Name:

Enrolment No:

UPES

End Semester Examination, December 2024

Course: Rocket Propulsion **Semester: VII**

Program: B.Tech ASE **Time : 03 hrs.**

Course Code: ASEG 4011P **Max. Marks: 100**

Instructions: All questions are compulsory
Assume necessary data if not given.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the functioning of gas generator-based propellant feed systems in liquid rocket engines. How do these systems contribute to engine operation?	**4**	**CO1**
Q 2	Describe the role and significance of igniters in rocket motors. Why are they essential for the operation of the rocket propulsion system?	**4**	**CO2**
Q 3	In what ways does multi-staging of rockets enhance their performance? Provide a detailed explanation of its contribution to the efficiency of rocket flight.	**4**	**CO3**
Q 4	Discuss the advantages of electrical propulsion engines (thrusters) compared to chemical rocket engines. What makes electrical propulsion a viable alternative in certain applications?	**4**	**CO4**
Q 5	What are the primary causes of combustion instability in rocket engines? Discuss methods that can be employed to control or mitigate these instabilities.	**4**	**CO1**
	SECTION B **(4Qx10M= 40 Marks)**		
Q 6	Evaluate the modern design approaches used in conducting burn rate studies for solid propellant strands, considering recent advancements such as high-fidelity simulation tools and real-time data collection methods. Discuss how these innovations are integrated into performance estimation tests conducted in state-of-the-art facilities like the Space Technology Lab.	**10**	**CO4**
Q 7	The following measurements were made in a sea level test of a solid propellant rocket motor: Burn duration 40 sec Initial mass before test 1210kg Mass of rocket motor after test 215kg Average thrust 62,250 N Chamber pressure 7.00 MPa	**10**	**CO1**

	Nozzle exit pressure 0.070 MPa Nozzle throat diameter 0.0855 m Nozzle exit diameter 0.2703 m Determine mass flow rate (m.), V_2, C^*, C, and Is at 1000 and 25000 m altitude. Assume an invariant thrust and mass flow rate and negligible short start and stop transients. (At 1000, Pa= 0.0898 MPa and At 25000 m, Pa= 0.00255 MPa) **OR** A rocket has a total mass of 5000 kg, including propellant. Its specific impulse is 300 seconds, and its propellant flow rate is 50 kg/s. The rocket is launched vertically upwards and experiences negligible air resistance. (a) What is the rocket's initial acceleration? (**3 marks**) (b) What is the maximum velocity the rocket can achieve? (**4 marks**) (c) What is the total impulse of the rocket motor during its entire burn time? (**3 marks**)		
Q 8	Analyze the key factors influencing injector behavior in the thrust chambers of Liquid Propellant Rocket Engines, especially with respect to innovations like 3D-printed injectors and advanced materials used in modern rockets. How have these technologies enhanced the efficiency of engines such as the ISRO's GSLV and LVM-3, which are pivotal for launching satellites and crewed space missions?	**10**	**CO1**
Q 9	Explain the principles of thrust vector control (TVC) and how it has evolved with the development of modern rockets, such as the integration of fluidic TVC in next generation launch systems like SpaceX's Falcon Heavy or NASA's Space Launch System (SLS).	**10**	**CO3**
SECTION-C (2Qx20M=40 Marks)			
Q 10	The Saturn V rocket used by NASA during the Apollo missions was a multistage rocket, consisting of three stages. The first stage used five F-1 engines, the second stage used five J-2 engines, and the third stage used a single J-2 engine. The rocket had a total height of 110 meters and a liftoff mass of 2.8 million kg. (a) Compare and contrast the design of the first, second, and third stages of the Saturn V rocket in terms of their engines, fuel, and performance parameters. (**6 marks**) (b) The first stage of the Saturn V rocket burned for approximately 2.5 minutes before separating from the rest of the rocket. If the first stage had a thrust of 34 million newtons and a specific impulse of 263 seconds, what was its total impulse? (**4 marks**) (c) The second stage of the Saturn V rocket burned for approximately 6 minutes before separating from the rest of the rocket. If the second stage had a thrust of 5 million newtons and a specific impulse of 421 seconds, what was its total impulse? (**4 marks**) (d) If the third stage of the Saturn V rocket had a thrust of 1 million newtons and a specific impulse of 421 seconds, what was its maximum velocity? Assume that the third stage burned for 2 minutes. (**6 marks**)	**20**	**CO4**

	OR Critically examine the droplet combustion model used in liquid fuel combustion for modern rocket engines, considering recent advancements in computational simulations. Discuss the conditions under which the shape of the flame front is affected, and how emerging technologies, such as combustion instability mitigation techniques and advanced injector designs, influence flame front dynamics in cutting-edge propulsion systems like those used in ISRO's GSLV or SpaceX's Raptor engine.		
Q 11	Analyze the key design features and innovations of ISRO's Small Satellite Launch Vehicle (SSLV), focusing on its propulsion system, payload capacity, and mission flexibility. Discuss the recent SSLV-D2/EOS-07 mission, highlighting its performance and the vehicle's advantages over traditional rockets like PSLV in terms of rapid deployment and cost-effectiveness. Evaluate how the SSLV contributes to ISRO's future space missions and suggest areas for further improvement based on current propulsion technologies.	**20**	**CO4**