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

Total Number of Pages: 02 **M. Tech**
TFPE205

2nd Semester Back Examination 2017-18
Aircraft and Rocket Propulsion
BRANCH: MECH. ENGG (THERMAL & FLUID ENGG), THERMAL & FLUID ENGG
Time: 3 Hours
Max Marks: 100
Q.CODE: C1098
Answer Question No.1 which is compulsory and any FIVE from the rest.
The figures in the right hand margin indicate marks.
Answer all parts of a question at a place.

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

a) Define ram efficiency.

b) Define the surging in a compressor.

c) Define thrust coefficient for a rocket engine and write its formula in terms of thrust developed (F_R), pressure of combustion chamber (P_c), and throat area (A*) of the nozzle.

d) Draw the P-V diagram for a rocket engine.

e) What do you mean by a level flight condition? In a level flight condition, how the drag is related to the vehicle weight.

f) Draw a free hand curve for the thermal efficiency *vs* pressure ratio for an ideal Brayton cycle.

g) In aircraft gas turbine, why it is usually preferred to use convergent propelling nozzles over the use of convergent-divergent propelling nozzle.

h) What do you mean by air-breathing engine? Give four examples of air-breathing engine.

i) Write the expression for velocity co-efficient (c*) for a rocket motor in terms of the pressure of combustion chamber (P_c) and the throat area of the nozzle.

j) Define degree of reaction for an axial flow compressor.

Q2 **a)** The first stage of an axial flow compressor is designed on free-vortex principle, with no inlet guide vanes. The rotational speed is 6000 rpm and stagnation pressure rise is 20 K. The hub-tip ratio is 0.6, the work done factor is 0.93 and isentropic efficiency of stage is 0.89. Assuming an inlet velocity of 140 m/s and ambient conditions of 1.01 bar and 288 K, Find the tip radius and corresponding rotor air angles, if the Mach number relative to tip is limited to 0.95. Also find the mass flow rate entering the stage. **(5)**

b) For the above problem, find the stage stagnation pressure ratio and power required. **(5)**

Q3 **a)** Derive an expression for thrust developed by a rocket engine and write the conditions for maximum thrust. Derive the expression for the same. **(5)**

b) With neat sketch describe the working of a liquid propellant rocket engine. Mention various methods of injecting the liquid propellant into the combustion chamber. **(5)**

Q4 **a)** A simple gas turbine with heat-exchanger has a compressor and turbine having respective isentropic efficiencies η_c and η_t. Show that the combined effect of small pressure drops Δp_{hg} (in gas side of heat-exchanger) and Δp (total in combustion chamber and air side of heat-exchanger) is to reduce the specific work output by an amount given by $\frac{\gamma-1}{\gamma}\times\frac{c_p T_3 \eta_t}{r^{(\gamma-1)/\gamma} p_1}\left[\Delta p_{hg}+\frac{\Delta p}{r}\right]$, where T_3 = turbine inlet temperature, p_1 = compressor inlet pressure and r = compressor pressure ratio. Assume c_p and γ are constant throughout the cycle. **(5)**

b) Write short notes on the variation of thrust of jet engine with rotational speed, foreword speed and altitude. **(5)**

Q5 **a)** A ramjet is to propel an aircraft at Mach 3 at high altitude where the ambient pressure is 8.5 k Pa and temperature T_a is 220 K. The turbine inlet temperature is 2540 K. If all the components of the engine are ideal, and assuming the specific heat ratio 1.4 and fuel air ratio $f << 1$, determine the thermal efficiency. **(5)**

b) Also determine the propulsion and overall efficiencies for the above case. **(5)**

Q6 **a)** A turbojet engine with zero bypass ratio has a pressure ratio of 30 and maximum temperature of 1700 K. The component efficiencies and ambient conditions are given as follows: **(5)**

Diffuser efficiency	η_d	0.97
Compressor efficiency	η_c	0.85
Burner efficiency	η_b	1.00
Turbine efficiency	η_t	0.90
Nozzle efficiency	η_n	0.98

Fuel heating value 45,000 kJ/kg

The aircraft is flying at Mach 0.85 where ambient pressure and temperature are 18.75 k Pa and 216.7 K. Taking constant specific heat of 1.4, determine specific thrust and the thrust specific fuel consumption.

b) For the above problem, find also the engine thermal efficiency, propulsion efficiency and overall efficiency. **(5)**

Q 7 **a)** What is the purpose of injectors in rocket engines? Describe an injector with add of a sketch. **(5)**

b) How are regressive, neutral and-progressive burning of the solid propellant grain achieved? Explain With the aid of diagram. **(5)**

Q8 **Answer any two** **(5X2)**

a) Write short notes on the Surging of air compressor.

b) Write short notes on Solid propellant rockets and liquid propellant rockets.

c) Describe the events leading to pressure oscillation In a rocket Combustor.