INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**AIRCRAFT PROPULSION 1**			
Course Code	**A52108**			
Regulation	**R13-JNTUH**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	-	-	4
Course Coordinator	Dr. P.Srinivas Rao			
Team of Instructors	P.Srinivas Rao , Professor, C.Satya Sandeep, Assistant Professor			

I. COURSE OVERVIEW

This course presents aerospace propulsive devices as systems, with functional requirements and engineering and environmental limitations along with requirements and limitations that constrain design choices. Both air-breathing and rocket engines are covered, at a level which enables rational integration of the propulsive system into an overall vehicle design. Mission analysis, fundamental performance relations, and exemplary design solutions are presented.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisite
UG	4	4	Basic concepts of Fluids Some mathematical concepts and equations of thermodynamics and fluid mechanics

III. MARKS DISTRIBUTION

Sessional Marks	University End Exam Marks	Total Marks
Mid Semester Test There shall be two midterm examinations. Each midterm examination consists of subjective type and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. **Assignment** Five marks are marked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course	75	100

IV. EVALUATION SCHEME

S No	Component	Duration	Marks
1	I Mid examination	80 minutes	20
2	I Assignment	--	05
3	II Mid examination	80 minutes	20
4	II Assignment	--	05
5	External examination	3 hours	75

V. COURSE OBJECTIVES:

I. **Discuss** and revise the basic thermodynamics and propulsion concepts.
II. **Understand** the all types of engines for atmospheric travel and space travel.
III. **Analyze** parametric cyclic analysis of all Air breathing Engines
IV. **Knowledge** of all types of engines construction and its parts
V. **Understand** type of flow inside the engines..
VI. **Discuss** the all types of engines working models with examples.

VI. COURSE OUTCOMES

At the end of the course the students are able to:

1. **Apply** knowledge and understand the essential facts, concepts and principles of thermodynamics.
2. **Apply** the basic knowledge in mathematics, physical science in propulsion.
3. **Apply** the basic knowledge to design a mathematical system or a Mechanical system or a process that meets desired specifications and requirements.
4. **Analyze** the all types of engines.
5. **Analyze** how the aerodynamics affects the aircraft engine design and its operation.
6. **Analyze** the working principle of all air breathing engines and rocket propulsion.
7. **Analyze** the all parts of Atmospheric Vehicles.
8. **Evaluate** the Engine performance values.
9. **Analyze** the Visualized data from calculated values and graphs.
10. **Analyze** the Aircraft Engines future scope also

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program outcomes		Level	Proficiency assessed by
PO1	**General knowledge:** An ability to apply the knowledge of mathematics, science and Engineering for solving multifaceted issues of Aeronautical Engineering	H	Assignments
PO2	**Problem Analysis**: An ability to communicate effectively and to prepare formal technical plans leading to solutions and detailed reports for Aeronautical systems		
PO3	**Design/Development of solutions**: To develop Broad theoretical knowledge in Aeronautical Engineering and learn the methods of applying them to identify, formulate and solve practical problems involving Aerodynamics	H	Assignments, Discussion
PO4	**Conduct investigations of complex problems**: An ability to apply the techniques of using appropriate technologies to investigate, analyze, design, simulate and/or fabricate/commission complete systems involving complex aerodynamics flow situations.	H	Exercise
PO5	**Modern tool usage**: An ability to model real life problems using different hardware and software platforms, both offline and real-time with the help of various tools along with upgraded versions.	S	

PO6	**The engineer and society**: An Ability to design and fabricate modules, control systems and relevant processes to meet desired performance needs, within realistic constraints for social needs	S	Exercise
PO7	**Environment and sustainability**: An ability To estimate the feasibility, applicability, optimality and future scope of power networks and apparatus for design of eco-friendly with sustainability	S	Discussion, Seminars
PO8	**Ethics**: To Possess an appreciation of professional, societal, environmental and ethical issues and proper use of renewable resources		
PO9	**Individual and team work**: An Ability to design schemes involving signal sensing and processing leading to decision making for real time Aeronautical systems and processes at individual and team levels.	S	Discussions
PO10	**Communication**: an Ability to work in a team and comprehend his/her scope of work, deliverables, issues and be able to communicate both in verbal, written for effective technical presentation	S	Discussion, Seminars
PO11	**Project management and finance**: To be familiar with project management problems and basic financial principles for a multi-disciplinary work	S	Assignments
PO12	**Life-long learning**: An ability to align with and upgrade to higher learning and research activities along with engaging in life-long learning.		

S – Supportive **H – Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	H	Lectures, Assignments
PSO2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	S	Tutorials
PSO3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	S	Seminars and Projects
PSO4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats	S	Assignments

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IX. SYLLABUS

UNIT-I

FLIGHT PROPULSION- AIRCRAFT GAS TURBINE ENGINES- GENERATION OF THRUST- ENGINE PERFORMANCE PARAMETERS

History of flight propulsion. Role of reciprocating engines. Operating envelope of flight vehicles. Engine operational limits. Air breathing engines- types. Aircraft gas turbine engines- types, operating principles, distinguishing features- schematic diagrams, relative merits, applications. Engine components- function, schematic diagram, layout, and engine station numbering. Thrust generation- momentum equations. Gross, net, uninstalled, installed thrust, propulsive efficiency. Engine performance parameters- specific thrust, specific fuel consumption, total efficiency- performance trends. Effect of flight conditions, jet exit speed, exit pressure. Role of propulsion in aircraft performance. Criteria for engine selection, airframe-engine matching.

UNIT- II

AEROTHERMODYNAMIC MODELING OF ENGINE AND COMPONENTS- PARAMETRIC CYCLE ANALYSIS OF ENGINES

Engine components- performance requirements, thermodynamic processes- pressure ratios, temperature ratios. Energy transfer, losses - Performance- polytrophic, stage and component efficiencies, burning efficiency, under and over expansion - figures of merit- significance- ideal component characteristics.Aircraft gas turbine engines - cycle representation- turbojet, turbojet with reheat, turbofan- identification of engine components in the cycle. Computation of net work, thermal efficiency- application to thrust equationParametric cycle analysis- definition, purpose- determination of engine performance parameters- effect of component performance, engine design choices, design constraints, flight conditions, operating parameters determination of engine design point, design point performance. Computation for ideal Turbojet, Turbo fan engines.

UNIT- III

AIRCRAFT ENGINE COMPONENTS- NON-ROTATING- INLETS AND EXHAUST NOZZLES COMBUSTION SYSTEMS- COMBUSTORS, AFTERBURNERS, DUCTS AND MIXERS

Subsonic inlets- function, performance requirements, geometry, operating conditions, flow field, capture area, sizing. Flow distortion, diffuser losses- methods for mitigation. Performance Characteristics- Supersonic inlets- compression process, types, construction, losses, performance characteristics.Exhaust nozzles- primary nozzle, fan nozzle- governing equations of flow- choking, engine back pressure control, nozzle-area ratio, thrust reversing, vectoring- mechanisms. Performance - performance maps.Combustion process- characteristics- effects of fuel-air mixture ratio, mass flow rate, combustor volume, pressure. Combustion loading parameter, sizing of combustor. 1-D modeling of flow. Burners- types, components- function, schematic diagram, airflow distribution, cooling- types, cooling effectiveness. Combustor performance parameters- effect of combustor design. Fuel injection, atomization, vaporization, recirculation- flame stabilization, flame holders. Afterburners, function, components, design requirements, design parameters. The bypass duct- total pressure losses. Mixing process- pressure losses. Aircraft gas turbine engine fuels- composition, specifications of commonly used fuels.

UNIT- IV

ROTATING MACHINERY- AXIAL FLOW COMPESSORS - AXIAL FLOW TURBINES

Axial Flow Compressors - Operating principle, description of flow field. Construction- Flow analysis- Flow analysis- Euler’s turbo-machinery equations, Velocity diagram analysis. Stage parameters- Flow losses- causes- efficiency, relation to total pressure loss coefficient.Axial flow turbines- similarities and differences with compressors. Velocity diagram analysis- no exit swirl condition, flow losses- causes- Computation of stage parameters for ideal and real Compressors and turbine of given cascade–blade geometry and initial flow conditions and turbine speed- procedure. Limits on achievable performance of compressors and turbines – flow problems – surge, separation, rotating stall, wind-milling, blade stresses, temperatures – solutions – variable stators, multi-staging, multi- spooling, blade cooling. Operation at off design speeds. Range of typical axial flow compressor and turbine design parameters. Typical blade profiles.

UNIT- V

PERFORMANCE ANALYSIS- COMPONENT MATCHING

Non dimensionalisation and correction of engine and component characteristic parameters- merits- corrected performance. Performance analysis of compressor, fan, burner, turbine, exhaust nozzle. Relation between compressor pressure ratios, mass flow rate, efficiency, engine speed. Engine control- throttle lever setting, fuel flow, burner temperature ratio, turbine speed, flow coefficient, mass flow rate- relations. Off design performance of compressor- compressor operating line- significance, application to engine performance analysis. Engine thrust ratings.Component matching- significance, requirements, and simplifying assumptions- choked turbine and exhaust nozzle flow, constant component efficiencies. Turbine inlet temperature as control parameter. Engine working lines. Effect of exhaust nozzle area, turbine inlet vane. Component matching for gas generator, turbo jet engine. Engine performance maps. Use of matching data to second stage design. Review of aircraft-engine matching.

TEXT BOOKS

1. Mattingly, J.D., Elements of Gas Turbine Propulsion, McGraw-Hill, 1996, ISBN0-07-912196-9.
2. Flack, R.D., Fundamentals of Jet Propulsion with Applications, Cambridge University Press, 2005, ISBN 0-521-81983-0.
3. Oates, G.C., ed., Aerothermodynamics of Aircraft Engine Components, AIAA, 1985, ISBN 0-915928-97-3.
4. The Jet Engine, Rolls Royce plc. 1986, ISBN 0-902121-2-5.

REFERENCES

1. Cumpsty, N., Jet Propulsion, 2ndend. Cambridge University Press, 2005, ISBN 0-521-54144-1.
2. Kerrebrock, J.L., Aircraft Engines and Gas Turbines, 2ndend. , MIT Press, 1992, ISBN 0-262-11162-4.
3. Hill, P.G. and Peterson, C.R., Mechanics and Thermodynamics of Propulsion, 2ndend. , Addison Wesley, 1992.
4. Saravanamuttoo, H.I.H., Rogers, G.F.C. and Cohen, H., Gas Turbine Theory, 5thend. Prentice Hall, 2001.
5. El-Sayed, A.F., Aircraft Propulsion and Gas Turbine Engines, CRC Press, 2008, ISBN 978-0-8493-9196-5.
6. Boyce, M.P., Gas Turbine Engineering Handbook, 2ndend. Gulf Professional Publishing, 2002, ISBN 0-88415-732-6.
7. The Aircraft Gas Turbine Engine and Operation, Pratt& Whitney, 1988.

X. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No	Course Learning Outcomes	Topics to be covered	Reference
1-2	**Explain** basic concept of Flight Propulsion system	**UNIT-I FLIGHT PROPULSION- AIRCRAFT GAS TURBINE ENGINES- GENERATION OF THRUST-ENGINE PERFORMANCE PARAMETERS** Introduction	T1,T2
3-5	**Describe** Reciprocating Working principle	History of flight propulsion. Role of reciprocating engines. Operating envelope of flight vehicles	T1,T2
6-7	**Define** Air breathing engines in detail	Engine operational limits. Air breathing engines- types. Aircraft gas turbine engines- types	T1,T2
8-9	**Discuss** operating principle of different gas turbine engines	operating principles, distinguishing features- schematic diagrams, relative merits, applications	T1,T2
10-12	**Discuss** components of engines and functions	Engine components- function, schematic diagram, layout, engine station numbering	T1,T2
13-15	**Define** thrust and momentum equations	Thrust generation- momentum equations	T1,T2
16-18	**Discuss installed** and uninstalled thrust and prop. efficiency	Gross, net, uninstalled, installed thrust, propulsive efficiency	T1,T2
19-21	**Derive** Engine performance parameters.	Engine performance parameters- specific thrust, specific fuel consumption	T1,T2
22-23	**Define** efficiency and performance trends	Total efficiency- performance trends. Effect of flight conditions	T1,T2

24-26	**Discuss** jet exit speeds and exit pressure	Jet exit speed, exit pressure. Role of propulsion in aircraft performance	T1,T2
27-28	**Discuss** criteria for engine selection	Criteria for engine selection	T1,T2
29-30	**Explain** Airframe engine matching	airframe-engine matching	T1,T2
31-33	**Justify** thermodynamic principles	**AEROTHERMODYNAMIC MODELING OF ENGINE AND COMPONENTS- PARAMETRIC CYCLE ANALYSIS OF ENGINES**	T1,T2
34-36	**Discuss** Engine components and performance requirements	Engine components- performance requirements, thermodynamic processes	T1,T2
37-38	**Discuss** Pressure ratios and temp. ratios inside the duct	Pressure ratios, temperature ratios. Energy transfer	T1,T2
39-40	**Explain** Performance characteristics of an engine	losses - Performance- polytrophic, stage and component efficiencies	T1,T2
41-43	**Derive** burning efficiency, under and over expansion	burning efficiency, under and over expansion	T1,T2
44-46	**Explain** ideal component characteristics	Figures of merit- significance- ideal component characteristics.	T1,T2
47-49	**Explain** gas turbine engines	Aircraft gas turbine engines - cycle representation	T1,T2
50-52	**Discuss and analyze** Turbo jet & turbo fan	turbojet with reheat, turbofan	T1,T2
53-55	**Discuss and analyze** engine components in the cycle	identification of engine components in the cycle	T1,T2
56-59	**Analyze** thermal efficiency & thrust equation	Computation of net work, thermal efficiency- application to thrust equation	T1,T2
60-62	**Discuss** parametric cycle analysis	Parametric cycle analysis- definition, purpose	T1,T2
63-65	**Explain** engine performance parameters	determination of engine performance parameters	T1,T2

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
I		H											H			
II														H		
III			H						H		H					H
IV				H			H					H		H		

V			H							H					H	
VI		H					H					H	H	H		

S – Supportive **H - Highly related**

XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Outcomes	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1	H	H	H		H						H					
2							H		H				H			H
3			H			H					H			H		
4								H							H	
5					H											
6				H						H	H			H		H
7		H			H		H									
8									H						H	
9							H							H		H
10	H		H									H				

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