AEROSPACE PROPULSION

I Semester: AEROSPACE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
BAEB02	Core	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

COURSE OBJECTIVES:

The course should enable the students to:

I. Understand the basic working principles of different types of air breathing engines.
II. Understand analysis and design principles of IC engines.
III. Analyze and design different components of gas turbine.
IV. Analyze and design different components of solid and liquid propellant rockets.

COURSE OUTCOMES (COs):

CO 1: Describe the various types, basic function, and performance analysis of air-breathing engine.
CO 2: Understand the various inlets and combustion chamber performance parameters affecting it.
CO 3: Describe principle operations of compressors, with work done and pressure rise explaining the design and performance parameters of turbine, understand configuration associated
CO 4: Discuss the working principle of solid and liquid propellant rockets and gain basic knowledge of hybrid rocket propulsion.
CO 5: Demonstrate the working principle of liquid propellant rockets and gain basic knowledge of rocket propulsion and its feed systems.

COURSE LEARNING OUTCOMES (CLOs):

1. Demonstrate different type's aircraft engine operating principle.
2. Understand steps involved in performance analysis of all aircraft engine.
3. Analyze the engine performance parameters and parameters influencing them.
4. Describe operational modes of subsonic inlets and parameters influencing it.
5. Understand different types of combustion chamber and functions of all the components.
6. Describe supersonic inlets, starting problem in it and their operating modes.
7. Understand different design of compressor and limitations of each method.
8. Describe principle of operation of centrifugal and axial flow turbine.
9. Analyze performance characteristics of axial and centrifugal compressor.
10. Appreciate the different propellant feed system options for both chemical and electric propulsion systems, and their similarities/differences.
11. Demonstrate the salient features of solid propellants rockets and estimate the grain configuration designs suitable for different missions.
12. Identify the applications of standard and reverse hybrid systems with an overview of its limitations.
13. Discuss the various feed systems and injectors for liquid propellants rockets and associated heat transfer problems
14. Appreciate the different propellant feed system options for both chemical and electric propulsion systems, and their similarities/differences.
15. Discuss the various feed systems and injectors for liquid propellants rockets and associated heat transfer problems.

MODULE-I	**AIR-BREATHING ENGINES**	**Classes: 09**
Classification, operational envelopes; Description and function of gas generator, turbojet, turbofan, turboprop, turbo shaft, ramjet, scramjet, turbojet/ramjet combined cycle engine; Engine thrust, takeoff thrust, installed thrust, thrust equation; Engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency, engine overall efficiency and its impact on aircraft range and endurance; Engine cycle analysis and performance analysis for turbojet, turbojet with afterburner, turbofan engine, turboprop engine.		
MODULE -II	**AIRCRAFT ENGINE INLETS, EXHAUST NOZZLES, COMBUSTORS AND AFTERBURNERS**	**Classes: 09**
Subsonic inlets: Function, design variables, operating conditions, inlet performance, performance parameters; Supersonic inlets: Compression process, types, construction, losses, performance characteristics; Exhaust nozzles: primary nozzle, fan nozzle, converging nozzle, converging-diverging nozzle, variable nozzle, and performance maps, thrust reversers and thrust vectoring, Combustors and Afterburners: Geometries, flame stability, ignition and engine starting, adiabatic flame temperature, pressure losses, performance maps, fuel types and properties.		
MODULE-III	**AXIAL FLOW COMPRESSORS AND TURBINES**	**Classes: 09**
Axial flow Compressors: Geometry, definition of flow angles, stage parameters, cascade aerodynamics, aerodynamic forces on compressor blades, rotor and stator frames of reference, compressor performance maps, velocity polygons or triangles, single stage energy analysis, compressor instability, stall and surge. Axial Flow Turbines: Geometry, configuration, comparison with axial flow compressors, velocity polygons or triangles, single stage energy analysis, performance maps, thermal limits of blades and vanes, blade cooling, blade and vane materials, blade and vane manufacture.		
MODULE-IV	**SOLID-PROPELLANT ROCKET MOTORS**	**Classes: 09**
Background description: Classification of rocket propulsion systems; Performance of an ideal rocket, rocket thrust equation, total and specific impulse, effective exhaust velocity, rocket efficiencies, characteristic velocity, thrust coefficient; Description of solid propellant rocket motor, solid propellant grain configurations, homogeneous propellant, heterogeneous or composite propellant, different grain cross sections, propellant burning rate, combustion of solid propellants, physical and chemical processes, ignition process, combustion instability; Hybrid propellant rockets: Hybrid rocket operation and hybrid rocket characteristics.		
MODULE-V	**LIQUID PROPELLANT ROCKET ENGINES: PROPELLANT TYPES**	**Classes: 09**
Bipropellant, monopropellant, cold gas propellant, cryogenic propellant, storable propellants, gelled propellant; Propellant Storage, different propellant tank arrangements, propellant feed system-pressure feed, turbo-pump feed; Thrust chambers, injectors, combustion chamber, nozzle, starting and ignition, variable thrust; Combustion of liquid propellants: Combustion process, combustion instability, thrust vector control.		
Text Books:		
1. Ronald D. Flack, "Fundamentals of Jet Propulsion with Applications", Cambridge University Press, 3rd Edition, 2011. 2. George P. Sutton, Oscar Biblarz, "Rocket Propulsion Elements", Wiley India Pvt. Ltd, 7th Edition, 2010.		
Reference Books:		
1. Jack D. Mattingly, "Elements of Propulsion: Gas Turbines and Rockets", AIAA Education Series, 3rd Edition, 2006.		

2. Saeed Farokhi, “Aircraft Propulsion”, Wiley, 2nd Edition, 2014.
3. David R. Greatrix, “Powered Flight: The Engineering of Aerospace Propulsion”, Springer, 3rd Edition, 2012.

Web References:

1. http://www.aero.iisc.ernet.in/page/propulsion
2. https://afreserve.com/aerospace-propulsion
3. http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems- spring-2012/Syllabus/

E-Text Books:

1. http://as.wiley.com/WileyCDA/WileyTitle/productCd-1118307984.html
2. http://www.freeengineeringbooks.com/AeroSpace/Propulsion-Books.php
3. http://www.springer.com/us/book/9781447124849?token=prtst0416p