Register Number:……………..

B.E/B.TECH DEGREE EXAMINATIONS: NOV /DEC 2024

(Regulation 2018)

Fourth Semester

AERONAUTICAL ENGINEERING

U18AEI4201**:** Low Speed Aerodynamics

<u>COURSE OUTCOMES</u>

CO1: Apply conservation laws to solve incompressible flow regime.
CO2: Solve the problems on potential flows.
CO3: Apply Joukowski transformation to fluid flow problems.
CO4: Explain airfoil and wing characteristics.
CO5: Apply propeller theory to predict blade performance.
CO6: Measure the aerodynamic forces on various aerodynamic bodies.

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

Answer all the Questions:-
PART A (10 x 1 = 10 Marks)

1. Figures (a) - (d) below show four objects. Dimensions and surface conditions of the objects are shown in the respective figures. All four objects are placed independently in a steady, uniform flow of same velocity and the direction of flow is from left to right as shown in (a). The flow field can be considered as 2-D, viscous and incompressible. Following statements are made regarding the drag that these objects experience. CO6 [K_4]

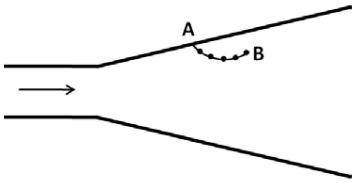
(i) Drag of object (a) is more than the drag of object (d)
(ii) Drag of object (a) is less than the drag of object (d)
(iii) Drag of object (b) is more than the drag of object (c)
(iv) Drag of object (c) is more than the drag of object (b)
(v) Drag of object (a) is more than the drag of object (b)

Choose the correct combination of statements from the options given above

a) (i), (iii), (v) b) (ii), (iv), (v)

c) (i), (iv), (v) d) (i), (iii)

2. To observe unsteady separated flow in a diverging channel, bubbles are injected at each 10*ms* interval at point A as shown in figure. These bubbles act as tracer particles and follow the flow faithfully. The curved line AB shown at any instant represents: CO1 [K_3]



a) Streamline, streakline and pathline b) Streamline and pathline

c) Only a pathline d) Only a streakline

3. In a low-speed wind tunnel, the angular location(s) from the front stagnation point on a circular cylinder where the static pressure equals the free-stream static pressure, is CO2 [K_5]

a) $\pm 38^0$ b) $\pm 30^0$

c) $\pm 60^0$ d) 0^0

4. Due to a body in potential flow, the velocity at a point A in the flow field is 20 m/s while the free stream velocity is only 10 m/s. The value of coefficient of pressure (Cp) at the point A is CO2 [K_5]

a) -3 b) -2

c) -1 d) -4

5. For a NACA2415 airfoil of chord length 'c', which of the following is true? CO4 [K_3]

a) Maximum camber is located at 0.2c from the leading edge b) Maximum thickness is located at 0.15c from the leading edge

c) Maximum camber is 0.02c d) Maximum thickness is 0.05c

6. A NACA 0012 airfoil has a trailing edge flap. The airfoil is operating at an angle of attack of 5 degrees with un-deflected flap. If the flap is now deflected by 5 degrees downwards, the C_L versus α curve CO4 [K_4]

a) shifts right and slope increases. b) shifts left and slope increases.

c) shifts left and slope stays the same. d) shifts right and slope stays the same.

7. The pitching moment of a positively cambered NACA airfoil about its leading edge at zerolift angle of attack is CO4 [K_2]

a) negative. b) positive.

c) indeterminate. d) zero.

8. For a thin flat plate at 2 degrees angle of attack, the pitching moment coefficient about the trailing edge is CO6 [K_4]

a) 0.216 b) 0.124

c) 0.324 d) 0.165

9. Choose the correct answer: CO3 [K_2]

Assertion (A): The Karman-Trefftz profiles are solutions to the potential flow equations for fluid flow around a circular cylinder.

Reason (R): The Karman-Trefftz transformation maps a circular cylinder in the physical plane to a straight line segment in the transformed plane, allowing for the application of conformal mapping techniques to solve fluid flow problems.

a) Both A and R are Individually true and R is the correct explanation of A
b) Both A and R are Individually true but R is not the correct explanation of A
c) A is true but R is false
d) A is false but R is true

10. Choose the correct answer: CO5 [K_2]

Assertion (A): The Froude momentum theory is suitable for estimating the performance of fixed pitch propellers, while the Blade Element Theory is better suited for variable pitch propellers.

Reason (R): The Froude momentum theory assumes uniform inflow velocity across the propeller disk. On the other hand, the Blade Element Theory considers the varying pitch angles of the blades.

a) Both A and R are Individually true and R is the correct explanation of A
b) Both A and R are Individually true but R is not the correct explanation of A
c) A is true but R is false
d) A is false but R is true

PART B (10 x 2 = 20 Marks)
(Answer not more than 40 words)

11.	Represent the aerodynamic forces and moments acting on an airplane.	CO6	[K_1]
12.	Indicate various types of drag.	CO6	[K_2]
13.	An aircraft is equipped with a Pitot tube to measure airspeed. The Pitot tube is installed in a location where it experiences a total pressure of 101.3 kPa and a static pressure of 97.5 kPa. The air temperature outside the aircraft is 15°C. Determine the airspeed of the aircraft in meters per second.	CO1	[K_3]
14.	Outline the applications of the Joukowski transformation in fluid flow problems.	CO3	[K_2]
15.	Indicate conditions for a function to satisfy the Cauchy-Riemann equations.	CO3	[K_1]
16.	Represent a typical cambered airfoil nomenclature.	CO4	[K_1]
17.	State Kutta condition.	CO1	[K_1]
18.	How does the Magnus effect influence the trajectory of a spinning object?	CO1	[K_2]
19.	Predict the factors which influence the coefficient of thrust in propeller performance.	CO5	[K_2]
20.	Outline the key differences between fixed pitch and variable pitch propellers in terms of performance and efficiency.	CO5	[K_2]

Answer any FIVE Questions:-
PART C (5 x 14 = 70 Marks)
(Answer not more than 350 words)

21.	a)	Derive the continuity equation by applying the fundamental principle.	6	CO1	[K_3]
	b)	Derive the general momentum equation for a steady 1D inviscid flow.	8	CO1	[K_3]
22.	a)	Obtain the relationship between the stream function and velocity potential function.	6	CO2	[K_3]
	b)	Explain about the 'second elementary flow - source flow' with a neat sketch.	8	CO2	[K_2]
23.	a)	Illustrate the nonlifting flow over a circular cylinder.	7	CO2	[K_2]
	b)	Consider the lifting flow over a circular cylinder. The lift coefficient is 5. Calculate the peak (negative) pressure coefficient.	7	CO2	[K_3]
24.	a)	Summarize about the Kutta-Joukowski theorem and the generation of lift.	7	CO4	[K_2]
	b)	Consider a thin flat plate at 5 deg. angle of attack. Calculate the: (i) lift coefficient, (ii) moment coefficient about the leading edge, (iii) moment coefficient about the quarterchord point, and (iv) moment coefficient about the trailing edge.	7	CO4	[K_4]
25.	a)	Interpret about the aerodynamic center.	7	CO6	[K_2]
	b)	Illustrate downwash and induced drag.	7	CO6	[K_2]
26.	a)	Explain about Prandtl's classical lifting-line theory.	8	CO4	[K_2]
	b)	Interpret the fundamental relationship between Froude momentum and Blade Element Theories in the context of fluid dynamics, and how do these theories contribute to our understanding of the performance and design of propellers, turbines, and other rotary devices in various engineering applications?	6	CO5	[K_2]

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