Marks: 50

A)

B)

Exam Date & Time: 09-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

SEVENTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, DECEMBER 2023

Jet Propulsion and Rocket Technology [MME 4071]

Α

Answer	all	the	questions.
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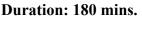
Instructions t	to Candidates: Answer ALL questions Missing data may be suitably assumed
1)	Explain the bleed burn cycle of Thrust Augmentation.

The effective jet velocity from a jet engine is 3200 m/s. The forward flight velocity is 1400 m/s and the air flow rate is 65 kg/s. Calculate

(i) Thrust Power (ii) Propulsive efficiency

C) Determine the specific work output, fuel consumption and cycle efficiency for a simple (5) cycle gas turbine with a free power turbine given the following specifications:

Compressor pressure ratio:	12
Turbine inlet temperature:	1350 K
Isentropic efficiency of compressor:	0.86
Isentropic efficiency of each turbine:	0.89
Mechanical efficiency of each shaft:	0.99
Combustion efficiency:	0.99
Combustion chamber pressure loss:	6% compressor delivery pressure
Exhaust pressure loss:	0.03 bar
Ambient pressure:	1 bar
Ambient temperature:	288 K



(3)

(2)

Section Duration: 180 mins

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2)	A)	It is required to install engines to an aircraft running at an altitude where ambient temperature and pressure are 236 K and 0.38 bar respectively. The 2 possible engines are Turbojet and Ramjet. The Turbojet has a maximum operating temperature of 1300 K with a compression ratio of 10. The maximum operating temperature of Ramjet is 2400 K. The aircraft has to run at a speed of Mach 1.2. Considering there are no aerodynamics losses at any component in both the turbojet and ramjet engines (i.e. all components have 100% efficiency), compare the TSFC of both these engines and suggest a suitable engine for the application.	(5)
		Assume $P_e = P_a$, $\gamma_a = \gamma_g = 1.4$, $C_{pa} = C_{pg} = 1.0$ kJ/kgK, Heating value of fuel = 45 MJ/kg.	
		Hint: Use $f = \dot{m}_f / \dot{m}_a$ wherever applicable.	
	B)	With a neat sketch, explain the working of a turbo-shaft engine and its applications.	(3)
	C)	Explain the effects of regeneration in a gas turbine unit.	(2)
3)		A rocket has the following characteristics:	
		Initial mass: 180 kgs	
	A)	Mass after rocket operation: 110 kgs	
		Payload: 70 kgs	
		Operating duration: 5 seconds	(4)
		Average specific impulse of propellant: 200 seconds	
		Determine the propellant mass fraction, propellant flow rate, thrust-to-weight ratio, acceleration of the vehicle, and the total impulse.	
	B)	Using first principles, prove that the semi-divergence angle of a conical nozzle is optimum at 15°.	(3)
	C)	From first principles, derive an expression to find expansion ratio of nozzle.	(3)
4)	•	Discuss the drawbacks associated with liquid propellant tanks having a gas pressure feed system. How are those drawbacks addressed in turbopump feed systems? With a neat sketch, explain the working of a Gas generator combustion cycle turbopump feed system.	(4)
	A)	System.	
	B)	Give the advantages of Gelled propellants over solid or liquid propellants.	(2)
	C)	A rocket traverses from 0 to 20 km in altitude. The nozzle is designed for 9 km altitude. The chamber pressure is 10 MPa and $\gamma_g = 1.3$. Area of throat is 0.2 m ² . Determine	(4)
		(i) Nozzle expansion ratio	
		(ii) Nozzle exit area A _e	

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	(iii) Optimum thrust coefficient at 9 km altitude	
	Take $T_a = -46.6$ °C and $P_a = 0.306$ bars	
5)	With a neat sketch, explain the working of a Hall effect thrusters.	
		(3)
A)		
B)	A satellite system is to be designed for space travel to outer solar system. Among the advanced propulsion techniques of solar sails and ion-propulsion thrusters, which would be preferred for a duration of operation of 20 years? Justify your answers.	(4)
C)	With a neat sketch, explain the working of an Arcjet thruster. What are its limitations?	(3)

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