INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING
TUTORIAL QUESTION BANK

Course Title	**AEROSPACE PROPULSION**				
Course Code	BAEB02				
Programme	M. Tech				
Semester	I	AEROSPACE			
Course Type	Core				
Regulation	**IARE - R18**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. Shiva Prasad U, Assistant Professor				

COURSE OBJECTIVES

The course should enable the students to:

S. No	Description
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):

Students, who complete the course, will be able to demonstrate the ability to do the following

CO1	Describe the various types, basic function, and performance analysis of air-breathing engine.
CO2	Understand the various inlets and combustion chamber performance parameters affecting it.
CO3	Describe principle operations of compressors, with work done and pressure rise explaining the design and performance parameters of turbine, understand configuration

	associated
CO4	Discuss the working principle of solid and liquid propellant rockets and gain basic knowledge of hybrid rocket propulsion.
CO5	Demonstrate the working principle of liquid propellant rockets and gain basic knowledge of rocket propulsion and its feed systems.

COURSE LEARNING OUTCOMES (CLOs):

BAEB02.01	Demonstrate different type's aircraft engine operating principle.
BAEB02.02	Understand steps involved in performance analysis of all aircraft engine.
BAEB02.03	Analyze the engine performance parameters and parameters influencing them.
BAEB02.04	Describe operational modes of subsonic inlets and parameters influencing it.
BAEB02.05	Understand different types of combustion chamber and functions of all the components.
BAEB02.06	Describe supersonic inlets, starting problem in it and their operating modes.
BAEB02.07	Understand different design of compressor and limitations of each method.
BAEB02.08	Describe principle of operation of centrifugal and axial flow turbine.
BAEB02.09	Analyze performance characteristics of axial and centrifugal compressor.
BAEB02.10	Appreciate the different propellant feed system options for both chemical and electric propulsion systems, and their similarities/differences.
BAEB02.11	Demonstrate the salient features of solid propellants rockets and estimate the grain configuration designs suitable for different missions.
BAEB02.12	Identify the applications of standard and reverse hybrid systems with an overview of its limitations.
BAEB02.13	Discuss the various feed systems and injectors for liquid propellants rockets and associated heat transfer problems
BAEB02.14	Appreciate the different propellant feed system options for both chemical and electric propulsion systems, and their similarities/differences.
BAEB02.15	Discuss the various feed systems and injectors for liquid propellants rockets and associated heat transfer problems.

TUTORIAL QUESTION BANK

MODULE I				
AIR-BREATHING ENGINES				
Part - A (Short Answer Questions)				
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes (CLOs)**
1	Write different types of gas turbine engine?	Remember	CO 1	BAEB02.01
2	Differentiate ramjet and turbojet engine.	Remember	CO 1	BAEB02.01
3	What is the type of engine that would be used in a helicopter	Remember	CO 1	BAEB02.01
4	How is a turboprop different from a turbojet?	Remember	CO 1	BAEB02.01
5	What is the type of engine that powers most of today's airliners and why?	Remember	CO 1	BAEB02.01
6	What is the difference between ramjet and scramjet engine?	Remember	CO 1	BAEB02.01
7	Define bypass ratio.	Remember	CO 1	BAEB02.02
8	Define thermal efficiency	Understand	CO 1	BAEB02.02
9	Define propulsive efficiency	Understand	CO 1	BAEB02.02
10	Write thrust equation for simple turbojet engine.	Remember	CO 1	BAEB02.02
11	Define specific thrust	Remember	CO 1	BAEB02.02
12	Describe specific fuel consumption	Understand	CO 1	BAEB02.02
13	Define specific impulse	Understand	CO 1	BAEB02.03
14	What is the need for after burner?	Understand	CO 1	BAEB02.03
15	Write parameters influencing engine thrust	Understand	CO 1	BAEB02.03
16	What is air-breathing engine?	Understand	CO 1	BAEB02.03
17	What is non-air breathing engine?	Understand	CO 1	BAEB02.03
18	What are the factors that affect engine thrust?	Remember	CO 1	BAEB02.03
19	Why turbo fan has better propulsive efficiency?	Remember	CO 1	BAEB02.03
20	What is mean by combined cycle engine	Remember	CO 1	BAEB02.03
Part - B (Long Answer Questions)				
1	Compare between turboprop, turbofan, and turbojet engines (draw figures to illustrate their configurations).	Understand	CO1	BAEB02.01
2	Compare ramjet engines and scramjet engines and highlight their differences based on principle of operation.	Understand	CO1	BAEB02.01
3	Draw and explain in detail the functions of all the major components in the turbojet engine.	Understand	CO1	BAEB02.01
4	Derive thrust equation for ideal turbojet engine and clearly expand the nomenclature of each equation.	Remember	CO1	BAEB02.01
5	Illustrate with proper label the scramjet engine and explain the functions of all the components.	Understand	CO1	BAEB02.01
6	Write short notes on performance parameters of gas turbine engine and give an equation for any one performance parameter.	Understand	CO1	BAEB02.02
7	Explain the need for an air breathing engine. Is an air-breathing engine different from a non-air-breathing engine? explain	Understand	CO1	BAEB02.01
8	Derive isentropic efficiency of a simple turbojet engine. Explain with proper nomenclature for the same.	Understand	CO1	BAEB02.02

9	Sketch a neat and labeled diagram of a turbofan engine and explain its working principle.	Remember	CO1	BAEB02.02
10	Explain in detail the working of a ramjet engine. Also, explain how a ramjet engine is different from a scramjet engine.	Understand	CO1	BAEB02.02
11	Explain and draw a detailed diagram of a turbojet engine with neat sketch. Is a turboprop different from turbofan? Justify	Understand	CO1	BAEB02.02
12	List and explain the factors affecting the engine thrust with neat sketch. Also, explain how a turbofan is different from turboshaft.	Understand	CO1	BAEB02.02
13	What is the difference between ram jet and turbojet and enumerate their advantages and disadvantages.	Understand	CO1	BAEB02.02
14	Explain the flight limit and operational limits for different engines with neat sketch.	Understand	CO1	BAEB02.02
15	Write short notes on air-breathing and non-air-breathing engines and describe about gas generator.	Understand	CO1	BAEB02.03
16	Plot and explain in detail about variation of pressure temperature and velocity across turbojet engine.	Understand	CO1	BAEB02.03
17	What are the advantages and disadvantages of turbojet, turbo prop and turbo fan engines.	Remember	CO1	BAEB02.03
18	What is the need for after burner? Draw and explain the T-S diagram for turbojet engine with and without after burner cycle.	Understand	CO1	BAEB02.03
19	Write short notes on combined cycle engine and explain any one of combined cycle engine with neat sketch.	Remember	CO1	BAEB02.03
20	Derive the equation for propulsive efficiency and explain the reason for turbofan having better propulsive efficiency.	Understand	CO1	BAEB02.03
Part - C (Problem Solving and Critical Thinking Questions)				
1	Air flows through a jet engine at the rate of 30 kg/s and the fuel flow rate is 1 kg/s. The exhaust gases leave the jet nozzle with a relative velocity of 610 m/s. Pressure equilibrium exists over the exit plane. Compute the velocity of the airplane if the thrust power is 1.12 × 106 W.	Understand	CO1	BAEB02.01
2.	A turbojet engine is powering a fighter airplane. Its cruise altitude and Mach number are 10 km and 0.8, respectively. The exhaust gases leave the nozzle at a speed of 570 m/s and a pressure of 0.67 bar. The exhaust nozzle is characterized by the ratio $A_e/\dot{m}_a = 0.006 m^2 \cdot s/kg$. The fuel-to-air ratio is 0.02. It is required to calculate The specific thrust $(T/\dot{m}_a)$.The propulsive efficiency using the different expressions defined above.	Understand	CO1	BAEB02.01
3	Boeing 747 aircraft is powered by four CF-6 turbofan engines manufactured by General Electric Company. Each engine has the following data: Thrust force 24.0 kN, Air mass flow rate 125 kg/s, Bypass ratio 5.0, Fuel mass flow rate 0.75 kg/s, Operating Mach number 0.8, Altitude 10 km Ambient temperature 223.2 K, Ambient pressure 26.4 kPa, Fuel heating value 42,800 kJ/kg If the thrust generated from the fan is 75% of the total thrust, determine (a) The jet velocities of the cold air and hot gases (b) The specific thrust (c) The thrust specific fuel consumption (TSFC)	Understand	CO1	BAEB02.01

4	A Boeing 747 aircraft has a lift-to-drag ratio of 17. The fuel-to-air ratio is 0.02 and the fuel heating value is 45,000 kJ/kg. The ratio between the weight of the aircraft at the end and start of cruise is 0.673. The overall efficiency is 0.35. 1. Calculate the range of aircraft. 2. What will be the fuel consumed in the cruise if the takeoff mass of aircraft is 385,560 kg? 3. If the fuel consumed during the engine start, warming, and climb is 4.4% of the initial aircraft weight and the fuel consumed during descent, landing, and engine stop is 3.8% of the aircraft weight at the end of cruise, calculate the fuel consumed in the whole trip.	Remember	CO1	BAEB02.02
5	The airplane has turbojet engine which produces 12.12 KN thrust at an altitude of 9150 m, where the ambient conditions are 32 kPa and 240 K. The pressure ratio across the compressor is 12 and temperature at the turbine inlet is 1400 K. The aircraft speed is 310 m/s. Assume ideal operation for all components; assume un-choked nozzle and constant specific heat in all processes, Cp = 1005 J/kgK. The heating value of the fuel is 42,700 kJ/kg. Determine (a) The fuel-to-air ratio(b) The velocity of the exhaust gases (c) The air mass flow rate	Remember	CO1	BAEB02.02
6	An aircraft having ideal turbojet engine flying at an altitude where the ambient conditions are 0.458 bar and 248 K. Speed of the aircraft: 805 km/h, Compressor pressure ratio: 4:1, Turbine inlet temperature: 1100 K, Nozzle outlet area 0.0935 m^2, Heat of reaction of the fuel: 43 MJ/kg. Find the thrust and TSFC assuming c_p as 1.005 kJ/kg K and γ as 1.4.	Understand	CO1	BAEB02.02
7	The idling turbojet engines of a landing airplane produce forward thrust when operating in a normal manner, but they can produce reverse thrust if the jet is property deflected. Suppose that, while the aircraft rolls down the runway at 100 mph, the idling engine consumes air at 100 lbm/s and produces an exhaust velocity of 450 ft/s. a) What is the forward thrust of the engine? b) What is the magnitude and direction (forward or reverse) if the exhaust is deflected 90°and if the mass flow is kept constant?	Understand	CO1	BAEB02.03
8	*DASSAULT MIRAGE G* is a two seat Strike and Reconnaissance fighter powered by one *SNECMA TF-306C* turbofan engine. It has the following characteristics: Flight Mach number 0.8, Altitude 65,000 ft, Ambient temperature 216.7 K Ambient pressure 5.5 kPa, Fuel heating value 42,700 kJ/kg, Thrust force 53.4 kN, Air mass flow rate 45 kg/s, Fuel mass flow rate 2.5 kg/s Aircraft gross weight (65,000 ft) 156 kN, Aircraft takeoff weight 173.3 kN Wing area 26.4 m^2, Fuel weight 5. kN, Maximum lift coefficient *C*L max=1.8 *C*D0 = 0.012 *K*1 = 0.2 *K*2 = 0.0, Air density at take-off 1.225 kg/m3 Air density at 650,000 ft 0.88 kg/m3 **Calculate:** The specific thrust TSFC, The exit velocity	Understand	CO1	BAEB02.03

9	The maximum range of an aircraft is given by the relation: $S_{max}=(V_g/TSFC)\ (1/g)(L/D)\ \ln(m1/m2)$ where V_g is the air relative speed including the effect of wind as shown in figure for either head wind or tail wind conditions: 1. Calculate the mass of fuel consumed during a trip where its range is 4000 km, flight speed is 250 m/s, L/D = 10, TSFC = 0.08 kg/N/h, and $m1$ = 50, 000 kg in the following two cases: (i) Head wind = 50 m/s (ii) Tail wind = 50 m/s 2. Calculate the time for such a trip in the above two cases. 	Remember	CO1	BAEB02.03
10	Turbofan engine is powering an aircraft flying at Mach number 0.9, at an altitude of 33,000 ft, where the ambient temperature and pressure are −50.4°and 26.2 kPa. The engine by pass ratio is 3, and the hot airflow passing through the engine core is 22.7 kg/s. Preliminary analysis provided the following results: Fuel-to-air ratio f = 0.015, Pec= 55.26 kPa uec = 339.7 m/s Aec = 0.299m2, Peh= 32.56 kPa ueh= 452 m/s Aeh = 0.229 m^2, Calculate the thrust force and the propulsive efficiency using the first and second expressions.	Understand	CO1	BAEB02.03
MODULE -II				
AIRCRAFT ENGINE INLETS, EXHAUST NOZZLES, COMBUSTORS AND AFTERBURNERS				
Part - A (Short Answer Questions)				
1	Describe about flame holder and its function	Remember	CO2	BAEB02.04
2	Define stoichiometric ratio.	Understand	CO2	BAEB02.04
3	Define combustion efficiency.	Understand	CO2	BAEB02.04
4	Define equivalence ratio	Remember	CO2	BAEB02.04
5	Define combustion intensity	Remember	CO2	BAEB02.04
6	Write different types of internal flow in straight walled diffuser.	Remember	CO2	BAEB02.04
7	What is the function of swirl vanes in combustion chamber?	Remember	CO2	BAEB02.05
8	Describe the function of liner in combustion chamber.	Remember	CO2	BAEB02.05
9	Write different types of subsonic inlets.	Remember	CO2	BAEB02.05
10	Write different types of supersonic inlets.	Remember	CO2	BAEB02.05
11	Define under-expansion	Understand	CO2	BAEB02.05
12	What is the need for variable area nozzle?	Remember	CO2	BAEB02.06
13	Write different techniques used to create variable area nozzle.	Understand	CO2	BAEB02.06
14	Describe about thrust reversal.	Remember	CO2	BAEB02.06
15	What is the need for thrust reversal	Understand	CO2	BAEB02.06
16	What is under expanded condition?	Remember	CO2	BAEB02.06
17	What is the need for variable area nozzle?	Understand	CO2	BAEB02.06
18	What is impulse-to-weight ratio?	Remember	CO2	BAEB02.06
19	Define C* (c-star) and state its equation	Understand	CO2	BAEB02.06
20	What is characteristics Mach number	Remember	CO2	BAEB02.06

Part - B (Long Answer Questions)				
1	Describe about subsonic inlet function and modes of operation with neat sketch.	Understand	CO2	BAEB02.04
2	What is nacelle? What is its purpose? Explain the subsonic inlet nomenclature with neat and labeled sketch.	Remember	CO2	BAEB02.04
3	What do you understand by isentropic efficiency of a diffuser? Does the change in enthalpy change the kinetic energy? Justify	Remember	CO2	BAEB02.04
4	Write short note on starting problem in supersonic inlets. Are the problems predominant in any other forms of inlet?	Remember	CO2	BAEB02.04
5	Write short notes on shock swallowing by area variation. What are the adverse effects of shocks? Explain.	Remember	CO2	BAEB02.04
6	Write short notes on the different types of combustion chamber with neat and labeled sketch.	Remember	CO2	BAEB02.04
7	What do you understand by buzz? What are the factors influencing combustion chamber design.	Understand	CO2	BAEB02.04
8	What do you understand by stoichiometric ratio? Write short notes on flame stabilization in combustion chamber.	Remember	CO2	BAEB02.05
9	Explain the functions of each component in gas turbine combustion chamber. Draw a suitable sketch for it.	Remember	CO2	BAEB02.05
10	What do you understand by equivalence ratio? Write the advantages and disadvantages of the various types of combustion chamber.	Remember	CO2	BAEB02.05
11	A fixed area convergent-divergent nozzle can deliver different Mach number. Explain.	Understand	CO2	BAEB02.05
12	Explain how over-expanded operating condition is possible for convergent nozzle.	Remember	CO2	BAEB02.05
13	Will there be any wave formation in correctly expanded nozzle. Justify your answer.	Understand	CO2	BAEB02.05
14	What is the condition for convergent-divergent nozzle to deliver supersonic Mach number?	Remember	CO2	BAEB02.06
15	Brief about the theory of flow through nozzle and derive an equation for the showing the flow through nozzle.	Understand	CO2	BAEB02.06
16	Write brief note on nozzle choking and illustrate with a labeled diagram, the conditions.	Remember	CO2	BAEB02.06
17	Derive an equation for the flow through nozzle and explain its operating conditions with a diagram.	Understand	CO2	BAEB02.06
18	How is thrust reversal achieved? Is thrust vectoring similar to thrust reversal? Justify your answer.	Remember	CO2	BAEB02.06
19	What is the need for variable area nozzle? Explain your answer justifying the need to introduce such a nozzle.	Understand	CO2	BAEB02.06
20	Write short notes on effective exhaust velocity. Determine why C* is an important characteristic in determining exhaust velocity.	Remember	CO2	BAEB02.06
Part - C (Problem Solving and Critical Thinking Questions)				
1	An aircraft which is flying at an altitude of 10,000m, is powered by a turbojet engine. where Ta = 218K and Pa = 25kPa. The flight Mach number is found to be 0.92. The inlet conditions to the nozzle were found to be 1010 K and 58kPa. The specific heat ratio of air and gases at nozzle are 1.4 and 4/3. The nozzle efficiency is 0.98. Find the thrust per inlet frontal area for C-D nozzle.	Remember	CO2	BAEB02.04
2	What do you understand by characteristic Mach number, and favorable pressure gradient? Also explain correctly expanded condition.	Remember	CO2	BAEB02.04

3	Derive area Mach number relation with clearly determining each nomenclature and its importance.	Remember	CO2	BAEB02.04
4	State the forces developed by thrust reversal during landing and give an equation where V_f is the flight speed and Vj is the exhaust speed, f is the fuel- to-air ratio, and β is the inclination of the exhaust gases leaving the buckets measured from the engine longitudinal axis.	Understand	CO2	BAEB02.04
5	Calculate the dragging force developed by thrust reversers of the *two* engine aircraft in the following case $\dot{m}_a = 50$ kg/s, $f = 0.02$, $\beta = 60^\circ$, $V_j = 600$ m/s and $V_f = 80$ m/s.	Understand	CO2	BAEB02.05
6	Air flows through a jet engine at the rate of 30 kg/s and the fuel flow rate is 1 kg/s. The exhaust gases leave the jet nozzle with a relative velocity of 610 m/s. Pressure equilibrium exists over the exit plane. Compute the velocity of the airplane if the thrust power is 1.12 × 106 W.	Understand	CO2	BAEB02.05
7	A turbojet engine is powering a fighter airplane. Its cruise altitude and Mach number are 10 km and 0.8, respectively. The exhaust gases leave the nozzle at a speed of 570 m/s and a pressure of 0.67 bar. The exhaust nozzle is characterized by the ratio $A_e/\dot{m}_a = 0.006 m^2 \cdot s/kg$. The fuel-to-air ratio is 0.02. It is required to calculate 1. The specific thrust ($T/\dot{m}_a$). 2. The propulsive efficiency using the different expressions defined above.	Remember	CO2	BAEB02.05
8	Boeing 747 aircraft is powered by four CF-6 turbofan engines manufactured by General Electric Company. Each engine has the following data: Thrust force 24.0 kN, Air mass flow rate 125 kg/s, Bypass ratio 5.0, Fuel mass flow rate 0.75 kg/s, Operating Mach number 0.8, Altitude 10 km Ambient temperature 223.2 K, Ambient pressure 26.4 kPa, Fuel heating value 42,800 kJ/kg If the thrust generated from the fan is 75% of the total thrust, determine (a) The jet velocities of the cold air and hot gases (b) The specific thrust (c) The thrust specific fuel consumption (TSFC)	Remember	CO2	BAEB02.06
9	A Boeing 747 aircraft has a lift-to-drag ratio of 17. The fuel-to-air ratio is 0.02 and the fuel heating value is 45,000 kJ/kg. The ratio between the weight of the aircraft at the end and start of cruise is 0.673. The overall efficiency is 0.35. 1. Calculate the range of aircraft. 2. What will be the fuel consumed in the cruise if the takeoff mass of aircraft is 385,560 kg? 3. If the fuel consumed during the engine start, warming, and climb is 4.4% of the initial aircraft weight and the fuel consumed during descent, landing, and engine stop is 3.8% of the aircraft weight at the end of cruise, calculate the fuel consumed in the whole trip.	Understand	CO2	BAEB02.06
10	Derive the equation for propulsive efficiency and explain the reason for turbofan having better propulsive efficiency.	Understand	CO2	BAEB02.06
MODULE -III				
AXIAL FLOW COMPRESSORS AND TURBINES				
Part - A (Short Answer Questions)				
1	Define stage loading	Understand	CO3	BAEB02.07
2	How number of stages calculated in axial flow compressor.	Understand	CO3	BAEB02.07

3	Define blade efficiency	Understand	CO3	BAEB02.07
4	Define stage efficiency for compressor.	Understand	CO3	BAEB02.07
5	Describe about compressor cascade.	Understand	CO3	BAEB02.07
6	What do you understand by isentropic efficiency of a compressor?	Remember	CO3	BAEB02.07
7	Define polytropic efficiency of a compressor.	Remember	CO3	BAEB02.07
8	What do you understand by surge in compressor?	Understand	CO3	BAEB02.07
9	What is IGV and why is it provided?	Understand	CO3	BAEB02.08
10	Define hysteresis.	Understand	CO3	BAEB02.08
11	What is the function of turbine?	Understand	CO3	BAEB02.08
12	What is the difference between axial flow and radial flow turbine?	Understand	CO3	BAEB02.08
13	Write limitations of radial flow turbine.	Understand	CO3	BAEB02.08
14	Differentiate between turbine and compressor.	Understand	CO3	BAEB02.08
15	Define stage efficiency of turbine.	Understand	CO3	BAEB02.09
16	What is the need for turbine blade cooling?	Remember	CO3	BAEB02.09
17	Write different types of turbine blade cooling.	Remember	CO3	BAEB02.09
18	Describe about profile loss in turbine blade.	Understand	CO3	BAEB02.09
19	What is the function of guide vanes in turbine?	Understand	CO3	BAEB02.09
20	What is the reason for decrease in total pressure across turbine?	Understand	CO3	BAEB02.09
Part - B (Long Answer Questions)				
1	Write short notes on principle of operation of centrifugal compressor and illustrate a labeled diagram of a compressor	Understand	CO3	BAEB02.07
2	Explain about basic operation of axial flow compressor and illustrate a labeled diagram of a compressor	Remember	CO3	BAEB02.07
3	Explain about factors affecting stage pressure ratio. Do you think that stage pressuring ratio is needed?	Remember	CO3	BAEB02.07
4	Write (a) advantages of centrifugal compressor over axial flow compressor. (b) advantages of axial flow compressor over centrifugal compressor.	Understand	CO3	BAEB02.07
5	Draw the velocity diagram of axial and centrifugal compressor, and neatly label each part.	Understand	CO3	BAEB02.07
6	Write a brief note on performance characteristics of axial and centrifugal compressor.	Understand	CO3	BAEB02.07
7	Write short notes on (a) Compressor stall (b) Surge (c) Rotating stall.	Remember	CO3	BAEB02.07
8	Explain about the methods used to control surge. Also differentiate between stall and surge in a compressor.	Understand	CO3	BAEB02.07
9	Explain in brief the functions of the components in a centrifugal compressor with a diagram	Understand	CO3	BAEB02.08
10	Explain the variation of enthalpy, pressure, temperature across stator and rotor of axial flow compressor with neat sketch.	Understand	CO3	BAEB02.08
11	What is the difference between axial flow and radial flow turbine? Draw a neat sketch for both the turbine.	Understand	CO3	BAEB02.08

12	What do you understand by annulus loss? What is the reason for decrease in total pressure across turbine?	Remember	CO3	BAEB02.08
13	What do you understand by micro gas turbine? Why is it used and explain about the dimension limitations, if any?	Understand	CO3	BAEB02.08
14	What are the flame stability issues in a ramjet combustor? Elucidate on the issues and explain about the each in brief.	Understand	CO3	BAEB02.08
15	Draw with a neat and labeled sketch of the radial turbine. Elaborate on the working principle of the radial turbine.	Understand	CO3	BAEB02.09
16	Define stage efficiency of a turbine. Write the limitations of the radial flow turbine and compare that with an axial turbine.	Understand	CO3	BAEB02.09
17	Draw with a neat and labeled sketch of the axial turbine. Elaborate on the working principle of the radial turbine.	Remember	CO3	BAEB02.09
18	Explain on the working principle of a turbine and a compressor. Elaborate on the differences between turbine and compressor.	Understand	CO3	BAEB02.09
19	Differentiate between the closed and open cycle gas turbine. State the advantages of closed cycle gas turbine over an open cycle gas turbine.	Understand	CO3	BAEB02.09
20	What is the need for turbine blade cooling? Explain about the various types of cooling methods available for turbine blade.	Understand	CO3	BAEB02.09
Part - C (Problem Solving and Critical Thinking Questions)				
1	A basis for the design of a single-sided centrifugalcompressor gave the following data of power input factor c 1.03, slip factor s 0.9, rotational speed N 285 rev/s, overall diameter of impeller 0.4 m, eye tip diameter 0.3 m, eye root diameter 0.15 m, air mass flow m 10 kg/s, inlet stagnation temperature T01 296 K, inlet stagnation pressure p 12 bar, isentropic efficiency hc 0.79. Determine the following:- (a) Pressure ratio of the compressor (b) the power required to drive it assuming that the velocity of the air at the inlet is axial (b) The inlet angle of the impeller vanes at the root and tip radii of the eye, assuming that the axial inlet velocity is constant across the eye annulus	Understand	CO3	BAEB02.07
2	Derive the equation for work done and pressure rise across centrifugal compressor	Understand	CO3	BAEB02.07
3	Define slip factor. And obtain an equation along a labeled diagram showing the compressor staging.	Understand	CO3	BAEB02.07
4	Derive the equation for blade efficiency of a compressor and the stage efficiency of a compressor	Remember	CO3	BAEB02.07
5	Explain in detail about the compressor cascade with a neat and labeled diagram showcasing the cascading in a compressor.	Remember	CO3	BAEB02.08
6	Combustion gases enter the first stage of a gas turbine at a stagnation temperature and pressure of 1200 K and 4.0 bar. The rotor blade tip diameter is 0.75m, the blade height is 0.12 m and the shaft speed is 10,500 rpm. At the mean radius the stage operates with a reaction of 50%, a flow coefficient of 0.7and a stage loading coefficient of 2.5. Determine (a) the relative and absolute flow angles for the	Remember	CO3	BAEB02.08

	stage; (b) the velocity at nozzle exit; (c) the static temperature and pressure at nozzle exit assuming a nozzle efficiency of 0.96 and the mass flow.			
7	A single stage axial flow turbine operates with an inlet temperature of 1100 K and total pressure of 3.4 bar. The total temperature drop across the stage is 144 K and the isentropic efficiency of the turbine is 0.9. The mean blade speed is 298 m/s and the mass flow rate is 18.75 kg/s. The turbine operates with a rotational speed of 12000 rpm. If the convergent nozzle is operating under choked condition determine (a) blade-loading coefficient (b) pressure ratio of the stage and (c) flow angles.	Understand	CO3	BAEB02.08
8	A multi-stage axial turbine is to be designed with impulse stages and is to operate with an inlet pressure and temperature of 6 bar and 900 K and outlet pressure of 1 bar. The isentropic efficiency of the turbine is 85 %. All the stages are to have a nozzle outlet angle of 75oand equal inlet and outlet rotor blade angles. Mean blade speed is 250 m/s and the axial velocity is 150 m/s and is a constant across the turbine. Estimate the number for stages required for this turbine.	Understand	CO3	BAEB02.09
9	A pulsejet engine is employed in powering a vehicle flying at a Mach number of 2 at an altitude of 40,000 ft. The engine has an inlet area 0.084 m2. The pressure ratio at combustion chamber is P03/P02 = 9, fuel heating value is 43,000 kJ/kg, and combustion efficiency is 0.96. Assuming ideal diffuser (P02 = P0a), it is required to calculate	Remember	CO3	BAEB02.09
10	A single stage gas turbine operates at its design condition with an axial absolute flow at entry and exit from the stage. The absolute flow angle at the nozzle exit is 70 deg. At stage entry, the total pressure and temperature are 311 kPa and 850oC respectively. The exhaust static pressure is 100 kPa, the total to static efficiency is 0.87 and mean blade speed is 500 m/s. Assuming constant axial velocity through the stage, determine (a) the specific work done (b) the Mach number leaving the nozzle (c) the axial velocity (d) total to total efficiency (e) stage reaction.	Remember	CO3	BAEB02.09
MODULE -IV				
SOLID-PROPELLANT ROCKET MOTORS				
Part - A (Short Answer Questions)				
1	List out the important parts of a solid rocket motor.	Understand	CO4	BAEB02.10
2	Write a short note on solid propellants.	Understand	CO4	BAEB02.10
3	List out the examples of solid propellant boosters.	Understand	CO4	BAEB02.10
4	Discuss the parameters used in the selection of rocket propulsion systems.	Remember	CO4	BAEB02.10
5	Define Combustion Stability.	Understand	CO4	BAEB02.10
6	Define charge design.	Remember	CO4	BAEB02.11
7	Explain the fundamental physical limitations of thermal rockets?	Remember	CO4	BAEB02.11
8	Brief the particular of upcoming propulsion systems for space travel.	Remember	CO4	BAEB02.11
9	List out some of the solid rocket propellant fuels.	Remember	CO4	BAEB02.11

10	Write a short note on solid propulsion.	Remember	CO4	BAEB02.11
11	Define burning temperature.	Remember	CO4	BAEB02.12
12	What is pulse detonation engine?	Understand	CO4	BAEB02.12
13	Define corrosion.	Remember	CO4	BAEB02.12
14	What are different types of nozzles	Understand	CO4	BAEB02.12
15	Define ablation.	Remember	CO4	BAEB02.12
16	What are different types of igniters?	Understand	CO4	BAEB02.12
17	Define propellant burning rate.	Remember	CO4	BAEB02.12
18	What is thrust vector control?	Understand	CO4	BAEB02.12
19	Sketch different types of grains.	Understand	CO4	BAEB02.12
20	Define ignition and liner.	Understand	CO4	BAEB02.12
Part - B (Long Answer Questions)				
1	Explain in detail about Solid Rocket propulsion	Understand	CO4	BAEB02.10
2	Explain the process of initiating the combustion in a solid propellant rocket motor.	Understand	CO4	BAEB02.10
3	A solid rocket motor burns along the face of a central cylindrical channel 10 meters long and 1 meter in diameter. The propellant has a burn rate coefficient of 5.5, a pressure exponent of 0.4, and a density of 1.70 g/ml. Calculate the burn rate and the product generation rate when the chamber pressure is 5.0 MPa.	Understand	CO4	BAEB02.10
4	Explain the major application categories for solid propellant rocket motors.	Understand	CO4	BAEB02.10
5	Explain the burning rate relation with pressure and temperature?	Remember	CO4	BAEB02.10
6	Describe about the selection criteria of solid propellant grains for various grain configurations.	Understand	CO4	BAEB02.10
7	Describe the different phases of solid propellant burning from initial to the final phase?	Understand	CO4	BAEB02.10
8	A solid rocket motor burns along the face of a central cylindrical channel 10 meters long and 1 meter in diameter. The propellant has a burn rate coefficient of 4.5, a pressure exponent of 0.4, and a density of 1.90 g/ml. Calculate the burn rate and the product generation rate when the chamber pressure is 8.0 MPa.	Remember	CO4	BAEB02.11
9	What is meant by the Monopropellant Engines? Write the practical applications of the same.	Understand	CO4	BAEB02.11
10	Write a short note on a) ignition surface recession rate b) gas generation rate c) effect of propellant temperature	Understand	CO4	BAEB02.11
11	Describe about the pyro technique with neat sketches	Understand	CO4	BAEB02.11
12	Derive an equation for change in velocity for a case with no external surface or body forces acting on the vehicle.	Understand	CO4	BAEB02.11
13	Give a brief note on the physical quantities measured in rocket testing.	Remember	CO4	BAEB02.11
14	A rocket engine produces a thrust of 1,000 KN at sea level with a propellant flow rate of 400 kg/s. Calculate the specific impulse.	Understand	CO4	BAEB02.12
15	What is the safety provisions included for modern test facility of rocket engines?	Understand	CO4	BAEB02.12

16	Derive the equation for incremental velocity of rocket (rocket equation).state the assumptions made and show the variation of velocity increment with respect to mass ratio.	Remember	CO4	BAEB02.12
17	Explain the concept of single state to orbit and mention its advantages and limitations.	Understand	CO4	BAEB02.12
18	Differentiate between rocket propulsion and jet propulsion.	Understand	CO4	BAEB02.12
19	Explain about the propulsion for Maneuvers of rockets and satellites.	Understand	CO4	BAEB02.12
20	Derive an equation in terms of velocity at any point on an Elliptical orbit under two body motions.	Understand	CO4	BAEB02.12
Part - C (Problem Solving and Critical Thinking Questions)				
1	Explain propellant grain and grain configuration with neat sketches.	Understand	CO4	BAEB02.10
2	Explain the classification of different types of solid propellants.	Understand	CO4	BAEB02.10
3	Explain the solid propellant characteristics in detail.	Understand	CO4	BAEB02.10
4	Explain with suitable sketches the need and methods for cooling of rockets engine thrust chamber.	Remember	CO4	BAEB02.11
5	Explain propellant grain and grain configuration with neat sketches.	Remember	CO4	BAEB02.11
6	Explain a. Charge design b. thrust profile c. burning stability d. erosive burning	Remember	CO4	BAEB02.11
7	Explain the concept of strand burner and T- burner applications in solid rocket propulsion.	Understand	CO4	BAEB02.11
8	Explain the combustion instabilities in liquid propellant rockets and the corrective measure to minimize the effect.	Understand	CO4	BAEB02.12
9	Sketch and explain the working principles of the pulse detonation engine and the rotary rocket engine.	Understand	CO4	BAEB02.12
10	Explain a. Charge design b. thrust profile c. burning stability d. erosive burning	Understand	CO4	BAEB02.12
MODULE -V				
LIQUID PROPELLANT ROCKET ENGINES: PROPELLANT TYPES				
Part - A (Short Answer Questions)				
1	Write a short note on liquid propulsion.	Understand	CO5	BAEB02.13
2	Define gelled propellants.	Remember	CO5	BAEB02.13
3	What is a difference between self-impinging and non-impinging type injector.	Remember	CO5	BAEB02.13
4	Write any one principal function of propellant feed system.	Understand	CO5	BAEB02.13
5	In which case pressure feed system gives a vehicle performance superior to turbo-pump system.	Remember	CO5	BAEB02.13
6	Write the names of any two common types of propellant feed system.	Understand	CO5	BAEB02.13
7	Name the principal types of combustion instability in liquid propellant rocket engines.	Understand	CO5	BAEB02.13
8	Write an expression for Space time averaged regression rate.	Remember	CO5	BAEB02.14

9	Give two applications of hybrid rocket propellants.	Remember	CO5	BAEB02.14
10	Why boundary layer theory is important in combustion.	Understand	CO5	BAEB02.14
11	A two-stage rocket has the following masses: 1st-stage propellant mass 120,000kg, 1st-stage dry mass 9,000 kg, 2nd-stage propellant mass 30,000 kg, 2nd-stagedry mass 3,000 kg, and payload mass 3,000 kg. The specific impulses of the1st and 2nd stages are 260s and 320s respectively. Calculate the rocket's total ΔV.	Understand	CO5	BAEB02.14
12	Derive the tsiolkovsky rocket equation.	Remember	CO5	BAEB02.14
13	Describe the working principles of different rocket motors with neat sketches.	Remember	CO5	BAEB02.15
14	Explain the concepts of nozzle less propulsion with neat sketches.	Understand	CO5	BAEB02.15
15	Why jet engines were not used in space applications? Justify the answer.	Remember	CO5	BAEB02.15
16	Explain the concept of single state to orbit and mention its advantages and limitations.	Remember	CO5	BAEB02.15
17	Differentiate between rocket propulsion and jet propulsion.	Remember	CO5	BAEB02.14
18	Explain about the propulsion for Maneuvers of rockets and satellites.	Remember	CO5	BAEB02.15
19	Derive an equation in terms of velocity at any point on an Elliptical orbit under two body motions.	Remember	CO5	BAEB02.15
20	An artificial Earth satellite is in an elliptical orbit which brings it to an altitude of 250 km at perigee and out to an altitude of 500 km at apogee. Calculate the velocity of the satellite at both perigee and apogee.	Understand	CO5	BAEB02.15
Part - B (Long Answer Questions)				
1	What are the factors important in comparison of different types of rockets	Understand	CO5	BAEB02.13
2	Explain film cooling and transpiration cooling applied to rocket engine nozzles and turbine blades.	Understand	CO5	BAEB02.13
3	What are the advantages of liquid propulsion over Solid rocket propulsion?	Understand	CO5	BAEB02.13
4	Explain Injection process in Liquid propellant rocket system.	Understand	CO5	BAEB02.13
5	Describe the events leading to pressure oscillations in a rocket combustor.	Understand	CO5	BAEB02.13
6	Enumerate and explain the merits and disadvantages of various feed systems.	Understand	CO5	BAEB02.13
7	Detail about the peculiar problems associated with operation of cryogenic engines.	Understand	CO5	BAEB02.13
8	Illustrate the combustion mechanism in hybrid rocket propulsion system with the help of sketches and plots.	Understand	CO5	BAEB02.14
9	With neat sketch explain the hybrid rocket propulsion system and label the parts.	Understand	CO5	BAEB02.14
10	What are the common problems associated with liquid propellants and what are the desired properties of liquid propellants.	Understand	CO5	BAEB02.14
11	Illustrate about launch assist profile with the help of neat sketches.	Understand	CO5	BAEB02.14
12	Justify “no earth launch SSTO launch vehicles have ever been constructed”.	Understand	CO5	BAEB02.14

13	Explain the necessity of Launch Vehicle Satellite criteria in space technology.	Understand	CO5	BAEB02.14
14	Explain briefly about different propulsion systems in launching.	Understand	CO5	BAEB02.15
15	Derive the equation for incremental velocity of rocket (rocket equation).state the assumptions made and show the variation of velocity increment with respect to mass ratio.	Understand	CO5	BAEB02.15
16	Explain the concept of single state to orbit and mention its advantages and limitations.	Understand	CO5	BAEB02.15
17	Differentiate between rocket propulsion and jet propulsion.	Understand	CO5	BAEB02.15
18	Explain about the propulsion for Maneuvers of rockets and satellites.	Understand	CO5	BAEB02.15
19	Derive an equation in terms of velocity at any point on an Elliptical orbit under two body motions.	Understand	CO5	BAEB02.15
20	An artificial Earth satellite is in an elliptical orbit which brings it toan altitude of 250 km at perigee and out to an altitude of 500 km at apogee. Calculate the velocity of the satellite at both perigee and apogee.	Understand	CO5	BAEB02.15
Part - C (Problem Solving and Critical Thinking Questions)				
1	Explain Basic configuration of Liquid propellant rocket system using neat sketches.	Understand	CO5	BAEB02.13
2	Write short note on a. Gas pressure feed system b. Turbo pump feed system	Understand	CO5	BAEB02.13
3	Discuss about oxidizers and fuels of liquid propellant rocks. Also state what is monopropellant and bipropellant?	Understand	CO5	BAEB02.13
4	Describe about the different types of liquid fuel injectors used in liquid rocket engines with the help of sketches.	Remember	CO5	BAEB02.14
5	Explain the combustion instabilities in liquid propellant rockets and the corrective measure to minimize the effect.	Understand	CO5	BAEB02.14
6	List out the essential differences from liquid propellant rocket engines to solid propellant rocket. Discuss on which one is best for space travel.	Remember	CO5	BAEB02.14
7	With the help of neat sketches compare the standard and reverse hybrid systems.	Understand	CO5	BAEB02.15
8	Detail the selection criteria of liquid propellant rocket engine and give it importance.	Understand	CO5	BAEB02.15
9	What are the limitations of combustion mechanism theory in hybrid propulsion?	Understand	CO5	BAEB02.15
10	Why the initial temperature change causes much less change in the regression rate of a hybrid fuel than in the burning rate of a solid propellant. Explain and derive an equation for regression rate.	Remember	CO5	BAEB02.15

Prepared By:
Mr. Shiva Prasad U, Assistant Professor **HOD, AE**