Course code	Course Name	L-T-P - Credits	Year of Introduction
AO301	AERODYNAMICS - II	3-1-0-4	2016

Prerequisite: AO201 Aerodynamics -I

Course Objectives

- To introduce the concepts of compressibility,
- To make the student understand the theory behind the formation of shocks and expansion fans in Supersonic flows.

Syllabus

Compressibility, Governing equations for steady one dimensional flow, Operating characteristics of nozzles, Introduction to hypersonic flows, Normal shock relations, Moving normal shock waves, Rayleigh flow, Fanno flow, Expansion waves, Potential equation for 2-dimensional compressible flow, Method of characteristics, Critical Mach number, Shock Stall, Supercritical Airfoil Sections, Transonic area rule, Swept wing, Airfoils for supersonic flows , Shock-expansion theory

Expected Outcome

The students will

- Understand the characteristics of fluid flows
- Gain knowledge on shock phenomenon and shock waves.
- Understand fluid flow characteristics over wings, airfoils and airplanes.

Text Books:

1. Anderson, J. D, "Modern Compressible Flow", McGraw-Hill & Co., 2002.
2. Rathakrishnan., E, "Gas Dynamics", Prentice Hall of India, 2004.

Data Book (Approved for use in the examination):

1. Rathakrishnan E, Gas Tables, Orient Blackswan Private Limited - New Delhi (2013)
2. S M Yahya, Gas Tables for Compressible Flow Calculations, New Age International Publishing, 2012

References:

1. Oosthuizen,P.H., &Carscallen,W.E., "Compressible Fluid Flow", McGraw- Hill & Co.,1997
2. Shapiro, A. H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press, 1982.
3. Zucrow, M. J. and Anderson, J. D., "Elements of Gas Dynamics", McGraw- Hill & Co., 1989.

Course Plan

Module	Contents	Hours	End Sem. Exam Marks
I	Compressibility, Continuity, Momentum and energy equations for steady one dimensional flow, Compressible Bernoulli's equation	4	15%
	velocity relation, Mach cone, Mach angle,	2	
	Operating characteristics of nozzles- introduction to hypersonic flows.	3	
II	Normal shock relations, Prandtl's relation, Hugoniot equation	3	15%
	Rayleigh Supersonic Pitot tube equation,	3	

	Moving normal shock waves.	3	
	Area- Mach number relation	1	
FIRST INTERNAL EXAMINATION			
III	Shock Polar, Reflection of oblique shocks, left running and right running waves	3	15%
	Interaction of oblique shock waves, introduction to slip line	2	
	Introduction to boundary layer interaction	2	
	compression corner effect – incident shock interaction.	2	
IV	Rayleigh flow, Fanno flow (simple numerical examples)	4	15%
	Expansion waves, Prandtl-Meyer expansion	2	
	Maximum turning angle	2	
	Simple and non-simple regions.	1	
SECOND INTERNAL EXAMINATION			
V	Critical Mach number, drag divergence Mach number, Shock Stall	3	20%
	Supercritical Airfoil Sections, Transonic area rule	3	
	Swept wing, Airfoils for supersonic flows supersonic wings	3	
VI	Lift, drag, Pitching moment and Center of pressure for supersonic profiles,	3	20%
	Shock-expansion theory, wave drag	3	
	Design considerations for supersonic aircraft- aerodynamic heating.	3	
END SEMESTER EXAM			

Question Paper Pattern

Maximum marks: 100 Exam duration: 3 hours

The question paper shall consist of three parts

Part A
4 questions uniformly covering modules I and II. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
4 questions uniformly covering modules III and IV. Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
6 questions uniformly covering modules V and VI. Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: In all parts, each question can have a maximum of four sub questions, if needed.