2021-22

File No......................

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

NAAC Accredited Institution

(Approved by All India Council For Technical Education, New Delhi)
Affiliated to Anna University, Chennai - 600 025

OFFICE FILE

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

ACADEMIC YEAR : 2023-24 ODD SEM

COURSE FILE

SUBJECT CODE : CME 386

SUBJECT NAME : Gas Dynamics and Jet Propulsion

YEAR/ SEM : III / V

DEPARTMENT : Mechanical Engineering

" Nizara Educational Campus"
Muthapudupet, Avadi IAF, Chennai - 600 055.
Phone : 044-26842627 Fax : 044 - 26842456
E-mail : info@aalimec.ac.in. Web : www.aalimec.ac.in

AALIM MUHAMMED SALEGH COLLEGE OF CHENNAI 600 055

PRINCIPAL
AALIM MUHAMMED SALEGH
COLLEGE OF ENGINEERING

Semester from 27. 7. 23 to 17.11.23

Branch : Mechanical Engineering

Subject : Code No. : CME386

Name : Gas Dynamics and Jet propulsion

Name and Designation of the Teacher : Asst. Prof. T.N. Jafar Ali

	End of 1st Month	End of 2nd Month	End of 3rd Month	End of Semester
Staff	[signature]	[signature]	[signature] 7.11.23	[signature] 11.01.24
HOD	[signature] 1/9/23	[signature] 20/10/23	[signature] 7/11/23	[signature] 11/1/24.
Principal	[signature] 2/9/23	[signature] 20/10/2023	[signature] 12/02/24	[signature] 12/2/24

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING CHENNAI 600 055

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AALIM MUHAMMED SALEGH
COLLEGE OF ENGINEERING

ATTENDANCE

S.No.	Roll No.	Name	7/28/1	8/1/3	8/1/6	8/2/1	8/2/2	8/4/4	8/8/3	8/8/6	8/11/4	8/16/1	8/16/2	8/18/4	8/22/3	8/22/6
1.	001	Abdul Ajeez. M	A	A	A	A	A	/	/	/	/	/	/	/	/	/
2.	002	Abdul Wahid. M	OD	OD	OD	OD	OD	OD	OD	OD	/	/	/	/	/	/
3.	003	Ahamed Baisul. M	A	A	A	A	/	/	/	/	/	/	/	A	/	/
4.	004	Ahamed Kabeer. H	A	A	A	/	/	/	/	/	/	A	/	/	/	/
5.	005	AhZan Barudus Samad. S	A	A	A	A	A	/	/	/	/	/	/	/	/	/
6.	006	Dilli Babu. V	/	/	/	/	/	/	A	/	/	/	/	/	/	/
7.	007	Furqaan. N	A	A	A	/	/	/	/	/	/	A	/	/	/	/
8.	008	Karthi Keyan. B	A	A	A	A	/	/	/	/	/	/	/	/	/	/
9.	009	Khaleel. S	/	/	/	/	/	/	A	/	/	/	/	/	/	/
10.	010	Mahmood Sulaiman. A	A	A	A	/	/	/	/	/	/	/	/	/	/	/
11.	011	Marki Antony. J	OD	/	/	/	/	/	/	/	/	/	/	/	/	/
12.	012	Mohaideen Abdul Kadar. S	A	A	/	/	/	/	/	/	/	/	/	/	/	/
13.	013	Mohamed Abdul Kareem. M	A	A	A	/	/	/	/	/	/	/	/	/	/	/
14.	014	Mohamed AZarudeen. K	A	A	/	/	/	/	/	/	/	/	/	/	/	/
15.	015	Mohamed Rayeen. S	A	A	A	A	/	/	/	/	/	/	/	/	A	/
16.	016	Mohamed Thameerudeen. A	OD	OD	OD	OD	OD	OD	OD	OD	/	/	/	/	/	/
17.	017	Mohamed Fayasudeen. M	A	A	A	A	/	/	/	/	/	/	/	/	/	/
18.	018	Mohammed Shakeel. J	A	/	/	/	A	A	/	/	/	/	A	/	/	/
19.	019	Nawasir Husain. S	A	A	/	/	/	/	/	/	/	/	/	/	/	/
20.	020	Raiyan. A.S	OD	OD	OD	OD	OD	OD	OD	OD	/	/	/	/	/	/

S.No.	8/23/1	8/23/2	8/25/4	8/29/3	8/29/6	8/30/1	8/30/2	9/1/4	9/2/1	9/2/2	9/5/3	9/5/6	9/8/4	9/12/3	9/12/6	9/13/1	9/13/2	9/15/4	9/19/3	9/19/6	9/20/1	9/20/2	9/22/4	9/26/3	Remarks
1.	A	/	OD	/	/	/	/	/	/	/	/	/	A	/	/	/	A	/	/	/	/	/	A	/	
2.	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
3.	/	/	OD	/	/	/	/	/	/	/	A	/	/	/	/	/	A	/	/	/	/	/	/	A	
4.	/	/	OD	/	/	/	/	/	/	/	/	/	/	A	/	/	/	/	/	/	/	/	/	/	
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6.	/	/	OD	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	A	/	/	
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19.	/	/	/	/	/	/	/	/	/	/	/	/	/	/	A	/	/	/	/	/	/	/	/	/	
20.	A	A	/	/	/	/	/	/	/	A	/	/	/	/	/	/	/	/	/	/	/	/	/	/	

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CHENNAI
600 055

RECORD OF CLASS WORK

Date	Period	Topics Covered	Initials
		Unit - II	
16.8.23	2	Flow through constant area duct with heat transfer (Rayleigh flow)	[signature]
18.8.23	4	Problems on Rayleigh flow	[signature]
22.8.23	3	Problems on Rayleigh flow	[signature]
22.8.23	6	Flow through constant area ducts with friction (Fanno flow)	[signature]
23.8.23	1	Problems on fanno flow	[signature]
23.8.23	2	Problems on Fanno flow	[signature]
25.8.23	4	Variation of flow properties	[signature]
29.8.23	3	Chocking - Isothermal flow with friction	[signature]
29.8.23	6	Use of Gas tables - Problems on Isothermal flow	[signature]
30.8.23	1	problems on Isothermal flow	[signature]

RECORD OF CLASS WORK

Date	Period	Topics Covered	Initials
		Unit - III	
30.8.23	2	Governing equation of normal shock	[signature] [signature] 4/9/23 [signature] 4/9/23
1.9.23	4	Variation of flow properties across the normal shock wave	[signature]
2.9.23	1	problem on normal shock	[signature]
2.9.23	2	problem on normal shock	[signature]
5.9.23	3	Rankine Hugoniot Equation	[signature]
5.9.23	6	Variation of flow parameters across the oblique shock	[signature]
8.9.23	4	prandtl mayer expansion	[signature]
12.9.23	3.	Use of gas tables - problems on oblique shock wave	[signature]
12.9.23	6	problem on oblique shock	[signature]
13.9.23	1	problem on oblique shock	[signature]

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	COLLEGE OF ENGINEERING	
	Muthapudupet, I.A.F Avadi Chennai - 600 055	

Department of Mechanical Engineering

Academic Year: 2023-2024

Regulation: 2021

Year/Sem/: III/ V

Subject Code & Subject Name: CME386 & Gas Dynamics and Jet Propulsion

Course Instructor Name & Designation: T. N. Jafar Ali & Assistant Professor

COURSE FILE CONTENTS

S.No	Name of the Item	Available / Not Available	Remarks
1	Vision and Mission of the Institution and Department	✓	
2	PEO'S,PSO'S and PO'S	✓	
3	Syllabus	✓	
4	CO-PO-PSO MAPPING	✓	
5	Name List of the Students	✓	
6	Individual Time Table	✓	
7	Course Plan with Dates	✓	
8	Unit wise Lecture Notes, PPTs, Videos	✓	
9	Content Beyond Syllabus Material	✓	
10	Question Bank for all Units	✓	

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11	Previous year Anna University Question Papers	✓	
12	Tutorial Problems with Solutions (for Tutorial Subjects)	—	
13	Assignment Topics with Samples	✓	
14	Internal Assessments and Model - Question Paper, Sample Answer Sheets (3 nos)	✓	
15	Special Class Schedule with Slow Learners List	—	
16	Course Exit Survey	—	
17	CO-PO-PSO Attainment Sheet	—	
18	Log Book	✓	

Prepared By
Course Instructor

Verified By
HOD

Approved By
Principal

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING
Department of Mechanical Engineering

Dr.S.RAMKUMAR, B.E.,M.E.,Ph.D.
HEAD
DEPARTMENT OF MECHANICAL ENGINEERING
AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

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600 055

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AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

Vision of the Institution

The College with Cutting-edge Excellence in Learning, Teaching and Research integrates Academia, Industry and National Progress.

Mission of the Institution

MISSION–1: To offer Project based learning for all the Subjects beyond the Syllabus

MISSION–2: To create multidisciplinary and Interdisciplinary Research Environment among the Students through solving complex Social Technical Problems

MISSION–3: To motivate Faculty Members and Students to undergo MOOC Courses and Certifications

MISSION–4: To collaborate with Academia and Industry for Intellectual ambience to develop intellectual environment holistically and improve Human Capabilities

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CME386 **GAS DYNAMICS AND JET PROPULSION**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

1 To study the fundamentals of compressible flow concepts and the use of gas tables.
2 To learn the compressible flow behaviour in constant area ducts.
3 To study the development of shock waves and its effects.
4 To study the types of jet engines and their performance parameters.
5 To learn the types of rocket engines and their performance parameters.

UNIT – I BASIC CONCEPTS AND ISENTROPIC FLOWS **9**

Energy and momentum equations of compressible fluid flows, Concepts of compressible flow – Mach waves and Mach cone. Flow regimes, effect of Mach number on compressibility. Stagnation, static, critical properties and their interrelationship. Isentropic flow and its relations. Isentropic flow through variable area ducts — nozzles and diffusers. Use of Gas tables.

UNIT – II COMPRESSIBLE FLOW THROUGH DUCTS **9**

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties. Choking. Isothermal flow with friction. Use of Gas tables.

UNIT – III NORMAL AND OBLIQUE SHOCKS **9**

Governing equations - Rankine-Hugoniot Relation. Variation of flow parameters across the normal and oblique shocks. Prandtl – Meyer expansion and relation. Use of Gas tables.

UNIT – IV JET PROPULSION **9**

Theory of jet propulsion – thrust equation – Performance parameters - thrust, power and efficiency. Operation, cycle analysis and performance of ram jet, turbojet, turbofan, turbo prop and pulse jet engines.

UNIT – V SPACE PROPULSION **9**

Types of rocket engines and propellants. Characteristic velocity — thrust equation. Theory of single and multistage rocket propulsion. Liquid fuel feeding systems. Solid propellant geometries. Orbital and escape velocity. Rocket performance calculations.

TOTAL:45 PERIODS

OUTCOMES: At the end of the course the students would be able to

1. Apply the fundamentals of compressible flow concepts and the use of gas tables.
2. Analyze the compressible flow behaviour in constant area ducts.
3. Analyze the development of shock waves and its effects.
4. Explain the types of jet engines and their performance parameters.
5. Explain the types of rocket engines and their performance parameters.

TEXT BOOKS:

1. Anderson, J.D., "Modern Compressible flow", Third Edition, McGraw Hill, 2003.
2. S.M. Yahya, "Fundamentals of Compressible Flow with Aircraft and Rocket propulsion", New Age International (P) Limited, 4th Edition, 2012.

REFERENCE BOOKS:

1. R. D. Zucker and O Biblarz, "Fundamentals of Gas Dynamics", 2nd edition, Wiley, 2011.
2. Balachandran, P., "Fundamentals of Compressible Fluid Dynamics", Prentice-Hall of India, 2007.
3. Radhakrishnan, E., "Gas Dynamics", Printice Hall of India, 2006.
4. Hill and Peterson, "Mechanics and Thermodynamics of Propulsion", Addison – Wesley, 1965.
5. Babu, V., "Fundamentals of Compressible Flow", CRC Press, 1st Edition, 2008.

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NAAC Accredited Institution
"Nizara Educational Campus", Muthapudupet, Avadi - IAF, Chennai - 600 055.
ANNA UNIVERSITY COUNSELLING CODE : 1101

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT NAME: GAS DYNAMICS AND JET PROPULSION

SUBJECT CODE: CME386

CO-PO-PSO MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	1	1					1			1	2	1
2	3	2	1	1					1			1	2	1
3	3	2	1	1					1			1	2	1
4	3	2	1	1					1			1	2	1
5	3	2	1	1					1			1	2	1
Low (1) ; Medium (2) ; High (3)														

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NACC Accredited Institution

"Nizara Educational Campus", Muthapudupet, Avadi - IAF, Chennai - 600 055.

DEPARTMENT OF MECHANICAL ENGINEERING

STUDENTS NAME LIST

YEAR / SEM : III / V

S.NO	REG.NO	NAME OF THE STUDENT
1	110121114001	ABDUL AJEEZ M
2	110121114002	ABDUL WAHID M
3	110121114003	AHAMED BAISUL M
4	110121114004	AHAMED KABEER H
5	110121114005	S. AHZAN BARUDUS SAMAD
6	110121114006	V DILLIBABU
7	110121114007	N.FURQAAN
8	110121114008	B.KARTHIKEYAN
9	110121114009	S.KHALEEL
10	110121114010	MAHMOOD SULAIMAN A
11	110121114011	J.MARK ANTONY
12	110121114012	S.MOHAIDEEN ABDUL KADAR
13	110121114013	M.MOHAMED ABDUL KAREEM
14	110121114014	MOHAMED AZARUDEEN. K
15	110121114015	S MOHAMED RAZEEN
16	110121114016	A.MOHAMED THAMEESUDEEN
17	110121114017	M. MOHAMED FAYASUDEEN
18	110121114018	J MOHAMMED SHAKEEL
19	110121114019	NAWASIR HUSAIN S
20	110121114020	A S RAIYAN
21	110121114021	S.SAEED WASEEM
22	110121114022	R. SEENI RIYAS KHAN
23	110121114023	M.SHAIK SHAHEEM
24	110121114024	M.SYED ABDUL RAHUMAN
25	110121114025	M.SYED IBRAMSHA
26	110121114301	ABDUL RAHIM
27	110121114302	ASIF. H
28	110121114303	DEVARAJAN. S
29	110121114304	DILIP
30	110121114305	FOWSAL HASSAN

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AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING
APPROVED BY AICTE, NEW DELHI, & AFFILIATED TO ANNA UNIVERSITY, CHENNAI
NAAC ACCREDITED INSTITUTION
ANNA UNIVERSITY COUNSELING CODE: 1101

Department of Mechanical Engineering

INDIVIDUAL TIME TABLE

Day	1	2	3	4	5	6	7	8
Monday								
Tuesday			GDJP			GDJP		
Wednesday	GDJP	GDJP						
Thursday								
Friday				GDJP				

26.7.23
Time Table Incharge

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING Department of Mechanical Engineering

26/7/23
HOD/MECH

Dr.S.RAMKUMAR, B.E.,M.E.,Ph.D.
HEAD
DEPARTMENT OF MECHANICAL ENGINEERING
AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

11/8/2023
Principal
Prof. Dr. S. SATHISH
B.E.,M.E.,Ph.D.,
PRINCIPAL
AALIM MUHAMMED SALEGH
COLLEGE OF ENGINEERING
MUTHAPUDUPET, IAF-AVADI
CHENNAI 600 055

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CHENNAI
600 055

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	LECTURE PLAN	Date :27.07.2023
	Subject :Gas Dynamics and Jet Propulsion Code :CME386 Branch :B.E. - MECH Semester :V Faculty Member : Asst. Prof. T. N. Jafar Ali	Page 01 of 07

REGULATION - 2021

SYLLABUS

COURSE OBJECTIVES:

1 To study the fundamentals of compressible flow concepts and the use of gas tables.
2 To learn the compressible flow behaviour in constant area ducts.
3 To study the development of shock waves and its effects.
4 To study the types of jet engines and their performance parameters.
5 To learn the types of rocket engines and their performance parameters.

UNIT – I BASIC CONCEPTS AND ISENTROPIC FLOWS 9

Energy and momentum equations of compressible fluid flows, Concepts of compressible flow – Mach waves and Mach cone. Flow regimes, effect of Mach number on compressibility. Stagnation, static, critical properties and their interrelationship. Isentropic flow and its relations. Isentropic flow through variable area ducts – nozzles and diffusers. Use of Gas tables.

UNIT – II COMPRESSIBLE FLOW THROUGH DUCTS 9

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties. Choking. Isothermal flow with friction. Use of Gas tables.

UNIT – III NORMAL AND OBLIQUE SHOCKS 9

Governing equations - Rankine-Hugoniot Relation. Variation of flow parameters across the normal and oblique shocks. Prandtl – Meyer expansion and relation. Use of Gas tables.

UNIT – IV JET PROPULSION 9

Theory of jet propulsion – thrust equation – Performance parameters - thrust, power and efficiency. Operation, cycle analysis and performance of ram jet, turbojet, turbofan, turbo prop and pulse jet engines.

UNIT – V SPACE PROPULSION 9

Types of rocket engines and propellants. Characteristic velocity – thrust equation. Theory of single and multistage rocket propulsion. Liquid fuel feeding systems. Solid propellant geometries. Orbital and escape velocity. Rocket performance calculations.

TOTAL:45 PERIODS

OUTCOMES: At the end of the course the students would be able to

1. Apply the fundamentals of compressible flow concepts and the use of gas tables.
2. Analyze the compressible flow behaviour in constant area ducts.
3. Analyze the development of shock waves and its effects.
4. Explain the types of jet engines and their performance parameters.
5. Explain the types of rocket engines and their performance parameters.

TEXT BOOKS:

1. Anderson, J.D., "Modern Compressible flow", Third Edition, McGraw Hill, 2003.
2. S.M. Yahya, "Fundamentals of Compressible Flow with Aircraft and Rocket propulsion", New Age International (P) Limited, 4th Edition, 2012.

REFERENCE BOOKS:

1. R. D. Zucker and O Biblarz, "Fundamentals of Gas Dynamics", 2nd edition, Wiley, 2011.
2. Balachandran, P., "Fundamentals of Compressible Fluid Dynamics", Prentice-Hall of India, 2007.
3. Radhakrishnan, E., "Gas Dynamics", Printice Hall of India, 2006.
4. Hill and Peterson, "Mechanics and Thermodynamics of Propulsion", Addison – Wesley, 1965.
5. Babu, V., "Fundamentals of Compressible Flow", CRC Press, 1st Edition, 2008.

Total No. of hours as per syllabus : 45
Total No of hours available as per academic calendar :

Units	1	2	3	4	5	Revision
Hours (Cumulative)	10	20	30	40	50	

24.7.23
FACULTY MEMBER

28/9/23
HEAD

11/8/2023
PRINCIPAL

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING Department of Mechanical Engineering

Dr.S.RAMKUMAR, B.E.,M.E.,Ph.D.
HEAD
DEPARTMENT OF MECHANICAL ENGINEERING
AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

Prof. Dr. S. SATHISH
B.E.,M.E.,Ph.D.,
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	LECTURE PLAN	
	Subject :Gas Dynamics and Jet Propulsion Code :CME386 Branch :B.E. - MECH Semester :V Faculty Member : Asst. Prof. T. N. Jafar Ali	

UNIT I - BASIC CONCEPTS AND ISENTROPIC FLOWS (10)

Lecture Series No.	Topics to be covered	Text / Reference Book No.	Mode of Teaching	Course Outcome
1	Energy and momentum equations of compressible fluid flows	T2 R2	Board Work	CO1
2	Concepts of compressible flow-Mach waves and Mach cone	T2 R2	Board Work	CO1
3	Concepts of flow regimes	T2 R2	Board Work	CO1
4	Effect of Mach number on compressibility, Stagnation & Static states and critical properties	T2 R2	Board Work	CO1
5	Isentropic flow and its relations	T2 R2	Board Work	CO1
6	Isentropic flow through variable area ducts	T2 R2	Board Work	CO1
7	Flow through Nozzles and Diffusers – Use of Gas tables	T2 R2	Board Work	CO1
8	Problems on stagnation states and isentropic flow	T2 R2	Board Work	CO1
9	Problems on nozzle and diffusers	T2 R2	Board Work	CO1
10	Problems on nozzle and diffusers	T2 R2	Board Work	CO1

TOTAL PERIODS : 10
DATE OF COMMENCEMENT :
DATE OF COMPLETION :
DEVIATIONS (IF ANY) :
CORECTIVE MEASURES :

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PRINCIPAL
AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

FACULTY MEMBER

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING Department of Mechanical Engineering

HEAD

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AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING

Lecture 1 / Unit 1

Introduction

Fluid is a substance that continuously deforms when shearing forces are applied. E.g., Liquids, gases, vapors and their mixtures.

Mechanics – study of forces acting on bodies. This can be divided into statics, dynamics and kinematics.

Fluid Mechanics - study of the mechanical properties of fluids, when it is subjected to internal and external forces.

Fluid Dynamics - study concerned with the movement of gases and liquids.

Types of fluids – Ideal (non viscous / inviscid), Real (viscous) and Perfect (non viscous and incompressible / Perfect fluid do not stick to the surface with which they are in contact).

Incompressible fluid – density does not change with time. i.e., $\frac{\partial \rho}{\partial t} = 0$ or $\nabla \rho = 0$. Flow of gases at low Mach number (< 0.3) can be assumed as incompressible.

Compressible fluid – density varies with pressure. Flow at Mach numbers higher than 0.3 is considered as compressible.

Gas dynamics – compressible fluid dynamics. Gas dynamics is a branch of fluid dynamics concerned with studying the motion of gases and its consequent effects. Gas dynamics combines the principles of fluid mechanics and thermodynamics.

System, surrounding, boundary, closed system, open system, isolated system.

Ideal gas – which obeys Boyle's law (pV = k, if temperature is kept constant within a closed system) and Charles's law (V α T, if pressure is constant / T is abs. temp.).

Semi perfect gas – is an ideal gas whose specific heats are functions of temperature. i.e., $C_p = f(T)$ and $C_v = f(T)$.

Perfect gas – whose specific heats remain constant at all temperatures.

<u>Types of energy forms in TD system:-</u>

1. **Potential energy** – energy possessed by the fluid by virtue of its height = gZ.
2. **Kinetic energy** – energy possessed by the fluid by virtue of its motion = $\frac{C^2}{2}$.
3. **Internal energy(u)** – Energy stored in the gas by virtue of its molecular motion. At temperature 'T', it is given by $u = C_v T$. In compressible flow, 'u' appears with the quantity pv.

   Hence, U + pv = h = U + $\frac{p}{\rho}$.

   For a perfect gas, h = $C_v T$ + RT = (C_v + R) T = C_p T.

4. Flow energy or displacement energy(pv) – The energy required to push the fluid into or out of the control volume is called the flow work or flow energy. Flow energy is necessary for maintaining a continuous flow through a control volume.

1 – Dimensional flow: Flow properties, such as pressure and velocity, at a given instant of time vary only in the direction of flow and not across the cross section.

Steady flow: Fluid properties, such as pressure, temperature and velocity, in the control volume do not change with time.

Unsteady flow: When one or more fluid property in the control volume change with time.

General form of energy equation:

$$Q = W + (U_2 - U_1) + mg(Z_2 - Z_1) + \frac{1}{2}m(c_2^2 - c_1^2)$$

Energy equation for a non flow process: (expansion and compression of gases in a cylinder with piston). The potential and kinetic energy terms are negligible compared to other quantities and the work term W includes only shaft work.

$$Q = W_s + (U_2 - U_1)$$

Energy equation for a flow process: (expansion of steam and gas in turbines and compression of air and gases in turbo compressors). In this, W includes the flow work also.

$$W = W_s + (p_2V_2 - p_1V_1)$$

and hence the energy equation can be written as

$$h_1 + gZ_1 + \frac{1}{2}c_1^2 + q = h_2 + gZ_2 + \frac{1}{2}c_2^2 + w_s \text{ --- SFEE}$$

Generally in flow problems of gases and vapors the magnitude of $g(Z_2 - Z_1)$ is negligible compared to other quantities. Therefore,

$$h_1 + \frac{1}{2}c_1^2 + q = h_2 + \frac{1}{2}c_2^2 + w_s \text{ --- SFEE}$$

Adiabatic Energy Equation (AEE): In some engineering problems, the heat transfer q during the process is negligibly small and can be ignored. Expansion of gases and vapors in turbines are examples of such processes.

Hence, $h_1 + \frac{1}{2}c_1^2 = h_2 + \frac{1}{2}c_2^2 + w_s$

AEE is involved for processes involving both energy transfer and energy transformation. Some adiabatic processes involve only energy transformation, e.g., expansion of gases in nozzles and compression of gases in diffusers. In these, shaft work is absent

$$h_1 + \frac{1}{2}c_1^2 = h_2 + \frac{1}{2}c_2^2 \text{ (when change in elevation is ignored)}$$

Stagnation or Total enthalpy (h_0): Stagnation enthalpy of a gas or a vapor is its enthalpy when it is adiabatically decelerated to zero velocity at zero elevation. Putting $h_1 = h$ and $c_1 = c$ for the initial state; $h_2 = h_0$ and $c_2 = 0$ for the final state, then

$$h_0 = h + \frac{1}{2}c^2$$

Consider a steady flow of a fluid through a duct such as nozzle or diffuser, where the flow takes place adiabatically with no shaft work and negligible potential energy, we get

$$h_1 + \frac{1}{2}c_1^2 = h_2 + \frac{1}{2}c_2^2 + w_s$$

$h_{01} = h_{02} \Rightarrow$ Stagnation enthalpy remains constant.

Unit - I

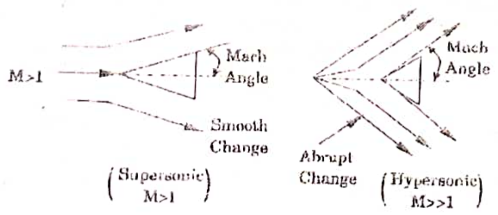
BASIC CONCEPTS AND ISENTROPIC FLOWS

PART – A

1. What is the basic difference between compressible and incompressible fluid flow?

Compressible	Incompressible
1. Fluid velocities are appreciable compared with the velocity of sound	1. Fluid velocities are small compared with the velocity of Sound
2. Density is not constant	2. Density is constant

2. Define mach angle and mach wedge.



Mach angle is formed, when an object is moving with supersonic speed. The wave propagation and changes are smooth. When an object is moving with hypersonic speed the changes are abrupt is shown in Fig. Hence for a supersonic flow over two - dimensional object **"mach wedge"** is used instead of **"mach cone"**

3. State the meaning of stagnation state, stagnation pressures and stagnation temperatures.

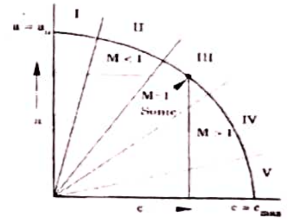
The state of a fluid attained by isentropically decelerating it to zero velocity at zero elevation is referred as stagnation state.
The pressure of the fluid when the fluid velocity is zero at zero elevation is known as "stagnation pressure".
The temperature of the fluid when the fluid velocity is zero at zero elevation is known as "stagnation temperature".

$$T_0 = T + \frac{c^2}{2c_p}$$

T = static temperature.
T_0 = stagnation temperature.
$\frac{c^2}{2c_p}$ = velocity temperature

4. What are the different regions of compressible flow?

The adiabatic energy equation for a perfect gas is derived in terms of fluid velocity © and sound velocity (a). This is then plotted graphically on the c- a co-ordinates, a steady flow ellipse is obtained.



The various regions of flow are:
(i) Incompressible region (M ≈ 0)
(ii) Subsonic region (M < 1)
(iii) Transonic region (0.8 – 1.2)
(iv) Supersonic region (M > 1 and M < 1)
(v) Hypersonic region (M ≥ 5)

5. What is the use of mach number and its uses?

Mach number is defined as the ratio between the local fluid velocity to the velocity of sound.

Mach Number $M = \frac{\text{local fluid velocity}}{\text{velocity of sound}} = \frac{c}{a}$

It is used for the analysis of compressible fluid flow problems. Critical mach number is a dimensionless number at which the fluid velocity is equal to its sound velocity.

$$M_{critical} = \frac{c}{a^*}$$

6. Define M* and give the relation between M and M*.

It is a non-dimensional mach number and is defined by the ratio between the local fluid velocity to its critical velocity of sound / fluid.

23/11/19/FN

Reg. No. :

Question Paper Code : 91851

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2019
Sixth Semester
Mechanical Engineering
ME 6604 – GAS DYNAMICS AND JET PROPULSION
(Regulations 2013)
(Common to PTME 6604 – Gas Dynamics and Jet Propulsion for B.E. (Part-Time) – Fifth Semester – Mechanical Engineering – Regulations 2014)

Time : Three Hours   Maximum : 100 Marks

Use of Standard Gas Tables Permitted.
Answer ALL questions.

PART – A   (10×2=20 Marks)

1. What do you understand by compressibility effect ?
2. Differentiate between first and third critical of CD nozzle.
3. In Rayleigh flow, what is the Mach number at which the total enthalpy is maximum ?
4. How do you specify the equivalent diameter for non circular cross sections ?
5. Distinguish between 'Shock angle' and 'deviation angle'.
6. What is the response of change of fluid stagnation states across a normal shock ?
7. What is after burning in turbojet engines ?
8. Differentiate between pressure thrust and momentum thrust.
9. Compare the merits and demerits of bi-propellants with monopropellants.
10. What is weight flow co-efficient ?

PART – B   (5×13=65 Marks)

11. a) i) Discuss the change of Mach number in CD nozzle under various back pressure. (5)

ii) An airplane is traveling while you are observing from the ground. How will you know whether it is subsonic or supersonic ? Explain. (5)

iii) How fluid stagnation states will change if the fluid flow in diffuser follows an adiabatic process ? (3)

(OR)

Name :-	Devarajan. S
Register No :-	110121114303
Subject :-	Gas Dynamics and Jet Propulsion
Subcode :-	CME386
Date :-	25.08.2023
Assignment No :-	Assignment No :- 1

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S. Devarajan

Given Data:-

$P_1 = 0.7\,bar = 0.7 \times 10^5\ N/m^2$

$T_1 = 300\,k$; $A_1 = 1200\,cm^2 = 1200 \times 10^{-4}\ m^2$

$M_1 = 1.98$

To find

1.) P^*, T^*, C^* at Throat Section

2.) P_t, T_t, C_t at Test Section

3.) mass flow Rate.

4) Power required to drive the compressor.

5.) Area of the Cross Section at the test Section

Soln:- At throat Section, $M = 1$

At $\gamma = 1.4$ & $M = 1$ (GT)

$$\frac{T^*}{T_0} = 0.834 \qquad \frac{P^*}{P_0} = 0.528$$

1.) $T^* = 0.834 \times T_0 \Rightarrow 250.2\,k = T^*$

$P^* = P_0 \times 0.528 \Rightarrow 0.369 \times 10^5\ N/m^2$

$C^* = a^* = \sqrt{\gamma R T^*} = \sqrt{1.4 \times 287 \times 250.2}$

$= 317.06\,m/s$

2/

From $M_1 = 1.98$ & $\gamma = 1.4$

$$\frac{T_t}{T_0} = 0.561;\quad \frac{P_t}{P_0} = 0.132;\quad \frac{A_t}{A^*} = 1.659$$

$T_t = 0.561 \times T_0 = 168.3\,k$

$P_t = 0.132 \times P_0 = 0.0924 \times 10^5\ N/m^2$

Reg. No: | | | | | | | | | | | | |

AALIM MUHAMMED SALEGH COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
INTERNAL ASSESSMENT EXAM I, 1st September 2023
Course Code & Title: CME386—Gas Dynamics and Jet Propulsion
(Regulations R 2021)

COs	Course Outcome: Upon the completion of this course the students will be able to...
CO1	Apply the fundamentals of compressible flow concepts and the use of gas tables.
CO2	Analyze the compressible flow behaviour in constant area ducts.
CO3	Analyze the development of shock waves and its effects.

(Use of Gas table is permitted)

Time: 3 Hours | **Maximum : 100 Marks**

Answer ALL Questions.
PART – A(10× 2=20 Marks)

No.	Question	BT	CO
1.	Distinguish static and stagnation quantities	BT-2	CO1
2.	When does maximum flow occur for an isentropic flow with variable area duct?	BT-1	CO1
3.	Higher velocity of supersonic flow, smaller the angle of Mach cone, comment on the validity of this statement.	BT-2	CO1
4.	Define crocco number.	BT-1	CO1
5.	Give assumption made of Rayleigh flow	BT-1	CO2
6.	Define Rayleigh line and state its applications.	BT-1	CO2
7.	What is known as chocked fanno flow?	BT-1	CO2
8.	List the governing equation that useful to describe the Rayleigh flow.	BT-1	CO2
9.	Give the difference between normal and oblique shock?	BT-2	CO3
10.	What is mean by oblique shock wave?	BT-1	CO3

PART – B (5× 13 = 65 Marks)

11\. A What is the effect of Mach number on compressibility? Prove for γ=1.4, $P_o - P / \frac{1}{2} P c^2 = 1 + \frac{1}{4}M^2 + \frac{1}{40} M^4 + \ldots\ldots$ — 13 BT-1 CO1

OR

11\. B Starting from Continuity equation derive the expression for the area variation in terms of Mach number and velocity variation and hence obtain the shape geometry. for both subsonic and supersonic nozzles and diffusers. — 13 BT-1 CO1

12\. A The pressure, temperature and fluid velocity of air at the entry of a flow passage are 3bar, 280K and 140m/s. The pressure ,temperature and velocity at the exit of the flow passage are 2bar,260K and 250m/s. The area of cross section at entry is 600cm^2. Determine for adiabatic flow, — 13 BT-3 CO1

1. Stagnation temperature
2. Maximum velocity
3. Mass flow rate
4. Area of cross section at exit
5. Area Ratio
6. Critical Temperature

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Internal - I ✓	Internal - II	Model
Subject Code	CME-386	
Subject Name	Gas Dynamics & Jet Propulsion	
Name of the Student	Abdul Wahid M	
Register No	110121114002	
Year / Section	III rd / V th / 'A' Sec	

Q.No	Marks	Q.No	Marks	Q.No	Marks	Q.No	Marks
1	2	6	2	11A	9	16a	4
2	2	7	2	12A	13	16b	6
3	2	8	2	13A	11	16c	3
4	2	9	2	14A	12		
5	2	10	2	15A	13		
Total	10		10				
Grand Total	91					Signature	

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91

Part—A

1.

Static Quantities	Stagnation Quantities
* It is denoted by ~~suffix~~ subscript '*'.	* It is denoted by subscript 'o'.
* It defines quantities such as speed/velocity, pressure, temperature, area, enthalpy & entropy.	* It defines qualities such as ~~as~~ velocity, pressure, temperature, area, enthalpy & entropy.
* It describes the initial conditions of $C^*, P^*, T^*, A^*, h^*, S^*$.	* It describes the stagnated conditions of $C_0, P_0, T_0, A_0, h_0, S_0$.

2

2. Maximum flow occurs for an isentropic flow with variable duct area if the mach number is 1; (M=1).

2

3. Higher velocity of supersonic flow gives smaller mach cone angle because in supersonic flow (M>1), then 'c' increases as a result mach cone ~~angle~~ shrinks and the mach cone angle gets smaller.