Registration No : | | | | | | | | | | |

Total Number of Pages : 03 **B.Tech.**
PAE6I102

6th Semester Regular Examination 2017-18
PROPULSION – II
BRANCH : AERO
Time : 3 Hours
Max Marks : 100
Q.CODE : C201
Answer Part-A which is compulsory and any four from Part-B.
The figures in the right-hand margin indicate marks.

Part – A (Answer all the questions)

Q1 **Answer the following questions : *Short answer type :*** **(2 x 10)**

a) Differentiate between Impulse and reaction blade.
b) List the methods used on turbine cooling.
c) Define the cyclic efficiency of a ramjet engine.
d) What are the application of integral ram-rocket propulsion system?
e) Define and write the equations for Specific impulse and specific thrust.
f) Explain the bell nozzle with suitable sketch.
g) What are design requirements for grain design of solid propellant rocket?
h) Explain about bipropellant liquid rocket engine with suitable sketch.
i) Why electrical rockets are called essentially power limited?
j) Write a note on nozzle less propulsion system.

Q2 **Answer the following questions : *multiple type or dash fill up type :*** **(2 x 10)**

a) The degree of reaction of an impulse turbine is
(a) 1, (b) 0.75, (c) 0.5 , (d) 0,

b) For an impulse turbine with identical stages, the hot gas exits from the stator of blades at the mean blade height at an absolute angle of 70^0 with the axis of the turbine. If the absolute inlet blade angle with the axis of the turbine at the mean blade height for the rotor blades is $37^{0,}$ then the absolute exit blade angle with the axis of the turbine at the mean blade height of the rotor blades is _____.
(a) 33^0, (b) 37^0, (c) 53^0, (d) 53.5^0

c) An ideal ramjet engine is flying at a Mach number M. The exhaust gas static temperature at the outlet of the nozzle is T_e. The ambient static temperature is T_a. Gas constant is R and specific heat ratio is γ do not vary through the ramjet. Assuming that nozzle exhaust static pressure is equal to the ambient pressure and fuel air ratio f<<1, the thrust per unit mass flow rate is:

(a) $\sqrt{\gamma RT_a}\left[\sqrt{\frac{T_e}{T_a}}\right]$ (b) $\sqrt{\gamma RT_a}\left[\sqrt{\frac{T_e}{T_a}}-1\right]$ (c) $M\sqrt{\gamma RT_a}\left[\sqrt{\frac{T_e}{T_a}}-1\right]$

(d) $M\sqrt{\gamma RT_a}\left[\sqrt{\frac{T_e}{T_a}}\right]$

d) A cruise missile with an *ideal* ramjet engine is flying at Mach 4.0 at an altitude where the ambient temperature is 100*K*. Consider ratio of specific heat as γ = 1.4 and specific gas constant R = 287*J/kgK*. If the stagnation temperature in the combustion chamber is equal to 2310*K*, the speed of the exhaust gases (in *m/s*) is _____.

e) The on-board rocket motor of a satellite of initial mass 2000kg provides a specific impulse of 280s. If this motor is fired to give a speed increment of 500m/s along the direction of motion, the mass of the propellant consumed is _____.
(a) 685kg., (b) 333kg., (c)1666kg. (d) 167kg.

f) A rocket motor has a chamber pressure of 100 bar and chamber temperature of 3000 K. Theambient pressure is 1 bar. Assume that the specific heat at constant pressure is 1 kJ/kg-K. Alsoassume that the flow in the nozzle is isentropic and optimally expanded. The exit static temperaturein K is _____.
(a) 805 (b) 845 (c) 905 (d) 945

g) A solid rocket motor is designed with a cylindrical end-burning propellant grain of length 1m and diameter 32cm. The density of the propellant grain is 1750kg/m^3. The specific impulse of the motor is 190s and the acceleration due to gravity is 9.8m/s^2. If the propellant burns for a period of 150s, then thrust (in N) produced by the rocket motor is _____.

h) The vacuum specific impulse of a rocket engine using liquid hydrogen and liquid oxygen as propellants is _____.
(a) 49s, (b) 450s, (c) 6000s, (d) 40000s.

i) In a stationary plasma thruster (STP), the mass flow rate is 5.3 x 10^{-6} kg/s, the specific impulse is 1600s, and the input power is 1350 W, the value of thrust and efficiency are _____ and _____ respectively.

j) The optimum specific impulse of a electric propulsion system depends parametrically on the specific powerplant mass, conversion efficiency, and mission time, but independent of _____.
(a) Voltage, (b) current, (c) Thrust, (d) Power.

Part – B (Answer any four questions)

Q3 a) In a single stage impulse turbine, the nozzle discharges the fluid on to the blades at an angle of 65^0 to the axial direction and the fluid leaves the blades with an absolute velocity of 300m/s at an angle of 30^0 to the axial direction. If the blade has equal inlet and outlet angles and there is no axial thrust, estimate the blade angle, power produced per kg/s of the fluid and blade efficiency. **(10)**

b) Describe the working of an axial flow turbine stage with a neat sketch and draw the T-S diagram and velocity triangles. **(5)**

Q4 a) A ramjet is propelling an aircraft at a Mach 3 at high altitude where the ambient pressure is 8.5Kpa and the ambient temperature T_a is 220K. The turbine inlet temperature T is 2540K. If all the components of the engine are ideal (frictionless), determine: **(10)**
i) The thermal Efficiency
ii) The propulsion efficiency
iii) The overall efficiency.

b) Explain with suitable sketches the subcritical, critical and supercritical condition of airflow in ramjet diffuser. **(5)**

Q5 a) The inlet conditions for a rocket nozzle are given as: T_T (total temperature) = 2800K, p_T (total pressure) 43x10^5pa, and the inlet velocity can be neglected when compared to nozzle outlet velocity. The nozzle throat diameter is 5.2cm. Estimate the mass flow rate through the nozzle. Assuming optimum expansion at sea level, determine nozzle exit velocity, exit Mach number and the thrust developed by the rocket unit. Take the ratio of specific heats as 1.35. **(10)**

	b)	With neat sketch derive the fundamental thrust equation of a rocket. Explain the basic operating principle of a rocket.	**(5)**
Q6	**a)**	A liquid rocket has a pressure and temperature of 2.8Mpa and 6250^0C,respectively, in the combustion chamber and is operating at an altitude where the ambient pressure is 1.4Mpa. The gases exit through an isentropic converging–diverging nozzle which produces a Mach number of 4.0. Approximate the exhaust gases by taking γ = 1.4 and a molecular weight of 20. Assume perfect gas behavior, determine the specific impulse and the effective exhaust velocity.	**(10)**
	b)	Write about the selection criteria of igniter for solid rocket propulsion.	**(5)**
Q7	**a)**	Classify the various types of electric rocket propulsion system. What are the limitation of electric rocket propulsion system? Explain about hall thruster with neat sketch.	**(10)**
	b)	Illustrate with suitable sketches the photon propulsion system.	**(5)**
Q8	**a)**	With neat sketches, explain the compressor-turbine matching procedure.	**(10)**
	b)	How does the shape of the nozzle affect performance? How do you overcome the thrust loss associated with overexpansion?	**(5)**
Q9	**a)**	State the various cooling technique used in liquid rocket engine with suitable examples.	**(10)**
	b)	With neat sketch explain the principle of operation of a Nuclear rocket.	**(5)**