J.J COLLEGE OF ENGINEERING AND TECHNOLOGY

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SOWDAMBIKAA GROUP OF INSTITUTIONS

ESTD. 1994

DEPARTMENT OF AERONAUTICAL ENGINEERING

AE3402–AIRBREATHING PROPULSION

QUESTION BANK

R-2021

INSTITUTE VISION & MISSION

VISION:

To become a globally recognized "Centre of Academic Excellence" providing Quality Education to all students.

MISSION:

To provide Quality Education in the fields of Engineering, Management, Information, Technology and other Engineering areas.

DEPARTMENT VISION & MISSION

VISION:

To prepare technically skilled and competent intellectual professional graduates to meet the challenges in the Aerospace industry.

MISSION:

M1: To produce technologically competent graduates to be front-runner in their profession.

M2: To provide state-of-the-art facilities and laboratories so as to enhance excellence in teaching and learning process.

M3: To provide need-based quality training programmes in the field of the Aerospace industry.

M4: Enhance the students' sound knowledge in the latest technologies by organizing technical programs and encouraging students to make them present papers and participate in technical events.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1	To employ comprehensive knowledge in Aeronautical Engineering and analytical skills to work towards solving complex problems to excel in the professional career.
PEO2	To design, analyze and produce cutting edge engineering solutions by employing modern techniques and adhering to moral values for sustainable development.
PEO3	To assume global careers and leadership responsibilities through consistent learning with idealistic managerial practices.

PROGRAM OUTCOMES (POs)

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineeringfundamentalsandanengineeringspecializationtothesolutionof complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions Using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including the design of experiments, Analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply to reason in formed by the contextual Knowledge to assess societal, health, safety, legal and cultural issues and the Consequent responsibilities relevant to the professional engineering practice.

PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and Responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a Member or leader in Diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able To comprehend And write effective reports and design documentation, make effective presentations, and give and Receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply These to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to Engage in in dependent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	To gather data using modern tools and apply design techniques to develop solutions for challenges in the domain of Aerodynamics, Propulsion, Aircraft Structures and Aircraft Maintenance with professional ethics.
PSO2	To function as engineering solution providers or entrepreneurs, who are able to manage, innovate, communicate, train and lead a team for continuous improvement.
PSO3	Graduate will be able to work as a team member which will be a main requirement in industry or research organization or in any business enterprise. This will pave the way for successful career for the graduate and also play a role for the success of the organization in which the graduate is employed.

AE3402 **AIR BREATHING PROPULSION** L T P C
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UNIT I PRINCIPLES OF AIR BREATHING ENGINES 9+6

Operating principles of piston engines – thermal efficiency calculations – classification of piston engines - illustration of working of gas turbine engines – factors affecting thrust – methods of thrust augmentation – performance parameters of jet engines.

UNIT II JET ENGINE INTAKES AND EXHAUST NOZZLES 9+6

Ram effect, Internal flow and Stall in subsonic inlets – relation between minimum area ratio and eternal deceleration ratio – diffuser performance – modes of operation - supersonic inlets – starting problem on supersonic inlets – shock swallowing by area variation – real flow through nozzles and nozzle efficiency – losses in nozzles – ejector and variable area nozzles - interaction of nozzle flow with adjacent surfaces – thrust reversal.

UNIT III JET ENGINE COMBUSTION CHAMBERS 9+6

Chemistry of combustion, Combustion equations, Combustion process, classification of combustion chambers – combustion chamber performance – effect of operating variables on performance – flame stabilization, Cooling process, Materials, Aircraft fuels, HHV, LHV, Orsat apparatus

UNIT IV JET ENGINE COMPRESSORS 9+6

Euler's turbo machinery equation, Principle operation of centrifugal compressor, Principle operation of axial flow compressor– Work done and pressure rise – velocity diagrams – degree of reaction – free vortex and constant reaction designs of axial flow compressor – performance parameters axial flow compressors– stage efficiency.

UNIT V JET ENGINE TURBINES 9+6

Principle of operation of axial flow turbines– limitations of radial flow turbines- Work done and pressure rise – Velocity diagrams – degree of reaction – constant nozzle angle designs – performance parameters of axial flow turbine– turbine blade cooling methods – stage efficiency calculations – basic blade profile design considerations – matching of compressor and turbine

TOTAL:75 PERIODS

COURSE OUTCOMES (COs)

On completion of the course, the student is expected :	
CO1	To be able to apply control volume and momentum equation to estimate the forces produced by aircraft propulsion systems
CO2	To be able to describe the principal figures of merit for aircraft engine
CO3	To be able to describe the principal design parameters and constraints that set the performance of gas turbine engines.
CO4	To apply ideal and actual cycle analysis to a gas turbine engine to relate thrust and fuel burn to component performance parameters.
CO5	Understanding the workings of multistage compressor or turbine, and to be able to use velocity triangles and the Euler Turbine Equation to estimate the performance of a compressor or turbine stage.

CO's – PO's & PSO's MAPPING

Correlation of COs with POs / PSOs															
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	1	1	2	3	1	1	1	2	3	1	1	3	1	1
CO2	3	2	2	3	3	2	3	2	2	3	1	1	3	1	1
CO3	3	3	3	3	2	1	2	1	3	2	1	1	3	1	1
CO4	3	3	3	2	3	2	2	1	2	1	2	1	3	1	1
CO5	3	3	2	2	3	1	1	1	1	1	1	1	3	1	1
AVG	**3**	**2.4**	**2.2**	**2.4**	**2.8**	**1.4**	**1.8**	**1.2**	**2**	**2**	**1.2**	**1**	**3**	**1**	**1**
3 – High; 2 – Medium; 1 - Low; - - No correlation															

TEXT BOOK:

1. Hill, P.G. & Peterson, C.R. “Mechanics & Thermodynamics of Propulsion” Pearson Education (2009)

REFERENCE BOOKS:

1. Cohen, H. Rogers, G.F.C. and Saravanamutto, H.I.H. “Gas Turbine Theory”, Pearson Education Canada; 6th edition, 2008.
2. Mathur, M.L. and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers & Distributors, Delhi, 2nd edition 2014.
3. Oates, G.C., “Aero thermodynamics of Aircraft Engine Components”, AIAA Education Series, New York, 1985.
4. “Rolls Royce Jet Engine”, Rolls Royce; 4th revised edition, 1986

UNIT– I

PRINCIPLES OF AIR BREATHING ENGINES

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define SFC and its significance	CO1	Remember	Low
2	Define propulsive efficiency	CO1	Remember	Low
3	Define thrust and specific thrust	CO1	Remember	Low
4	Determine the propulsive efficiency of turbojet whose flight speed is 250m/s, while exhaust jet velocity is 600m/s.	CO1	Understand	Low
5	Define thrust augmentation and its types	CO1	Remember	Low
6	Difference between air breathing and rocket Engine	CO1	Understand	Low
7	Define by pass ratio.	CO1	Remember	Low
8	Define IP and BP	CO1	Remember	Low
9	What is the condition for maximum productive efficiency?	CO1	Understand	Low
10	Mention relative merits of jet engines over piston engines.	CO1	Remember	Low
11	Define Brake horse power.	CO1	Remember	Low
12	What are the advantages and disadvantages of turboprop?	CO1	Understand	Low
13	What are the factors affecting? thrust?	CO1	Understand	Low

14	Write the advantages of turboprop over turbojet engine.	CO1	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Explain the working principle of turbojet with a neat schematic diagram. Also write relative merits and demerits.	CO1	Understand	Medium
2	Elaborate the working principle of turboprop with a neat schematic diagram. Also write relative merits and demerits.	CO1	Understand	Medium
3	Describe the working principle of turbofan with a neat schematic diagram. Also write relative merits and demerits.	CO1	Understand	Medium
4	Derive the thrust equation for jet engine	CO1	Create	High
5	An aircraft takes 45kg/sec of air from the atmosphere and flies at a speed of 950kmph. The air fuel ratio is 50 and the calorific value of the fuel is 42MJ/kg. for maximum thrust power 0.5. find: 1.Jet velocity 2. Thrust 3. Specific thrust 4. Thrust power 5. Propulsive efficiency 6. Thermal efficiency 7.Overall efficiency 8. TSFC 9. Specific impulse	CO1	Create	High
6	Discuss the thrust augmentation and its types with neat sketch.	CO1	Understand	Medium

7	Classify piston engines based on their construction and operation. Support your explanation with diagrams where applicable.	CO1	Understand	Medium
8	Illustrate about working principle of SI engine with neat sketches. Also write relative merits and demerits.	CO1	Analyze	High
9	Describe the principle of afterburner in thrust augmentation.	CO1	Understand	Medium
10	Explain with suitable graphs the performance of a jet engine.	CO1	Understand	Medium

UNIT – II

JET ENGINE INTAKES AND EXHAUST NOZZLES

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	What is Ram Effect?	CO2	Understand	Low
2	Differentiate between external and internal compression inlets.	CO2	Understand	Low
3	List down methods of shock swallowing in inlets.	CO2	Remember	Low
4	List down the modes of inlet operation.	CO2	Remember	Low
5	What are the functions of an exhaust nozzle?	CO2	Understand	Low
6	What do you mean by starting problem of supersonic inlets?	CO2	Understand	Low
7	What is thrust Reversal and its types?	CO2	Understand	Low
8	Compare supersonic inlet and nozzle.	CO2	Understand	Low
9	Define the phenomenon “buzz” in supersonic inlets.	CO2	Remember	Low
10	What are the requirements of an aircraft intake?	CO2	Understand	Low
11	What are the factors to be considered while designing a subsonic inlet?	CO2	Understand	Low
12	What are the factors to be considered while designing a supersonic inlet?	CO2	Understand	Low
13	What is the purpose of inlet?	CO2	Understand	Low
14	Define under expanded nozzle.	CO2	Remember	Low
15	Define over expended nozzle.	CO2	Remember	Low

PART–B				
Q.No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Derive relation between area ratio (A mas / Ai) and external Deceleration ratio (ui /ui)	CO2	Create	High
2	Explain successive steps in the acceleration and over dimensional supersonic inlet with sketches.	CO2	Understand	Medium
3	Explain "Starting problem" in case of supersonic inlets. What is shock swallowing by area variation?	CO2	Understand	Medium
4	With appropriate figure, define four modes of operation of supersonic inlets.	CO2	Understand	Medium
5	Write down the different types of nozzles that are used in aircraft designs.	CO2	Understand	Medium
6	Plot Mach number: static temperature, static pressure and static density variations along longitudinal axis of a convergent-divergent nozzle, when it flows full, explain the variations(Assume correct expansion).	CO2	Understand	Medium
7	A converging –diverging nozzle with an area ratio of 3.0 exhausts into a receiver where is 1 bar. The nozzle supplied by air at 22° C from a larger chamber. At what pressure should the air in the chamber be for the nozzle to operate at its design condition? What pressure should the air in the chamber be for first and second critical point?	CO2	Create	High

8	A de Laval nozzle has to be designed for an exit Mach number of 1.5 with exit diameter of 200mm.find the ratio of throat area necessary. The reservoir conditions are given as P0 = 1.0 bar: T0 =20°C; find also the maximum mass flow rate through the nozzle. What will be the exit pressure and temperature?	CO2	Create	High
9	Mention the methods of shock swallowing in the supersonic inlet operation. What is the need for it? And briefly explain any one method of shock swallowing.	CO2	Understand	High

UNIT – III
JET ENGINE COMBUSTION CHAMBERS

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define Stoichiometric ratio.	CO3	Remember	Low
2	Define Equivalence Ratio.	CO3	Remember	Low
3	Mention the functions of dilution zone in combustion chamber.	CO3	Remember	Low
4	Name the losses combustion chamber.	CO3	Remember	Low
5	What is the purpose of primary air in combustion chamber?	CO3	Understand	Low
6	What is heating value and its types?	CO3	Understand	Low
7	What is ORSAT Apparatus?	CO3	Understand	Low
8	What are the steps in process of combustion in gas turbines?	CO3	Understand	Low
9	Define efficiency of the combustion.	CO3	Remember	Low
10	Define efficiency of combustor.	CO3	Remember	Low
11	Name the major components of a typical gas turbine combustor.	CO3	Remember	Low
12	What are the factors to be considered for combustion chamber design?	CO3	Understand	Low
13	What are the requirements of combustor?	CO3	Understand	Low
14	What is the purpose of primary air in combustion chamber ?	CO3	Understand	Low

15	What are the different types of combustor used in gas turbines?	CO3	Understand	Low
16	Why Flame is to be stabilized inside combustor?	CO3	Understand	Low
17	Define combustion intensity.	CO3	Remember	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Describe the briefly the factors affection the combustion chamber design.	CO3	Understand	Medium
2	With neat be sketch explain the working of a typical combustion in gas turbine.	CO3	Understand	Medium
3	Briefly explain different techniques used for flame stabilization.	CO3	Understand	Medium
4	Write important factors that have to be considered in the selection and design of a gas turbine combustion chamber.	CO3	Understand	Medium
5	An aero engine is using $C_{12}H_{24}$ as a fuel. The temperature of the working fluid at the inlet and outlet of combustion chamber T_{01}=650 K and T_{02}=1600 K. The fuel heating value is Q_{HV} = 42800 kJ/kg. The specific heats of cold and hit streams are C_{pc}=1.005 kJ/kg-Calculate the equivalence ratio.	CO3	Create	High
6	Explain the working of Orast apparatus in detail with neat sketch.	CO3	Understand	Medium

UNIT – IV

JET ENGINE COMPRESSORS

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	What are the primary components of centrifugal compressor?	CO4	Understand	Low
2	Mention the purpose of IGV.	CO4	Remember	Low
3	What is Vortex blading?	CO4	Understand	Low
4	What is Free Vortex Condition?	CO4	Understand	Low
5	Define Stage Loading Coefficient.	CO4	Remember	Low
6	Write down the difference between centrifugal and axial flow compressor.	CO4	Understand	Low
7	Define Slip factor.	CO4	Remember	Low
8	Define Surging and Chocking.	CO4	Remember	Low
9	Define flow coefficient.	CO4	Remember	Low
10	Define degree of reaction of an axial compressor.	CO4	Remember	Low
11	Write the advantages of a centrifugal flow compressor.	CO4	Remember	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	With a neat sketch explain the operating principle of centrifugal compressor with necessary traingles.Derive an expression for work done.	CO4	Understand	Medium
2	What is the degree of reaction in an axial flow compressor stage? Illustrate the typical variation of air angles from root to tip of a blade for a constant reaction design using a labeled diagram.	CO4	Understand	Medium
3	A centrifugal compressor compresses air at ambient temperature and pressure 288K and 101.3 kpa respectively. The impeller runs at tip speed of 365 m/s the radial velocity at exit from the impeller is 30 m/s and slip factor is 0.9 calculate the Mach number of flow area from the impeller is $0.093m^3$. Calculate the mass flow rate of air assume zero whirl at inlet and radial blades($U_2 = C_{w2}$).	CO4	Create	High
4	Draw the h-s diagram of centrifugal compressor and derive the expression between blade loading co-efficient and degree of reaction.	CO4	Create	High
5	Explain the basic operation of an axial flow compressor. Prove that power input stage of the compressor can be written as; $W=m\ U\ c\ \alpha\ (\tan\beta_1 - \tan\beta_2)$	CO4	Understand	Medium
6	An axial flow compressor comprises a number of similar stages with equal work done per stage. The axial velocity remains constant throughout the compressor; overall pressure ratio			

	= 3.5,total inlet temperature = 333 K, Relative air angle at rotor inlet = 40°,relative air angle at rotor outlet = 10°, blade velocity =185 m/s .Overall head isentropic efficiency = 87%,Degrees of reaction = 0; (a) total head outlet temperature,(b) Number of stages.	CO4	Create	High
7	Explain how performance of axial flow compressors can be described by means of compressor characteristics.	CO4	Understand	Medium
8	An axial flow compressor stage has blade root, mean and tip velocities of 150,200 and 250 m/s. The stage is to be designed tor a stagnation temperature rise of20 K and axial velocity is 150 m/s, both constant from root to tip. The work done factor is 0.93, the reaction at mean radius is 0.5 .Calculate the stage air and blade angles at root mean tip section and also degree of reaction for free vortex design	CO4	Create	High
9	With a neat sketch explain the operating principle of axial flow compressor with necessary triangles.	CO4	Understand	Medium

UNIT – V
JET ENGINE TURBINES

PART–A				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Define Blade Loading Coefficient.	CO5	Remember	Low
2	Define Flow Coefficient	CO5	Remember	Low
3	Define blade to gas speed ratio.	CO5	Remember	Low
4	Differentiate between impulse stage and reaction stage turbines.	CO5	Understand	Medium
5	State the function of nozzle guide vane.	CO5	Remember	Low
6	Define Free Vortex Stage in Turbine.	CO5	Remember	Low
7	What are the limitations of Radial Turbines?	CO5	Understand	Low

PART–B				
Q. No	**Questions**	**CO Mapping**	**BT Level**	**Complexity**
1	Briefly explain the design considerations that has to be followed while designing axial turbine blades.	CO5	Understand	Medium
2	Derive the relation for degree of reaction in terms of pressure, velocity, enthalpy and flow geometry.	CO5	Create	High
3	Explain briefly about turbine blade cooling methods.	CO5	Understand	Medium
4	What is the need for matching of compressor and turbine? Write down the matching procedure with suitable sketches.	CO5	Understand	Medium
5	In a single stage impulse turbine, the nozzle discharges the fluid on to the blades at angles of 65° to the axial direction and the fluid leaves with an absolute velocity 300 m/s at an angle 30° to the axial direction. If the blades have equal inlet and outlet angles and there is no axial thrust, estimate the blade angle, power produced per kg / s of the fluid and the blade efficiency.	CO5	Create	High
6	Explain the working principle of impulse and reaction turbine with a neat schematic diagram.	CO5	Understand	Medium
7.	Explain the performance of axial flow turbine in details.	CO5	Understand	Medium

THANK YOU

ALL THE BEST