J.J COLLEGE OF ENGINEERING AND TECHNOLOGY

Approved by AICTE | Affiliated to Anna University | ISO 9001 : 2015 Certified
Accredited by NAAC with A Grade

SOWDAMBIKAA GROUP OF INSTITUTIONS

ESTD. 1994

DEPARTMENT OF AERONAUTICAL ENGINEERING

AE3401–AERODYNAMICS-I

QUESTION BANK

R-2021

INSTITUTE VISION & MISSION

VISION:

To become a globally recognized "Centre of Academic Excellence" providing Quality Education to all students.

MISSION:

To provide Quality Education in the fields of Engineering, Management, Information, Technology and other Engineering areas.

DEPARTMENT VISION & MISSION

VISION:

To prepare technically skilled and competent intellectual professional graduates to meet the challenges in the Aerospace industry.

MISSION:

M1: To produce technologically competent graduates to be front-runner in their profession.

M2: To provide state-of-the-art facilities and laboratories so as to enhance excellence in teaching and learning process.

M3: To provide need-based quality training programmes in the field of the Aerospace industry.

M4: Enhance the students' sound knowledge in the latest technologies by organizing technical programs and encouraging students to make them present papers and participate in technical events.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1	To employ comprehensive knowledge in Aeronautical Engineering and analytical skills to work towards solving complex problems to excel in the professional career.
PEO2	To design, analyze and produce cutting edge engineering solutions by employing modern techniques and adhering to moral values for sustainable development.
PEO3	To assume global careers and leadership responsibilities through consistent learning with idealistic managerial practices.

PROGRAM OUTCOMES (POs)

PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineeringfundamentalsandanengineeringspecializationtothesolutionof complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions Using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including the design of experiments, Analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply to reason in formed by the contextual Knowledge to assess societal, health, safety, legal and cultural issues and the Consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and Responsibilities and norms of the engineering practice.

PO9	**Individual and team work:** Function effectively as an individual, and as a Member or leader in Diverse teams, and in multidisciplinary settings.
PO10	**Communication:**Communicateeffectivelyoncomplexengineeringactivities with the engineering community and with society at large, such as, being able To comprehend And write effective reports and design documentation, make effective presentations, and give and Receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply These to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to Engage in in dependent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	To gather data using modern tools and apply design techniques to develop solutions for challenges in the domain of Aerodynamics, Propulsion, Aircraft Structures and Aircraft Maintenance with professional ethics.
PSO2	To function as engineering solution providers or entrepreneurs, who are able to manage, innovate, communicate, train and lead a team for continuous improvement.
PSO3	Graduate will be able to work as a team member which will be a main requirement in industry or research organisation or in any business enterprise. This will pave the way for successful career for the graduate and also play a role for the success of the organisation in which the graduate is employed.

AE3401 **AERODYNAMICS – I** L T P C
3 1 0 4

COURSE OBJECTIVES:

This course will familiarize the students with the concepts of mass, momentum and energy conservation relating to aerodynamics, and the student understand the concept of vorticity, irrotationality, theory of airfoil and wing sections, the different boundary layers and Blasius Solution.

UNIT I INTRODUCTION TO LOW-SPEED FLOW 9

Euler equation, incompressible Bernoulli's equation. circulation and vorticity, green's lemma and Stoke's theorem, barotropic flow, kelvin's theorem, streamline, stream function, irrotational flow, potential function, Equipotential lines, elementary flows and their combinations.

UNIT II TWO-DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW 9

Ram effect, Internal flow and Stall in subsonic inlets – relation between minimum area ratio and eternal deceleration ratio – diffuser performance – modes of operation - supersonic inlets – starting problem on supersonic inlets – shock swallowing by area variation – real flow through nozzles and nozzle efficiency – losses in nozzles – ejector and variable area nozzles - interaction of nozzle flow with adjacent surfaces – thrust reversal.

UNIT III AIRFOIL THEORY 9

Cauchy-Riemann relations, complex potential, methodology of conformal transformation, Kutta Joukowski transformation and its applications, thin airfoil theory and its applications.

UNIT IV SUBSONIC WING THEORY 9

Vortex filament, Biot and Savart law, bound vortex and trailing vortex, horse shoe vortex, lifting line theory and its limitations.

UNIT V INTRODUCTION TO BOUNDARY LAYER THEORY 9

Boundary layer and boundary layer thickness, displacement thickness, momentum thickness, energy thickness, shape parameter, boundary layer equations for a steady, two-dimensional incompressible flow, boundary layer growth over a flat plate, critical Reynolds number, Blasius solution, basics of turbulent flow.

TOTAL:45 PERIODS

COURSE OUTCOMES (COs)

On completion of the course, the student is expected to be able to:	
CO1	Apply the basics physics for low-speed flows.
CO2	Apply the concept of 2D, inviscid incompressible flows in low-speed aerodynamics.
CO3	Solve lift generation problems using aero foil theories.
CO4	Make use of lifting line theory for solving flow properties.
CO5	Solve the boundary layer equations for a steady, two-dimensional incompressible flow
CO6	Solve the properties of turbulent flow.

CO's – PO's & PSO's MAPPING

Correlation of COs with POs / PSOs															
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	1	-	-	-	-	1	1	1	3	2	-
CO2	3	2	1	1	2	-	-	-	-	1	1	1	3	2	-
CO3	3	3	2	-	2	-	-	-	-	1	1	2	3	1	-
CO4	3	2	1	1	2	-	-	-	-	1	1	1	3	1	-
CO5	3	2	1	1	2	-	-	-	-	1	1	1	3	2	-
CO6	3	3	2	-	3	1	1	2	-	1	1	2	1	3	2
AVG	**3**	**2.3**	**1.3**	**1**	**2**	**1**	**1**	**2**	**-**	**1**	**1**	**1.5**	**2.6**	**1.8**	**2**
3 – High; 2 – Medium; 1 – Low; - – No correlation															

TEXT BOOKS:

1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co., 2010
2. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 1989.
3. E Rathakrishnan, “Theoretical Aerodynamics”, John Wiley, NJ, 2013

REFERENCE BOOKS:

1. Clancey, L J.," Aerodynamics", Pitman, 1986
2. John J Bertin., "Aerodynamics for Engineers", Pearson Education Inc, 2002
3. Kuethe, A.M and Chow, C.Y, “Foundations of Aerodynamics”, Fifth Edition, John Wiley & Sons, 2000.
4. Milne Thomson, L.H., "Theoretical Aerodynamics", Macmillan, 1985

UNIT– I

INTRODUCTION TO LOW-SPEED FLOW

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define Aerodynamics.	CO1	Remember	Low
2	Difference between steady and unsteady flow.	CO1	Understand	Low
3	State the Bernoulli's theorem.	CO1	Remember	Low
4	What is the significance of Reynolds number?	CO1	Understand	Low
5	Define the concept of flow separation.	CO1	Remember	Low
6	What is the difference between internal and external flow?	CO1	Understand	Low
7	Define Mach number and its significance.	CO1	Remember	Low
8	What are the four fundamental forces acting on an aircraft?	CO1	Understand	Low
9	Differentiate between laminar flow and turbulent flow.	CO1	Understand	Low
10	What is the significance of a streamline in fluid flow?	CO1	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Explain the basic principles of aerodynamics and its application in aircraft design.	CO1	Understand	Medium
2	Discuss the classification of fluid flow with examples.	CO1	Understand	Medium
3	Derive Bernoulli's equation and explain its application in aerodynamics.	CO1	Create	High
4	Explain the significance of the Reynolds number in fluid flow and its effect on boundary layer development.	CO1	Understand	Medium
5	Derive the continuity equation and explain its use in aerodynamics.	CO1	Create	High
6	Discuss the different types of fluid forces encountered in a flow and explain their effects on aircraft performance.	CO1	Understand	Medium
7	Explain the concept of flow separation and its impact on aircraft stability and control.	CO1	Understand	Medium
8	Discuss the impact of compressibility on aerodynamics and its importance in high-speed flow.	CO1	Understand	Medium
9	Explain the concept of boundary layers in fluid flow and the effects of laminar and turbulent flow.	CO1	Understand	Medium
10	Derive and explain the expression for pressure distribution in a flow around a symmetrical airfoil.	CO1	Create	High

UNIT – II

TWO-DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define the term ‘streamline flow.’	CO2	Remember	Low
2	What is the significance of the Navier-Stokes equation in aerodynamics?	CO2	Understand	Low
3	State the principle of conservation of mass.	CO2	Remember	low
4	What is meant by vorticity in fluid dynamics?	CO2	Understand	Low
5	Differentiate between a velocity potential and a stream function.	CO2	Understand	Low
6	State the term ‘irrotational flow.’	CO2	Remember	Low
7	Define and explain the term ‘circulation.’	CO2	Remember	Low
8	What is a stagnation point in a flow?	CO2	Understand	Low
9	What do you understand by the term ‘conservation of momentum’ in fluid dynamics?	CO2	Understand	Low
10	What is the difference between pressure and shear stress in a fluid?	CO2	Understand	Low

PART–B				
Q.No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive and explain the continuity equation in fluid mechanics.	CO2	Create	High
2	Derive Euler's equation of motion and explain its physical significance.	CO2	Create	High
3	Explain the basic concepts of fluid dynamics including velocity, acceleration, and flow patterns.	CO2	Understand	Medium
4	Discuss the concept of a control volume and its application in aerodynamics.	CO2	Understand	Medium
5	Derive Bernoulli's equation from the first law of thermodynamics for incompressible flow.	CO2	Create	High
6	Explain the concepts of vorticity and circulation in fluid flow and their applications.	CO2	Understand	Medium
7	Discuss the types of potential flow and their significance in aerodynamics.	CO2	Understand	Medium
8	Explain the boundary conditions for a fluid in motion and their significance.	CO2	Understand	Medium
9	Discuss the kinematic boundary conditions and their application to airfoils.	CO2	Understand	Medium
10	Derive and explain the expression for the velocity potential and stream function for a potential.	CO2	Create	High

UNIT – III

AIRFOIL THEORY

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	What is an airfoil?	CO3	Understand	Low
2	Define the terms ‘chord line’ and ‘mean camber line’ of an airfoil.	CO3	Remember	Low
3	What is the significance of the angle of attack in airfoil aerodynamics?	CO3	Understand	Low
4	What is the difference between a symmetrical and cambered airfoil?	CO3	Understand	Low
5	What is the coefficient of lift (Cl)?	CO3	Understand	Low
6	Define the term ‘stall’ in the context of an airfoil.	CO3	Remember	Low
7	What is the aerodynamic center of an airfoil?	CO3	Understand	Low
8	Write the significance of the lift curve slope.	CO3	Understand	Low
9	What is meant by ‘zero-lift angle of attack’ for an airfoil?	CO3	Understand	Low
10	List the concept of induced drag in the context of an airfoil.	CO3	Remember	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive the theory of airfoil lift and its relationship to the angle of attack.	CO3	Create	High
2	Discuss the different types of airfoils and their characteristics.	CO3	Understand	Medium
3	Derive the lift equation for an airfoil and explain each term.	CO3	Create	High
4	Explain the concept of circulation and how it relates to the lift produced by an airfoil.	CO3	Understand	Medium
5	Derive and explain the Kutta-Joukowski theorem for the lift on a thin airfoil.	CO3	Create	High
6	Derive the different methods for calculating the lift coefficient of an airfoil.	CO3	Create	High
7	Explain the factors affecting the stall characteristics of an airfoil.	CO3	Understand	Medium
8	Derive the expression for induced drag on an airfoil and discuss its dependence on various parameters.	CO3	Create	High
9	Discuss the effect of camber on the aerodynamic performance of an airfoil.	CO3	Understand	Medium
10	Explain the concept of the lift curve and the factors influencing its slope.	CO3	Understand	Medium

UNIT – IV

SUBSONIC WING THEORY

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	What is the aspect ratio of a wing?	CO4	Understand	Low
2	Define wing loading.	CO4	Remember	Low
3	What is induced drag, and how is it related to the wing configuration?	CO4	Understand	Low
4	Define the concept of the vortex system around a wing.	CO4	Remember	Low
5	What is the relationship between the lift and drag coefficients for a wing?	CO4	Understand	Low
6	Define and explain the term 'spanwise flow' in the context of a wing.	CO4	Remember	Low
7	What is the role of the downwash in the aerodynamics of a wing?	CO4	Understand	Low
8	Define the term 'airfoil thickness to chord ratio.'	CO4	Remember	Low
9	What is the aerodynamic center of a wing?	CO4	Understand	Low
10	How does the sweep angle of a wing affect its aerodynamic characteristics?	CO4	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Explain the effect of aspect ratio on the performance of a wing.	CO4	Understand	Medium
2	Derive and explain the expression for the lift and drag of a wing.	CO4	Create	High
3	Discuss the vortex system created by a wing and its relation to induced drag.	CO4	Understand	Medium
4	Explain the effect of downwash on the aerodynamic performance of an aircraft.	CO4	Understand	Medium
5	Derive and explain the relationship between induced drag and aspect ratio.	CO4	Create	High
6	Discuss the factors influencing the aerodynamic center of a wing.	CO4	Understand	Medium
7	Explain the effect of sweepback on the lift distribution over a wing.	CO4	Understand	Medium
8	Discuss the concept of wing tip vortices and their effect on aircraft performance.	CO4	Understand	Medium
9	Explain the concept of wing loading and its importance in aircraft design.	CO4	Understand	Medium
10	Derive the expression for the induced drag on a wing and explain the concept of lift-induced drag.	CO4	Create	High

UNIT – V

INTRODUCTION TO BOUNDARY LAYER THEORY

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	What is the speed of sound and how is it defined?	CO5	Understand	Low
2	What is the Mach number, and how is it used in compressible flow analysis?	CO5	Understand	Low
3	Define subsonic, transonic, supersonic, and hypersonic flow.	CO5	Remember	Low
4	What are shock waves, and how do they form?	CO5	Understand	Low
5	State the term of 'Mach wave.'	CO5	Remember	Low
6	What is meant by 'choking' in the context of compressible flow?	CO5	Understand	Low
7	What is the relationship between pressure, temperature, and velocity in compressible flow?	CO5	Understand	Low
8	What is the Prandtl-Meyer function?	CO5	Understand	Low
9	Define the term 'isentropic flow' in compressible aerodynamics.	CO5	Remember	Low
10	What are the effects of compressibility on airfoil performance?	CO5	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive the relationship between Mach number, pressure, and temperature for compressible flow.	CO5	Create	High
2	Explain the concept of shock waves, including normal and oblique shocks, and their effects on aircraft performance.	CO5	Understand	Medium
3	Discuss the differences between compressible and incompressible flow and their significance in aerodynamics.	CO5	Understand	Medium
4	Derive the isentropic flow relations for compressible fluids.	CO5	Create	High
5	Explain the concept of the shock polar and its importance in high-speed aerodynamics.	CO5	Understand	Medium
6	Discuss the effect of shock waves on the drag of an aircraft.	CO5	Understand	Medium
7	Derive and explain the governing equations for compressible flow.	CO5	Create	High
8	Explain the process of expansion waves and their effects on the flow over an airfoil.	CO5	Understand	Medium
9	Discuss the concept of choking in a converging-diverging nozzle.	CO5	Understand	Medium
10	Explain the effects of compressibility on the aerodynamic characteristics of an airfoil at high speeds.	CO5	Understand	Medium

THANK YOU

ALL THE BEST