SEMESTER 8

HIGH SPEED PROPULSION SYSTEMS

Course Code	**PEAOT862**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Engineering Thermodynamics and Fluid mechanics	**Course Type**	Theory

Course Objectives:

1. Understand the basic working and application of ramjet, scramjet, and rocket engines.
2. Introduction to aerodynamics of hypersonic propulsion system.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**FUNDAMENTALS OF HIGH TEMPERATURE GAS DYNAMICS** High temperature effects, Calculation of entropy produced by equilibrium and non-equilibrium chemically reacting gases, governing equations for inviscid non-equilibrium flows, Normal shockwave, Oblique shock waves for equilibrium and non-equilibrium chemically reacting flows, equilibrium and non-equilibrium one dimensional nozzle flows.	8
2	**PRINCIPLE OF OPERATION OF RAMJET** Ideal ramjet performance, Ram jet calculations, various components of Ramjet engines and their efficiencies, combustion chamber, combustion efficiency, combustion in Ramjet engine, flame stability problems in ramjet combustors –integral ram rockets. Quasi one dimensional heat addition Ram jet intakes with different operation condition, (Numerical calculations).	8
3	**PRINCIPLE OF OPERATION OF SCRAMJET** Need of supersonic combustion, performance parameters, Scramjet inlets, Starting and contraction limit, high temperature effect, blunt leading-edge effect, viscous phenomenon, boundary layer interaction and separation, design and performance of scram jet inlets, three-dimensional inlet design. Combustor flow, step combustor, isolator combustor, different types of fuel	10

KTU SPECIAL

	injection, mixing, combustor reaction, dual mode combustor, isolator, thermal choking, and nozzles.	
4	**PRINCIPLE OF OPERATION OF ROCKET ENGINES** Solid propellant rocket: - Thrust equation, burning rate, different types of grain for different thrust requirements, propellant casting, importance if particle size, types of ignition systems, combustion of solid propellant, solid propellant motor design, solid propellants. (Numerical calculations). Operating principle of liquid propellant rocket engines, propellants injectors and feed systems, Types of ignition systems, gelled propellants, gaseous propellant, selection of nozzles, combustion chamber and combustion in liquid propellant**,** cryogenic engines, (Numerical Problems).	**10**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

KTU SPECIAL

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic equilibrium and non-equilibrium flow of different flow conditions.	**K2**
CO2	Apply the law of thermodynamics to find the values of performance parameters of RAMJET engine.	**K3**
CO3	Describe the fundamentals of SCRAMJET engines and its requirement.	**K2**
CO4	Elaborate the working of solid and liquid propellant rocket engines	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	1	1
CO2	3	2	-	-	-	-	-	-	-	-	1	2
CO3	2	1	-	-	-	-	-	-	-	-	1	1
CO4	2	1	-	-	-	-	-	-	-	-	1	1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

KTU SPECIAL

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1.	Gas Turbine Theory	H Cohen. G F C Rogers HIH Saravanamuthoo	Pearson	5th Edition
2.	Rocket Propulsion Elements	Sutton	Wiley	9th Edition
3.	Gas Turbine Theory	H Cohen. G F C Rogers HIH Saravanamuthoo	Pearson	5th Edition

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1.	Hypersonic Air breathing Propulsion	William H. Heiser and David T. Pratt	AIAA Education Series	
2.	Hypersonic Aerothermodynamics	John J. Bertin	AIAA Education Series	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1.	https://onlinecourses.nptel.ac.in/noc24_ae12/preview
2.	https://archive.nptel.ac.in/courses/101/104/101104084/
3.	https://archive.nptel.ac.in/courses/101/104/101104084/
4.	https://onlinecourses.nptel.ac.in/noc22_ae03/preview

KTU SPECIAL