J.J COLLEGE OF ENGINEERING AND TECHNOLOGY

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SOWDAMBIKAA GROUP OF INSTITUTIONS

ESTD. 1994

DEPARTMENT OF AERONAUTICAL ENGINEERING

AE3502–AERODYNAMICS- II

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, engineering fundamentals and an engineering specialization to the solution of 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:** Communicate effectively on complex engineering activities 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.

COURSE OBJECTIVES:

This course will familiarize the students with the concepts of compressibility, theory behind the formation of shocks and expansion fans in Supersonic flows, and the methodology of measurements in Supersonic flows, high speed flow over air foils, wings and airplane configuration and concepts of Transonic flow.

UNIT – I ONE DIMENSIONAL COMPRESSIBLE FLOW 9

Energy, Momentum, continuity and state equations, velocity of sound, adiabatic steady state flow equations, Flow through convergent- divergent passage, Performance under various back pressures.

UNIT II NORMAL AND OBLIQUE SHOCKS 9

Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Hodograph and pressure turning angle, shock polar, flow past wedges and concave corners, strong, weak and detached shocks.

UNIT – III EXPANSION WAVES AND METHOD OF CHARACTERISTICS 9

Flow past convex corners, Expansion hodograph, Reflection and interaction of shocks and expansion, waves. Method of Characteristics Two dimensional supersonic nozzle contours. Rayleigh and Fanno Flows.

UNIT – IV DIFFERENTIAL EQUATIONS OF MOTION FOR STEADY COMPRESSIBLE FLOWS 9

Small perturbation potential theory, solutions for supersonic flows, Mach waves and Mach angles, Prandtl-Glauert rule - affine transformation relations for subsonic flows, linearized two dimensional supersonic flow theory - Lift, drag, pitching moment and center of pressure of supersonic profiles.

UNIT – V TRANSONIC FLOW OVER WING 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 this course, the students expected to be able to:	
CO1	Calculate the compressible flow through a duct of varying cross section.
CO2	Use quasi one-dimensional theory to analyse compressible flow problems.
CO3	Estimate fluid properties in Rayleigh and Fanno type flows.
CO4	Estimate the properties across normal and oblique shock waves.
CO5	Understand the knowledge of various techniques and methods for solving differential equations of motion for steady compressible flows.
CO6	Predict the properties of transonic flows.

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	2	3	3	3	3	-	-	-	-	-	-	-	3	1	1
CO2	2	3	3	3	3	-	-	-	-	-	-	-	3	1	1
CO3	2	3	3	3	3	-	-	-	-	-	-	-	3	1	1
CO4	2	3	3	3	3	-	-	-	-	-	-	-	3	1	1
CO5	2	2	2	2	2	-	-	-	-	-	-	-	3	1	1
AVG	**2**	**2.8**	**2.8**	**2.8**	**2.8**	-	-	-	-	-	-	-	**3**	**1**	**1**

3 – High; 2 – Medium; 1 – Low; – No correlation

TEXT BOOKS:

1. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York, 1999.
2. L.J. Clancy, "Aerodynamics" Sterling Book House, 2006

REFERENCE BOOKS:

1. Rathakrishnan, E., "Gas Dynamics", 6th Edition, Prentice Hall of India, 2017.
2. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press, 1982.

UNIT– I
COMPRESSIBLE FLOW

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define compressibility and its significance.	CO1	Remember	Low
2	What is stagnation temperature?	CO1	Understand	Low
3	Define the Mach number and its physical significance.	CO1	Remember	Low
4	State the assumptions made in isentropic compressible flow.	CO1	Remember	Low
5	Differentiate between subsonic and supersonic flows.	CO1	Understand	Low
6	What is meant by choking in compressible flow?	CO1	Understand	Low
7	Define stagnation pressure and total pressure.	CO1	Remember	Low
8	What is the effect of area change in compressible flow?	CO1	Understand	Low
9	Write the concept of critical Mach number.	CO1	Understand	Medium
10	Write down the energy equation for compressible flow.	CO1	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive the energy equation for one dimensional compressible flow.	CO1	Create	High
2	Explain the concept of choking in isentropic flow through a nozzle.	CO1	Understand	Medium
3	Derive the relation between pressure, density, and temperature in compressible flow.	CO1	Create	High
4	Explain the effect of compressibility on aerodynamic forces.	CO1	Understand	Medium
5	Describe the significance of stagnation properties in compressible flow.	CO1	Understand	Medium
6	Discuss the Fanno flow and its governing equations.	CO1	Understand	Medium
7	Derive the expression for the speed of sound in compressible flows.	CO1	Create	High
8	Explain the impact of compressibility on flow properties at high speeds	CO1	Understand	Medium
9	Explain Rayleigh flow and derive the governing equations.	CO1	Understand	Medium
10	Discuss the importance of Prandtl Meyer expansion waves in compressible aerodynamics.	CO1	Understand	Medium

UNIT – II

TWO-DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define a normal shock wave.	CO2	Remember	Low
2	What are the properties of flow across a normal shock?	CO2	Understand	Low
3	State the Rankine Hugoniot equations.	CO2	Remember	Low
4	Write the terms of shock strength.	CO2	Understand	Medium
5	What is an oblique shock wave?	CO2	Understand	Low
6	Differentiate between attached and detached shock waves.	CO2	Understand	Low
7	Mention the concept of a shock polar diagram.	CO2	Understand	Medium
8	Define the shock angle in oblique shock waves.	CO2	Remember	Low
9	What is the significance of a Mach wave?	CO2	Understand	Low
10	What is meant by a compression corner in supersonic aerodynamics?	CO2	Understand	Medium

PART–B				
Q.No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive the governing equations for normal shock waves.	CO2	Create	High
2	Explain the flow properties across a normal shock wave.	CO2	Understand	Medium
3	Derive the oblique shock relations and explain their significance.	CO2	Create	High
4	Discuss the conditions for weak and strong oblique shocks.	CO2	Understand	Medium
5	Explain the interaction of shock waves with boundary layers.	CO2	Understand	Medium
6	Describe the different types of oblique shocks and their applications.	CO2	Understand	Medium
7	Explain the role of shock waves in supersonic inlets.	CO2	Understand	Medium
8	Describe shock expansion theory and its applications in aerodynamics.	CO2	Understand	Medium
9	Explain how oblique shocks can be used in supersonic nozzle design.	CO2	Understand	Medium
10	Explain the phenomenon of shock reflection and shock intersection.	CO2	Understand	Medium

UNIT – III

EXPANSION WAVES AND METHOD OF CHARACTERISTICS

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define expansion waves in supersonic flow.	CO3	Remember	Low
2	What is the Prandtl Meyer function?	CO3	Understand	Low
3	State the differences between shock waves and expansion waves.	CO3	Remember	Low
4	What are the advantages of using the method of characteristics in supersonic nozzle design?	CO3	Understand	Medium
5	What is meant by an expansion fan?	CO3	Understand	Low
6	Define compatibility equations in the method of characteristics.	CO3	Remember	Low
7	What are Riemann invariants?	CO3	Understand	Low
8	What is the function of expansion waves in supersonic flow over curved outward surfaces?	CO3	Understand	Medium
9	How do characteristic lines help in analyzing supersonic flow?	CO3	Understand	Low
10	What is the role of the method of characteristics in nozzle contour design?	CO3	Understand	Medium

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive the Prandtl-Meyer expansion wave relations.	CO3	Create	High
2	Explain the method of characteristics and its use in supersonic flows.	CO3	Understand	Medium
3	Describe how expansion waves develop over a supersonic airfoil.	CO3	Understand	Medium
4	Explain the difference between compression shocks and expansion waves.	CO3	Understand	Medium
5	Explain the formation and application of expansion fans.	CO3	Understand	Medium
6	Discuss the role of characteristic lines in solving compressible flow equations.	CO3	Understand	Medium
7	Explain the compatibility equations and their significance in compressible aerodynamics.	CO3	Understand	Medium
8	Describe how the method of characteristics is used in supersonic nozzle design.	CO3	Understand	Medium
9	Explain the concept of wave reflections and their aerodynamic applications.	CO3	Understand	Medium

UNIT – IV

DIFFERENTIAL EQUATIONS OF MOTION FOR STEADY COMPRESSIBLE FLOWS

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define the Euler equations for compressible flow.	CO4	Remember	Low
2	Can you describe the purpose of the continuity equation in engineering applications?	CO4	Understand	Medium
3	State the assumptions made in steady compressible flow analysis.	CO4	Remember	Low
4	What are the governing equations for compressible flow?	CO4	Understand	Low
5	Define the momentum equation in steady compressible flows	CO4	Remember	Low
6	What is meant by irrotational flow?	CO4	Understand	Low
7	How does potential flow theory assist in approximating compressible flow behavior?	CO4	Understand	Medium
8	Define stream function and velocity potential.	CO4	Remember	Low
9	What is meant by shock fitting?	CO4	Understand	Low
10	What is the significance of entropy in shock wave analysis?	CO4	Understand	Medium

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive the continuity equation for steady compressible flows and explain its significance.	CO4	Create	High
2	Explain the momentum equation for compressible flows and derive its differential form.	CO4	Understand	Medium
3	Discuss the energy equation for steady compressible flows and derive its governing equation.	CO4	Understand	Medium
4	Derive the Euler's equations for compressible flows and explain their importance in aerodynamics.	CO4	Create	High
5	Explain the significance of the potential flow equation and its application in steady compressible aerodynamics.	CO4	Understand	Medium
6	Describe the role of the Navier Stroke equation.	CO4	Understand	Medium
7	Discuss the concept of irrotational flow and derive the governing equation for compressible irrotational motion.	CO4	Understand	Medium
8	Derive the stream function and velocity potential function for steady compressible flows.	CO4	Create	High
9	Explain the importance of the entropy equation in compressible flow and derive its mathematical formulation.	CO4	Understand	Medium
10	Discuss the characteristics of steady compressible flow equations and their application in high.	CO4	Understand	Medium

UNIT – V

TRANSONIC FLOW OVER WING

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define transonic flow and its significance in aerodynamics.	CO5	Remember	Low
2	What is the drag divergence Mach number?	CO5	Understand	Low
3	Differentiate between subsonic, transonic, and supersonic flows	CO5	Understand	Low
4	Explain the concept of wave drag in transonic flows.	CO5	Understand	Medium
5	What are supercritical airfoils, and why are they used in transonic flight?	CO5	Understand	Low
6	What is transonic shock wave formation, and how does it affect aircraft performance?	CO5	Understand	Low
7	Define the Prandtl Glauert rule and its application in transonic flow.	CO5	Remember	Low
8	What is the effect of compressibility on lift and drag at transonic speeds?	CO5	Understand	Low
9	Explain the significance of the area rule in transonic aerodynamics.	CO5	Understand	Medium
10	What is shock induced separation in transonic airfoil flow?	CO5	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Explain the characteristics of transonic flow and its significance in aerodynamics.	CO5	Understand	Medium
2	Describe the formation of shock waves in transonic flow and their effects on airfoil performance.	CO5	Understand	Medium
3	What is the drag divergence Mach number? Explain its importance in transonic aerodynamics.	CO5	Understand	Medium
4	Discuss the transonic area rule and its role in reducing wave drag.	CO5	Understand	Medium
5	Explain the concept of supercritical airfoils and their advantages in transonic flight.	CO5	Understand	Medium
6	Derive the governing equations for transonic flow using potential flow theory.	CO5	Create	High
7	Discuss the effects of compressibility on aerodynamic forces and moments in the transonic regime.	CO5	Understand	Medium
8	Explain the role of shock boundary layer interactions in transonic flows and their impact on drag.	CO5	Understand	Medium
9	Describe the experimental and computational methods used to analyze transonic flow over wings.	CO5	Understand	Medium
10	Compare and contrast subsonic, transonic, and supersonic flow regimes over an airfoil.	CO5	Evaluate	Medium

THANK YOU

ALL THE BEST