INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**SPACE PROPULSION**				
Course Code	**AAE012**				
Programme	B.Tech				
Semester	VI	AE			
Course Type	**Core**				
Regulation	**IARE - R16**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Dr. Praveen Kumar Balguri, Associate Professor				
Course Faculty	Dr. Praveen Kumar Balguri, Associate Professor, Mr. Shiva Prasad .U, Assistant Professor.				

COURSE OBJECTIVES:

I	Appraise various space missions, parameters to be considered for designing trajectories and rocket mission profiles.
II	Classify the different chemical rocket propulsion systems, types of igniters and performance considerations of rockets.
III	Discuss the working principle of solid and liquid propellant rockets and gain basic knowledge of hybrid rocket propulsion.
IV	Illustrate electric propulsion techniques, ion, and nuclear rocket and the performances of different advanced propulsion systems.

COURSE OUTCOMES (COs):

CO 1	Evaluate various space missions, parameters to be considered for designing trajectories and rocket ission profiles.
CO 2	Classify the different chemical rocket propulsion systems, types of igniters and performance nsiderations of rockets.
CO 3	Discuss the working principle of solid propellant rockets, propellant grain designs and combustion.

CO 4	Demonstrate the working principle of liquid propellant rockets, feed systems and gain basic knowledge of ybrid rocket propulsion.
CO 5	Illustrate electric propulsion techniques, ion and nuclear rocket and the performances of different dvanced propulsion systems.

COURSE LEARNING OUTCOMES (CLOs):

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

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AAE012.01	CLO 1	Demonstrate the basic principles of space propulsion and its applications in different types of orbits.	PO1	3
AAE012.02	CLO 2	Describe the concept of orbital elements and basic orbital equations.	PO1	3
AAE012.03	CLO 3	Adapt the concepts of vertical takeoff and landing for space applications and launch trajectories.	PO1	3
AAE012.04	CLO 4	Explain the operating principle of the rocket engine and demonstrate the rocket equation.	PO2	2
AAE012.05	CLO 5	Discuss the different Newton's laws of motion and the relation of thrust generation to different laws of motion	PO1	3
AAE012.06	CLO 6	Describe the different types of propulsion systems and preliminary concepts in nozzle less propulsion and air augmented rockets.	PO2	2
AAE012.07	CLO 7	Demonstrate the salient features of solid propellants rockets and estimate the grain configuration designs suitable for different missions.	PO2	2
AAE012.08	CLO 8	Understand the erosive burning, combustion instability, and burners	PO 3	2
AAE012.09	CLO 9	Remember the applications and advantages of solid propellant rockets	PO 3	2
AAE012.10	CLO 10	Recognize the salient features of liquid propellant rockets, various feed systems, and injectors.	PO 3	2
AAE012.11	CLO 11	Understand the thrust control cooling, heat transfer problems, combustion instability in liquid propellant rockets	PO 3	2
AAE012.12	CLO 12	Understand the peculiar problems associated with the operation of cryogenic engines in different missions.	PO 3	2
AAE012.13	CLO 13	Recognize the standard and reverse hybrid systems, combustion mechanism, applications, and limitations.	PO 3	2
AAE012.14	CLO 14	Understand the different types of Electric, Ion, and Nuclear propulsion systems.	PO 3	2
AAE012.15	CLO 15	Identify the future applications of the electric propulsion system	PO 3	2

UNIT - I				
PRINCIPLES OF ROCKET PROPULSION				
PART - A (SHORT ANSWER QUESTIONS)				
S No	**QUESTIONS**	**Blooms taxonomy level**	**Course Outcome**	**Course Learning Outcomes**
1	Define Newton's law of motion.	Remember	CO1	AAE012:01
2	What are the types of orbits?	Understand	CO1	AAE012:01
3	What are the different types of orbital transfer orbits?	Understand	CO1	AAE012:01
4	Write the basic orbital equations.	Understand	CO1	AAE012:02
5	What are the launch assists?	Remember	CO1	AAE012:02
6	Define the concepts of VTOL for space applications.	Understand	CO1	AAE012:02
7	Define the orbital elements.	Remember	CO1	AAE012:02
8	Why velocity increment is needed for launch vehicles.	Remember	CO1	AAE012:03
9	Differentiate between thermal rocket engines from regular rockets.	Understand	CO1	AAE012:03
10	What is the function of a nozzle?	Remember	CO1	AAE012:03
	PART - B (LONG ANSWER QUESTIONS)			
1	Discuss the history of the rockets during the pre-world war era.	Understand	CO1	AAE012:01
2	Discuss the development of modern rocketry during the post-world war era.	Understand	CO1	AAE012:01
3	Describe the different types of orbits and mention their uses.	Understand	CO1	AAE012:01
4	Write the basic vehicle velocity equation and discuss the effect of mass ratio and effective exhaust velocity on it with the necessary diagram.	Understand	CO1	AAE012:01
5	Give the basic orbital equation and derive the expression for initial velocity (V_0) for different orbits.	Remember	CO1	AAE012:02
6	Discuss 'Elliptical transfer orbits' with the help of necessary equations and diagram.	Understand	CO1	AAE012:02
7	Write a short notes on (i). Launch trajectories (ii) The rotation of the Earth and (iii) The velocity increment needed for launch	Remember	CO1	AAE012:02
8	Explain thermal rocket engine with the help of sketches.	Understand	CO1	AAE012:02
9	Distinguish between SSTO and TSTO design considerations.	Understand	CO1	AAE012:03
10	Discuss different types of launch assist technologies with their advantages.	Remember	CO1	AAE012:03
	PART - C (PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)			
1	Demonstrate the types of launch assists.	Understand	CO1	AAE012:01
2	Justify "no earth launch SSTO launch vehicles have ever been constructed".	Remember	CO1	AAE012:01
3	How the shape of the orbit depend on initial velocity (injection velocity) and distance from the center of the Earth? Explain with the necessary equations and diagrams.	Understand	CO1	AAE012:01
4	How the spacecraft can transfer from the orbits? Explain with the necessary equations and diagrams.	Remember	CO1	AAE012:02
5	Derive and discuss the expression for initial velocity (V_0) to remain in low earth orbit and for a parabolic escape orbit.	Understand	CO1	AAE012:02
6	Explain the concept of a single state to orbit and mention its advantages and limitations	Remember	CO1	AAE012:02
7	Differentiate between rocket propulsion and jet propulsion.	Understand	CO1	AAE012:02

8	Describe with a neat sketch about two-stage- to orbit launching vehicle.	Remember	CO1	AAE012:03
9	Derive an equation in terms of velocity at any point on an Elliptical orbit	Understand	CO1	AAE012:03
10	A rocket of total mass 80 tonnes, carrying a spacecraft of 0.75 tonne. The engine develop a constant exhaust velocity of 2800 m/s. The structural mass is assumed to be 10% of the fuel mass. Find out the velocity of the rocket if it is a (i) single stage rocket and (ii) two stage rocket.	Understand	CO1	AAE012:03
	UNIT - II			
	FUNDAMENTALS OF ROCKET PROPULSION			
	PART - A (SHORT ANSWER QUESTIONS)			
1	Explain the Rocket equation.	Remember	CO2	AAE012:04
2	Write the classification of space propulsion engines.	Remember	CO2	AAE012:04
3	What is meant by specific impulse?	Understand	CO2	AAE012:04
4	What is meant by the ignition system?	Remember	CO2	AAE012:05
5	What are the types of igniters used in rockets?	Understand	CO2	AAE012:05
6	Classify the rocket nozzles.	Understand	CO2	AAE012:05
7	What is a motor in rocket terminology?	Understand	CO2	AAE012:05
8	How can an unintentional ignition or disaster occur?	Remember	CO2	AAE012:06
9	What do you mean by a propellant mass fraction?	Understand	CO2	AAE012:06
10	What are the safety considerations to be taken for rocket testing?	Remember	CO2	AAE012:06
	PART - B (LONG ANSWER QUESTIONS)			
1	Describe the pyro technique with neat sketches	Remember	CO2	AAE012:04
2	Derive an equation for the change in velocity for a case with no external surface or body forces acting on the vehicle.	Understand	CO2	AAE012:04
3	Give a brief note on performance characteristics of rockets.	Remember	CO2	AAE012:04
4	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	CO2	AAE01205
5	What are the safety provisions included for the modern test facility of rocket engines?	Understand	CO2	AAE012:05
6	Illustrate the concepts of air augmented rockets.	Remember	CO2	AAE012:05
7	A rocket of total mass 100 tones carrying a spacecraft of 5 tones and engine develop a constant exhaust velocity of 3500m/s. The structural mass is assumed to be 15% of the total mass. Calculate the final velocity of the rocket.	Understand	CO2	AAE012:06
8	A spacecraft's dry mass is 75,000 kg and the effective exhaust gas velocity of its main engine is 3,100 m/s. How much propellant must be carried if the propulsion system is to produce a total Δv of 700 m/s?	Remember	CO2	AAE012:06
9	Describe pulse rocket motors with necessary diagrams.	Understand	CO2	AAE012:06
10	With neat sketches illustrate the mounting options for igniters.	Remember	CO2	AAE012:06
	PART – C (PROBLEM SOLVING AND CRITICAL THINKING)			
1	Derive an equation for the change in velocity for a case with external surface and body forces acting on the vehicle.	Remember	CO2	AAE012:04
2	Describe the major systems or components required for chemical rocket propulsion systems.	Remember	CO2	AAE012:04
3	Briefly describe the pulse rocket motor with a neat sketch.	Understand	CO2	AAE012:04

4	Illustrate about different nozzle configurations and their flow effects.	Remember	CO2	AAE012:05
5	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 stage dry mass 3,000 kg, and payload mass 3,000 kg. The specific impulses of the1st and 2nd stages are 260 s and 320 s respectively. Calculate the rocket's total ΔV.	Remember	CO2	AAE012:05
6	Derive the Tsiolkovsky's rocket equation.	Understand	CO2	AAE012:05
7	Describe the working principles of different rocket motors with neat sketches.	Remember	CO2	AAE012:05
8	What are air augmented rockets? Discuss with advantages and disadvantages.	Understand	CO2	AAE012:06
9	Discuss static testing of rocket and safety considerations.	Remember	CO2	AAE012:06
10	How space engines are different from the regular combustion engines?	Understand	CO2	AAE012:06
	UNIT-III			
	SOLID ROCKET PROPULSION			
	PART - A (SHORT ANSWER QUESTIONS)			
1	List out the important parts of a solid rocket motor.	Understand	CO3	AAE012:07
2	Write a short note on solid propellants.	Understand	CO3	AAE012:07
3	List the examples of solid propellant boosters.	Understand	CO3	AAE012:07
4	Discuss the parameters used in the selection of rocket propulsion systems.	Understand	CO3	AAE012:07
5	Define Combustion Stability.	Understand	CO3	AAE012:07
6	Define charge design.	Remember	CO3	AAE012:07
7	Explain the fundamental physical limitations of thermal rockets.	Understand	CO3	AAE012:08
8	Brief the upcoming propulsion systems for space travel.	Remember	CO3	AAE012:08
9	List out some of the solid rocket propellant fuels.	Understand	CO3	AAE012:08
10	Write a short note on solid propulsion.	Remember	CO3	AAE012:18
11	Define the burning temperature.	Remember	CO3	AAE012:08
12	What is a pulse detonation engine?	Understand	CO3	AAE012:08
13	Define corrosion.	Understand	CO3	AAE012:08
14	What are the different types of nozzles?	Remember	CO3	AAE012:09
15	Define ablation.	Remember	CO3	AAE012:09
16	What are the different types of igniters?	Understand	CO3	AAE012:09
17	Define the propellant burning rate.	Remember	CO3	AAE012:09
18	What is thrust vector control?	Understand	CO3	AAE012:09
19	Sketch different types of grains.	Remember	CO3	AAE012:09
20	Define ignition and liner.	Understand	CO3	AAE012:09
	PART – B (LONG ANSWER QUESTIONS)			
1	Explain in detail about Solid Rocket propulsion	Remember	CO3	AAE012:07
2	Explain the process of initiating the combustion in a solid-propellant rocket motor.	Understand	CO3	AAE012:07
3	Explain the major application categories for solid propellant rocket motors.	Understand	CO3	AAE012:07
4	Explain the burning rate relation with pressure and temperature	Remember	CO3	AAE012:08
5	Describe the selection criteria of solid propellant grains for various grain configurations.	Understand	CO3	AAE012:08
6	Describe the different phases of solid propellant burning from the initial to the final phase.	Remember	CO3	AAE012:08

7	Explain erosive burning in solid propellant rockets.	Understand	CO3	AAE012:09
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 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.	Remember	CO3	AAE012:07
9	What is meant by the Monopropellant Engines? Write the practical applications of the same.	Understand	CO3	AAE012:09
10	Write a short note on a. Ignition surface recession rate b. Gas generation rate c. Effect of propellant temperature	Remember	CO3	AAE012:09
	PART – C (PROBLEM SOLVING AND CRITICAL THINKING)			
1	Explain propellant grain and grain configuration with neat sketches.	Remember	CO3	AAE012:07
2	Explain the classification of different types of solid propellants.	Understand	CO3	AAE012:07
3	Explain the solid propellant characteristics in detail.	Remember	CO3	AAE012:07
4	Explain with suitable sketches the need and methods for cooling of rockets engine thrust chamber	Remember	CO3	AAE012:08
5	Explain a. thrust profile b. burning stability c. erosive burning	Understand	CO3	AAE012:08
6	Explain the concept of strand burner and T- burner and their applications in solid rocket propulsion	Understand	CO3	AAE012:09
7	Explain the combustion instabilities in solid propellant rockets and the corrective measure to minimize the effect.	Remember	CO3	AAE012:09
8	How the burning rate of the solid propellant can be increased?	Understand	CO3	AAE012:09
	UNIT-IV			
	LIQUID AND HYBRID ROCKET PROPULSION			
	PART – A (SHORT ANSWER QUESTIONS)			
1	Write a short note on liquid propulsion.	Understand	CO4	AAE012:10
2	Define gelled propellants.	Remember	CO4	AAE012:10
3	What is the difference between self-impinging and non-impinging type injectors?	Understand	CO4	AAE012:10
4	Write any one principal function of the propellant feed system.	Remember	CO4	AAE012:11
5	In which case, the pressure feed system gives a vehicle performance superior to the turbo-pump system?	Understand	CO4	AAE012:11
6	Write the names of any two common types of the propellant feed system.	Remember	CO4	AAE012:11
7	Name the principal types of combustion instability in liquid propellant rocket engines.	Understand	CO4	AAE012:12
8	Write an expression for space time-averaged regression rate.	Remember	CO4	AAE012:12
9	Give two applications of hybrid rocket propellants.	Understand	CO4	AAE012:13
10	Why boundary layer theory is important in combustion?	Understand	CO4	AAE012:13
	PART – B (LONG ANSWER QUESTIONS)			
1	Discuss the important factors comparing different types of rockets.	Understand	CO4	AAE012:10
2	Explain film cooling and transpiration cooling applied to rocket engine nozzles and turbine blades.	Remember	CO4	AAE012:10
3	What are the advantages of liquid propulsion over Solid rocket propulsion?	Understand	CO4	AAE012:11
4	Explain injection process in liquid propellant rocket system.	Remember	CO4	AAE012:11

5	Describe the events leading to pressure oscillations in a rocket combustor.	Understand	CO4	AAE012:11
6	Explain the merits and demerits of various feed systems.	Understand	CO4	AAE012:12
7	Detail about the peculiar problems associated with the operation of cryogenic engines.	Remember	CO4	AAE012:12
8	Illustrate the combustion mechanism in a hybrid rocket propulsion system with necessary diagrams.	Understand	CO4	AAE012:12
9	With a neat sketch explain the hybrid rocket propulsion system and label the parts.	Remember	CO4	AAE012:13
10	What are the desired properties and the common problems associated with liquid propellants?	Understand	CO4	AAE012:13
	PART – C (PROBLEM SOLVING AND CRITICAL THINKING)			
1	Explain the basic configuration of the liquid propellant rocket system using neat sketches.	Remember	CO4	AAE012:10
2	Write a short note on a. Gas pressure feed system b. Turbopump feed system	Understand	CO4	AAE012:10
3	Discuss oxidizers and fuels of liquid propellant rocks. Also, state what is monopropellant and bipropellant?	Remember	CO4	AAE012:10
4	Describe the different types of liquid fuel injectors used in liquid rocket engines with the help of sketches.	Understand	CO4	AAE012:11
5	Explain the combustion instabilities in liquid propellant rockets and the corrective measure to minimize the effect.	Understand	CO4	AAE012:11
6	List out the essential differences from liquid propellant rocket engines to solid propellant rocket. Comment and justify the preferable propellant system for space travel.	Remember	CO4	AAE012:12
7	With the help of neat sketches compare the standard and reverse hybrid systems.	Understand	CO4	AAE012:12
8	Detail the selection criteria of liquid propellant rocket engines and give its importance?	Understand	CO4	AAE012:12
9	What are the limitations of the combustion mechanism theory in hybrid propulsion?	Remember	CO4	AAE012:13
10	Why the initial temperature change causes much less change in the regression rate of a hybrid fuel than in the burning rate of solid propellant. Explain and derive an equation for the regression rate.	Understand	CO4	AAE012:13
	UNIT-V			
	ADVANCED PROPULSION TECHNIQUES			
	PART - A (SHORT ANSWER QUESTIONS)			
1	What is electric propulsion?	Remember	CO5	AAE012:14
2	Define ion thruster.	Understand	CO5	AAE012:14
3	Define solar sail.	Remember	CO5	AAE012:14
4	What is the difference between the ion engine and the chemical engine?	Understand	CO5	AAE012:15
5	What is the principle of a nuclear thermal rocket?	Understand	CO5	AAE012:15
6	Explain about the combustion efficiency	Understand	CO5	AAE012:14
7	Explain about the presence of liquid drops and solid particles in chemical combustion	Remember	CO5	AAE012:15
8	What are the properties of a chemical rocket	Understand	CO5	AAE012:14
9	Explain the uses of electric thrusters.	Remember	CO5	AAE012:15
10	How the performance estimation of electrical thrusters is done.	Understand	CO5	AAE012:15
	PART - B (LONG ANSWER QUESTIONS)			
1	Discuss the working of ion rocket propulsion with the help of a neat	Remember	CO5	AAE012:14

	sketch.			
2	Enumerate the future applications of electric propulsion systems.	Understand	CO5	AAE012:14
3	Explain electric rocket propulsion system with examples and neat sketches.	Remember	CO5	AAE012:14
4	Explain the nuclear rocket engine with neat sketches.	Understand	CO5	AAE012:14
5	Compare the performance of electric, ion and nuclear propulsion systems with chemical rocket propulsion systems.	Understand	CO5	AAE012:14
6	Explain solar sails.	Understand	CO5	AAE012:14
7	How the performance measurement of a chemical rocket engine is implemented? Explain in detail.	Remember	CO5	AAE012:15
8	Write a short note on Cryogenic Reactants and explain their significance in the combustion of a chemical rocket.	Understand	CO5	AAE012:15
9	Describe the operating principles, components, system parameters, performance, and applications of the thermal propulsion.	Remember	CO5	AAE012:15
10	Explain the functions of a) Fuel cells b) Solar cell arrays c) Solar generators d) Nuclear power generators	Understand	CO5	AAE012:15
	PART – C (PROBLEM SOLVING AND CRITICAL THINKING)			
1	Explain liquid-propellant rocket engine with a gas pressure feed system	Remember	CO5	AAE012:14
2	Compare the different types of rocket propulsion systems.	Understand	CO5	AAE012:14
3	Explain electrothermal and non-thermal electrical thrusters.	Remember	CO5	AAE012:14
4	Describe the working principle of the ionic thruster with a neat sketch explaining each part and its functions.	Understand	CO5	AAE012:14
5	Explain the operating principles, components, system parameters, performance, and applications of the nuclear propulsion	Understand	CO5	AAE012:14
6	Write a short note on the electric space power supplies and power conditioning with their advantages and limitations.	Understand	CO5	AAE012:15
7	List out the specifications of some of the real-time space vehicles which use electric propulsion.	Remember	CO5	AAE012:15
8	Explain the advantages, limitations, and applications of nuclear propulsion.	Understand	CO5	AAE012:15

Prepared By:
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