# DHANALAKSHMI SRINIVASAN

**COLLEGE OF ENGINEERING AND TECHNOLOGY**

**MAMALLAPURAM, CHENNAI**

## DEPARTMENT OF AERONAUTICAL ENGINEERING

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| COURSE CODE | : | C304 |
| **SUBJECT CODE** | **:** | **AE8504 (Regulation 2017)** |
| **SUBJECT NAME** | **:** | **PROPULSION II** |
| **YEAR / SEMESTER** | **:** | **III / V** |

# QUESTION BANK

Subject Code & Name : AE8504 – PROPULSION II

Year / Sem : III / V

| RAMJET AND SCRAMJET PROPULSION | | | |
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| **Q.No** | **Question** | **BT Level** | **Competence** |
| PART – A | | | |
| 1. | Write the expression for thrust as a function of Mach number ideal Ramjet engines. | BTL1 | Remembering |
| 2. | Why circular geometry combustors are not preferred for scramjet engines? | BTL1 | Remembering |
| 3. | How scramjet engine is differing from ramjet engine? | BTL2 | Understanding |
| 4. | Why hydrogen is the suitable fuel used for hypersonic propulsion? | BTL1 | Remembering |
| 5. | Define shock train. | BTL1 | Remembering |
| 6. | Define hypersonic propulsion and its need | BTL1 | Remembering |
| 7. | What is the need for supersonic combustion in hypersonic propulsion? | BTL2 | Understanding |
| 8. | List the application of hypersonic vehicle briefly | BTL2 | Understanding |
| 9. | Draw a neat sketch of scramjet engine and list its parts. | BTL2 | Understanding |
| 10. | Write any 5-injection technique in scramjet engine | BTL1 | Remembering |
| 11. | Explain the engine/airframe integration aspects in scramjet engine | BTL3 | Understanding |
| 12. | What is the role of isolator in scramjet engine? | BTL1 | Remembering |
| 13. | Write down the various types of scramjet combustor. | BTL2 | Understanding |
| 14. | Draw a ramjet engine with parts. | BTL2 | Understanding |
| 15. | What do you mean by pylon injection technique? | BTL2 | Understanding |
| 16. | Write down the military application of scramjet engines. | BTL2 | Understanding |
| 17. | What is an isolator? | BTL2 | Understanding |
| 18. | What are the problems associated with the supersonic combustion? | BTL2 | Understanding |
| 19. | Explain viscous boundary layer interaction. | BTL2 | Understanding |
| 20. | Explain shock boundary layer interaction | BTL2 | Understanding |
| PART – B | | | |

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| 1. | A ramjet is to propel an aircraft at Mach 1.5 at an altitude where the ambient pressure temperature are 11.6 kPa and 205 K respectively. Maximum temperature in the engine is2500K. Heating value of fuel used is 45 MJ/kg . Take $\gamma$ =1.4 and C_P=1kJ/kgK.<br>i) Find the specific thrust of this ideal ramjet. (5)<br><br>ii) Find the specific thrust by considering the total pressure ratio across diffuser, combustor and nozzle of 0.88,0.89 and 0.9 respectively. The combustion efficiency is 98%. (8) | BTL3 | Apply |
| 2. | Derive an expression for specific thrust of an ideal ramjet engine and sketch the variation of specific thrust with flight Mach number | BTL3 | Apply |
| 3. | Sketch and explain different types of injectors and flame holder used in scramjet engines | BTL2 | Understanding |
| 4. | . i) Discuss the problems associated with supersonic combustion and how to overcome it?(7)<br><br>ii) Explain with neat sketch types of scramjet combustors. (6) | BTL2 | Understanding |
| 5. | Explain the salient features of scramjet engine and its application for hypersonic vehicles. | BTL2 | Understanding |
| 6. | A ramjet engine propels on aircraft at a Mach number of 1.6 and at altitude of 7000 m. The diameter of the inlet diffuser at entry is 55cm and specific value of the fuel is 46 MJ/kg . The stagnation temperature at the nozzle entry is 1800k. The properties of the combustion gases are same as those of air. $\gamma$ =1.4,R=287J/kgK. (13)<br>(i) Determine the following.<br>(ii) The efficiency of ideal cycle<br>(iii) Air flow rate<br>(iv) Diffuser pressure ratio<br>(v) Nozzle pressure ratio | BTL3 | Apply |
| 7. | Explain the different fuel injection schemes in scramjet combustors with a neat sketch. (13) | BTL2 | Understanding |
| 8. | Explain the engine/airframe integration aspects of hypersonic vehicles (13) | BTL2 | Understanding |

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| 9. | Explain the working principle of ramjet engine and scramjet engine. (13) | BTL2 | Understanding |
| 10 | With neat sketch briefly explain the operating principle and combustion process involved in Ramjet engine. | BTL2 | Understanding |
| 11. | Write short notes on :<br>i) The problems associated with supersonic combustion and explain how to overcome this. **(7)**<br>(i) ii) The need for supersonic combustion for hypersonic propulsion. **(6)** | BTL2 | Understanding |
| | PART - C | | |
| 1. | Briefly describe the current developments in advanced propulsion systems for rockets worldwide | BTL2 | Understanding |
| 2. | Compare the operating principle of a Scramjet and Liquid Propellant Rocket engines and briefly describe the combustion process involved in both engines. | BTL2 | Understanding |

| **UNIT II - CHEMICAL ROCKET PROPULSION** | | | |
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| **Q.No** | **Question** | **BT Level** | **Competence** |
| | PART – A | | |
| 1 | Define specific impulse of a rocket.. | BTL1 | Remembering |
| 2 | What are Pulse rocket motors ? | BTL1 | Remembering |
| 3 | Define effective exhaust velocity. | BTL1 | Remembering |
| 4 | What are air augmented rockets? | BTL1 | Remembering |
| 5 | What is a pulse rocket motor? | BTL1 | Remembering |
| 6 | What is a pulse rocket motor? | BTL1 | Remembering |
| 7 | What is total impulse? | BTL2 | Understanding |
| 8 | Explain the operating principle of chemical rockets. | BTL2 | Understanding |
| 9 | Define specific impulse of a rocket. | BTL2 | Understanding |
| 10 | List down the safety consideration in chemical rockets during testing. | BTL2 | Understanding |
| 11 | Give an account on nozzle-less propulsion concept. | BTL2 | Understanding |
| 12 | State the advantages of using pulsed rocket motor. | BTL1 | Remembering |
| 13 | State the advantages of using chemical rocket motor. | BTL2 | Understanding |
| 14 | Explain mini bulb igniter. | BTL3 | Applying |

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| 15 | Define effective jet velocity. | BTL2 | Understanding |
| 16 | Define characteristic velocity. | BTL2 | Understanding |
| 17 | Write the different type of igniter. | BTL2 | Understanding |
| 18 | What is the use of pressure transducers? | BTL2 | Understanding |
| 19 | Write any three fuel and oxidizer that is used in chemical rocket propulsion | BTL2 | Understanding |
| 20 | What are the instruments that are used in rocket testing? | BTL2 | Understanding |
| | PART – B | | |
| 1 | Obtain an expression for exit of Rocket nozzle with valid assumption. | BTL3 | Applying |
| 2 | Hot gases are generated at a temperature of 2000k and a pressure of 15 MPa in a rocket chamber. The molecular mass of the gas is 22kg/kmole and the specific heat ratio of the gas is 1.32. The gases are expanded to the ambient pressure of 0.1 MPa in a C-D nozzle having a throat area of 0.1m^2. Find the following: (13)<br>(i) Exit jet velocity<br>(ii) Characteristic velocity<br>(iii) Specific impulse<br>(iv) Ideal optimum thrust co-efficient. | BTL3 | Applying |
| 3 | 1. a) Discuss the concept of nozzle-less propulsion and how it differs from a C-D nozzle. Explain the various operating conditions of s C-D nozzle. (8)<br><br>b) What are the different types of igniter used in rocket propulsion? Explain. (7) | BTL2 | Understanding |
| 4 | The following measurement were made in a sea level test of a solid propellant rocket motor: initial mass before test 1210kg. Mass of the rocket after test 215kg. Average thrust 62250N.chamber pressure 7Mpa.Nozzle exit pressure 0.07Mpa. Nozzle throat diameter 0.0855m. Nozzle exit diameter 0.2703m. Determine the ṁ,$C^*$ ,$V_{je}$ an $I_{sp}$ at sea level and $I_{sp}$ at 1000 and 25000m altitude. Assume an invariant thrust and mass flow rate and negligible short start and stop transients. Where, ṁ-mass flow rate; $C^*$ -characteristic velocity; $I_{sp}$ -specific impulse;$V_{je}$ -effective jet velocity. (13) | BTL3 | Applying |

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| 5 | Explain about the different types of igniters used in rocket engine propulsion with a neat sketch. | BTL2 | Understanding |
| 6 | Explain about air augmented rocked and pulsed rocket motor engines. (13) | BTL2 | Understanding |
| 7 | i. Explain working principle of chemical rocket. (7)<br>ii. List out the performance consideration in the rocket engine.(6) | BTL2 | Understanding |
| 8 | Write down the standard procedures for static testing of rockets & instrumentation. | BTL2 | Understanding |
| | PART – C | | |
| 1. | Classify rocket nozzles and explain the concepts of nozzle less propulsion in Rockets. | BTL2 | Understanding |
| 2. | Explain in detail the two different types of igniters used in solid rocket propulsion. (15) | BTL3 | Applying |
| 3. | i) air augmented rockets<br>ii) specific impulse of a rocket | BTL3 | Applying |

| **UNIT III - SOLID ROCKET PROPULSION** | | | |
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| **Q.No** | **Question** | **BT Level** | **Competence** |
| | PART – A | | |
| 1. | What do you mean by vortex-shedding instability? | BTL1 | Remembering |
| 2. | What do you understand by thermal choking? | BTL1 | Remembering |
| 3. | Highlight the reasons to have low molecular weight and higher density of solid propellant. | BTL1 | Remembering |
| 4. | Give two examples of composite solid propellant rockets. | BTL1 | Remembering |
| 5. | Define adiabatic flame temperature | BTL1 | Remembering |
| 6. | Define burning rate. | BTL1 | Remembering |
| 7. | State the advantage of solid propellant rockets. | BTL2 | Understanding |
| 8 | What are factors that causes combustion instability in solid propellant rockets? | BTL2 | Understanding |
| 9. | Explain about progressive, neutral and regressive burning rate | BTL2 | Understanding |
| 10. | What are the different grain configuration in solid | BTL2 | Understanding |

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| | propellant? | | |
| 11. | What do you mean by propellant adiabatic flame temperature? | BTL3 | Applying |
| 12. | Define web fraction. | BTL2 | Understanding |
| 13. | Define web thickness. | BTL2 | Understanding |
| 14. | Define and explain about silvers. | BTL2 | Understanding |
| 15. | What are the different types of igniters used in solid rocket propulsion? | BTL2 | Understanding |
| 16. | Define ignition time lag | BTL2 | Understanding |
| 17. | Write down the application of solid rocket motors. | BTL2 | Understanding |
| 18. | Give some of the propellant grain configurations | BTL2 | Understanding |
| 19. | Difference between strand burner and T-burner. | BTL2 | Understanding |
| 20. | What is T-burner and its application? | BTL2 | Understanding |
| | PART – B | | |
| 1 | Explain methods of determining burning rate with strand burner. | BTL2 | Understanding |
| 2 | An end-burning rocket uses a cylindrical DB propellant grain with a diameter of the 190 mm and generates a thrust of 340N over a period of 280 seconds. The thrust co-efficient is 1.1. The characteristic of the propellant are as follows: Density =1450kg/$m^3$, $a_{70}$=4 mm/s, n=0.5, $C^*$=1500m/s. Determine the length of the grain and the throat diameter of the nozzle. | BTL3 | Applying |
| 3 | How do you classify solid propellant rockets? Also discuss the grain designs for restricted and unrestricted burning. | BTL3 | Applying |
| 4 | a) Discuss the combustion stability in solid rocket motor. (6)<br>b) What is adiabatic flame temperature? How it is estimated in a solid propellant rocket motor? (7) | BTL2 | Understanding |
| 5 | What are the factors that causes combustion instability in the solid propellant rocket engines? | BTL3 | Applying |
| 6 | Explain the Salient features of solid propellant rockets and its application. (13) | BTL2 | Understanding |
| 7 | Explain the selection criteria of solid propellants and advantage of solid propellant rockets. (13) | BTL2 | Understanding |
| 8 | The following requirements are given for a solid propellant rocket motor: Sea level thrust 2000 lbf, Duration average 10 sec, Chamber pressure 1000psia, Operating temperature | BTL3 | Applying |

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| | Propellant 1000 psia Ambient (approx. 70°F) Ammonium nitrate-hydrocarbon. Determine the specific impulse, the throat and exit areas, the flow rate, the total propellant weight, the total impulse, the burning area, and an estimated mass assuming moderately efficient design. Properties for this propellant are: $k$ = 1.26; $T1$ = 2700°F =3160 R; $r$ = 0.10 in./sec at 1000 psia; $c'$ = 4000 ft/sec; $Pb$= 0.056 lb/in.; molecular weight= 22 lbm/lb-mol; gas constant= 1544/22 = 70.2 ft-lbf/lbm-R. Explain the erosive burning in solid propellant rockets. (13) | | |
| | PART – C | | |
| 1. | Define combustion instability in rockets and briefly describe the various instabilities associated with solid propellants. | BTL3 | Applying |
| 2. | Briefly describe the salient features of solid propellant rocket with a neat sketch and explain the steps involved in selection of solid propellants. | BTL2 | Understanding |
| 3 | Combustion instability – strand burner and T-burner | BTL3 | Applying |
| 4. | Erosive burning in solid propellant rockets (15) | BTL2 | Understanding |

| **UNIT IV - LIQUID AND HYBRID ROCKET PROPULSION** | | | |
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| **Q.No** | **Question** | **BT Level** | **Competence** |
| | PART - A | | |
| 1. | State the limitations of hybrid propellant rockets. | BTL1 | Remembering |
| 2. | Name some of the liquid fuel and liquid oxidizer used in liquid propellant rockets. | BTL1 | Remembering |
| 3. | Mention any four liquid propellants with fuel and oxides. | BTL1 | Remembering |
| 4. | What are the advantages of coaxial injector? | BTL1 | Remembering |
| 5. | What is the need of hybrid rocket motor? | BTL1 | Remembering |
| 6. | What are cryogenic engines? | BTL1 | Remembering |
| 7. | Explain the cooling method in liquid propellant rockets. | BTL2 | Understanding |
| 8. | Define hypergolic propellant | BTL3 | Understanding |
| 9. | What is called “Thrust vector control” and mention its | BTL2 | Understanding |

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| | various types. | | |
| 10 | What is a cryogenic engine? | BTL2 | Understanding |
| 11 | Define film cooling and its advantage in liquid rocket propulsion. | BTL3 | Understanding |
| 12 | Explain the types of cooling methods of liquid rocket propulsion system. | BTL2 | Understanding |
| 13 | What are the problems associated with the operation of cryogenic engines? | BTL1 | Remembering |
| 14 | Define heat sink cooling. | BTL2 | Understanding |
| 15. | Write down the different injectors in liquid propulsion. | BTL2 | Understanding |
| 16. | Write down three fuel – oxidizer combination for hybrid propellant rockets? | BTL2 | Understanding |
| 17. | Explain the procedures for the selection of liquid propellant. | BTL2 | Understanding |
| 18. | What do you mean by characteristic chamber length? | BTL2 | Understanding |
| 19. | Write any three fuel and oxidizer that is used in liquid rocket propulsion | BTL2 | Understanding |
| | PART – B | | |
| 1 | (i) Explain in detail about film cooling and regenerative cooling of rocket thrust chamber with suitable sketches. | BTL2 | Understanding |
| 2 | a) What cause High frequency Instability (HFI) in liquid rocket engines? (9)<br>b) Discuss about any four methods adopted to eliminate HFI. (4) | BTL1 | Remembering |
| 3 | a) Explain typical tank arrangements of liquid rocket engines. (5)<br>b) With a neat sketch explain the operation of a turbopump feed system of a liquid propellant engine. (8) | BTL1 | Remembering |
| 4 | a) Explain with neat sketch the cooling in liquid rockets motors. (6)<br>b) Name any four liquid oxidizer and write their properties. (7) | BTL1 | Remembering |
| 5 | What are the various feed systems used in the liquid rocket propulsion? Explain with neat sketch. (13) | BTL2 | Understanding |
| 6 | Explain the various injectors used in the liquid rocket propulsion with a neat sketch. (13) | BTL2 | Understanding |
| 7 | Explain the parameters that cause the combustion instability in | BTL2 | Understanding |

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| | the liquid rocket propulsion. (13) | | |
| 8 | Explain the working of hybrid rocket propulsion with a neat sketch and state its advantages and disadvantages. (13) | BTL2 | Understanding |
| 9 | Explain about the standard and reverse hybrid propulsion with a neat sketch and state its advantages and disadvantages. (13) | BTL2 | Understanding |
| 10 | With neat sketch explain the different feed system used in liquid propellant rocket engines | BTL2 | Understanding |
| 11 | Write short notes on :<br>i. The peculiar problems associated with cryogenic engines.)<br>ii) Hybrid rocket with a schematic sketch. | BTL2 | Understanding |
| | PART - C | | |
| 1 | With a neat diagram, explain thrust control and cooling in liquid propellant rockets and the associated heat transfer problems | BTL3 | Applying |
| 2 | Explain Introduction to hybrid rocket propulsion (15) | BTL3 | Applying |

| **UNIT** V - **ADVANCED PROPULSION TECHNIQUES** | | | |
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| **Q.No** | **Question** | **BT Level** | **Competence** |
| | PART - A | | |
| 1. | List few applications of electric propulsion. | BTL1 | Remembering |
| 2. | What are the operational issues associated with nuclear rockets? | BTL1 | Remembering |
| 3. | What is the principle of nuclear propulsion rocket? | BTL1 | Remembering |
| 4. | What are the types of electric propulsion techniques? | BTL1 | Remembering |
| 5. | What is an electric propulsion and briefly explain about its working? | BTL1 | Remembering |
| 6. | What is the difference between thruster and engine? | BTL1 | Remembering |
| 7. | Define hall thruster. | BTL2 | Understanding |
| 8. | What are the advantages and disadvantages of ion propulsion? | BTL2 | Understanding |
| 9. | Define the concept of ion propulsion system. | BTL2 | Understanding |
| 10. | Define electromagnetic thruster | BTL2 | Understanding |
| 11. | Explain about the future application of electric propulsion. | BTL2 | Understanding |
| 12. | Define electro thermal thrusters. | BTL2 | Understanding |
| 13. | Define MPD thrusters. | BTL2 | Understanding |
| 14. | What are the advantages of pulsed plasma electrical propulsion system? | BTL2 | Understanding |
| 15. | Explain the solar sail concept. | BTL2 | Understanding |
| 16. | What are the advantages and disadvantages in the nuclear rocket propulsion? | BTL2 | Understanding |

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| 17. | What do you mean by SPT? | BTL2 | Understanding |
| 18. | Define field emission or colloid thrusters. | BTL2 | Understanding |
| 19. | What is called electro static thruster? Give an example | BTL2 | Understanding |
| 20. | Define the concept of arc jet propulsion | BTL2 | Understanding |
| | PART – B | | |
| c | Explain the principle of working of an electrostatic thruster and derive the expression for thrust per unit area of the thruster. | BTL1 | Remembering |
| 2 | Draw the schematic of a hall thruster and explain its principle of operation in details with necessary equations. | BTL1 | Remembering |
| 3 | 1. Discuss the following advanced propulsion technique with suitable sketches.<br>a) solar Sail.<br>b) Nuclear propulsion (13) | BTL2 | Understanding |
| 4 | Describe in detail about S/MIME. (13) | BTL1 | Remembering |
| 5 | Discuss authentication header and ESP in detail with their packet format. (13) | BTL2 | Understanding |
| 6 | Describe PGP cryptographic functions in detail with suitable block diagrams. .13) | BTL1 | Remembering |
| 7 | 1. (i Determine the flight characteristics of an electrical propulsion rocket for raising a low satellite orbit. Data given:<br>(13)<br>Is = 2000 sec<br>F = 0.20 N<br>Duration = 4 weeks = 2.42 x 106 sec<br>Payload mass = 100 kg<br>$\alpha$ = 100 W/kg $\dot{\eta}$ = 0.5<br>For an electron-bombardment ion rocket the following data are given: (13)<br>Working fluid =xenon (131.3 kg/kg-mol)<br>Net accelerator voltage = 700 V<br>Distance d between grids = 2.5 mm<br>Diameter D of each grid opening = 2.0 mm<br>Number of holes in the grid = 2200<br>Ionization potential for xenon =12.08eV.<br>Determine the thrust, exhaust velocity, specific impulse, mass flow rate, propellant needed for 91 days' operation, the power of the exhaust jets, and the thruster efficiency including ionization losses. | BTL2 | Understanding |
| 8 | Explain in detail about the hall thrusters with a neat sketch. | BTL2 | Understanding |
| 9 | Explain about Ion propulsion with a neat sketch and electric propulsion system. | BTL2 | Understanding |
| 10 | Explain the working operation of the resisto jet propulsion with a neat sketch. | BTL2 | Understanding |

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| 11 | Explain about Ion propulsion with a neat sketch | BTL2 | Understanding |
| | PART - C | | |
| 1. | Briefly explain the following :<br><br>i) Electric rocket propulsion.<br>ii) Ion rocket propulsion. | BTL3 | Applying |
| 2. | Compare the performance of nuclear rocket with chemical rocket propulsion | BTL2 | Understanding |