the classification for the fuselage. **[7M]**

   b) For a symmetric flow over the wing-fuselage system, draw the upwash and downwash distributions when considering the effect of (i) the fuselage on the wing (ii) the wing on the fuselage **[7M]**

UNIT – V

9. a) Describe temperature boundary layer. Give an example of a high-lift device which uses boundary layer control. **[7M]**

   b) The streamwise velocity component for a laminar boundary layer is sometimes assumed to be roughly approximated by the linear relation **[7M]**

   where $\delta = 1.25 \times 10^{-2}$ $\bar{}$. Assume that we are trying to approximate the flow of air at standard sea-level conditions past a flat plate where u_e = 2.337m/s. Calculate the streamwise distribution of the displacement thickness (δ^*), the velocity at the edge of the boundary layer (v_e), and the skin-friction coefficient (C_f).

10 a) Describe the process of transition in the development of a boundary layer and its effects on flow over airfoil. **[7M]**

   b) Air at standard day sea-level atmospheric pressure and 5°C flows at 200 km/h across a flat plate. Compare the velocity distribution for a laminar boundary layer and for a turbulent boundary layer at the transition point, assuming that the transition process is completed instantaneously at that location. Assume that the transition Reynolds number for this incompressible flow past a flat plate is 500,000. **[7M]**

COURSE OBJECTIVES :

The course should enable the students to:

I.	Understand basic philosophy and ideas of flow at different conditions and mediums.
II.	Understand the physics behind the governing equations to solve the flow field problems and flow models.
III.	Identify theory behind the forces and moments for which conditions the theories are appropriate.
IV.	Discuss the application of aerodynamics in various engineering disciplines and their effects.
V.	Understand the concept of boundary layer flows to increase the performance of the body.
VI.	Discuss the propeller aerodynamics and the effects of propeller on different wing configurations.
VII.	Understand the various types of wings and their performance at various conditions of aircraft.

COURSE LEARNING OUTCOMES (CLOs):

Students, who complete the course, will be able to demonstrate the ability to do the following:

CAAE004.01	Apply knowledge and understand the essential facts, concepts and principles of aerodynamics.
CAAE004.02	Adapt the basic knowledge of mathematics, science and engineering for problem solving.
CAAE004.03	Describe principles of physics and aerodynamics to study the wing-body interference junction.
CAAE004.04	Explain the concept of boundary layer flows to increase the performance of the body.
CAAE004.05	Understand the concept of source, sink, doublet and vortex.
CAAE004.06	Demonstrate importance of aerodynamics to develop effective aircraft design and operations.
CAAE004.07	Apply the concept of lifting line theory to study potential flows over different aerofoils.
CAAE004.08	Identify the elliptic load distribution for obtaining high lift performance on finite wings.
CAAE004.09	Evaluate the source and vortex panel method for non-lifting and lifting aerofoils.
CAAE004.10	Illustrate the propeller aerodynamics and the effects of propeller on the wing.
CAAE004.11	Understand the concept of Prandtl's lifting line theory and eliptical lift distribution.
CAAE004.12	Understand the lift augmentation techniques for high-lift devices and slats.
CAAE004.13	Understand aerodynamic effect of taper and twist applied to wings.
CAAE004.14	Apply temperature effects on boundary layer, transition and turbulent flow regimes.
CAAE004.15	Understand the aerodynamic effect of vortex formation around wings.
CAAE004.16	Evaluate flow past non lifting bodies and method of singularities
CAAE004.17	Understand the effect of sweep in the context of delta wings.
CAAE004.18	Understand the relation between circulation and lift.
CAAE004.19	Understand the various sources of drag including induced drag and skin friction drag.
CAAE004.20	Evaluate displacement thickness, momentum thickness, energy thickness.

MAPPING OF SEMESTER END EXAMINATION - COURSE LEARNING OUTCOMES

1	a	CAAE004.01	Apply knowledge and understand the essential facts, concepts and principles of aerodynamics.	CO 1	Understand
	b	CAAE004.02	Adapt the basic knowledge of mathematics, science and engineering for problem solving.	CO 1	Remember
2	a	CAAE004.01	Apply knowledge and understand the essential facts, concepts and principles of aerodynamics.	CO 1	Remember
	b	CAAE004.02	Adapt the basic knowledge of mathematics, science and engineering for problem solving.	CO 1	Understand
3	a	CAAE004.10	Illustrate the propeller aerodynamics and the effects of propeller on the wing.	CO 2	Remember
	b	CAAE004.12	Understand the lift augmentation techniques for high-lift devices and slats.	CO 2	Remember
4	a	CAAE004.07	Apply the concept of lifting line theory to study potential flows over different aerofoils.	CO 2	Understand
	b	CAAE004.07	Apply the concept of lifting line theory to study potential flows over different aerofoils.	CO 2	Remember
5	a	CAAE004.13	Understand the aerodynamic effect of vortex formation around wings.	CO 3	Understand
	b	CAAE004.06	Explain the concept of aerodynamics to develop effective aircraft design and operations.	CO 3	Remember
6	a	CAAE004.07	Apply the concept of lifting line theory to study potential flows over different aerofoils.	CO 3	Understand
	b	CAAE004.19	Understand the various sources of drag including induced drag and skin friction drag.	CO 3	Remember
7	a	CAAE004.10	Illustrate the propeller aerodynamics and the effects of propeller on the wing.	CO 4	Understand
	b	CAAE004.06	Explain the concept of aerodynamics to develop effective aircraft design and operations.	CO 4	Remember
8	a	CAAE004.09	Evaluate the source and vortex panel method for non-lifting and lifting aerofoils.	CO 4	Remember
	b	CAAE004.03	Describe principles of physics and aerodynamics to study the Wing- body interference junction.	CO 4	Understand
9	a	CAAE004.04	Explain the concept of boundary layer flows to increase the performance of the body.	CO 5	Remember
	b	CAAE004.12	Understand the lift augmentation techniques for high-lift devices and slats.	CO 5	Understand
10	a	CAAE004.14	Apply temperature effects on boundary layer, transition and turbulent flow regimes.	CO 5	Remember
	b	CAAE004.13	Understand aerodynamic effect of taper and twist applied to wings.	CO 5	Understand

Signature of Course Coordinator **HOD, AE**