Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2018

SUBJECT: TURBOMACHINERY AERODYNAMICS [AAE 4017]

REVISED CREDIT SYSTEM
(28/11/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. What do you mean by the term 'Turbomachinery'? List some of the turbomachinery components used in aircraft engine. **(2)**

1B. Explain different types of typical fuel tanks used in the aircraft industry **(3)**

1C. Air at 1.0 bar and 288 K enters an axial flow compressor with an axial velocity of 150 m/sec. there are no inlet guide vanes. The rotor stage has a tip diameter of 60 cm and a hub diameter of 50 cm and rotates at 100 rps. The air enters the rotor and leaves the stator in the axial direction with no change in velocity or radius. The air is turned through 30.2 degree as it passes through the rotor. Assume a stage pressure of 1.2 bar and overall pressure ratio 6. Find (i) The mass flow rate of air (ii) the power required to drive the compressor (iii) The degree of reaction at the mean diameter (iv) No. of compressor stages required if the isentropic efficiency is 0.75. **(5)**

2A. Write the advantages of Afterburner and ducted fan. **(2)**

2B. With the help of neat diagram explain the concept of multi spool arrangement in aircraft engine. **(3)**

2C. The following design data refers to an aircraft engine axial flow compressor air enters the compressor at 1 bar and 290 k. The first stage of the compressor designed on free vortex principles, with no inlet guide vanes. The rotational speed is 5500 rpm and stagnation temperature rise is 22 k. The hub tip ratio is 0.5, the work done factor is 0.92, and the isentropic efficiency of the stage is 0.90, assuming the inlet velocity of 145 m/sec. Calculate: (i) The tip radius and corresponding rotor air angles, if the Mach number relative to the tip is limited to 0.96 (ii) The mass flow at compressor inlet. (iii) The stagnation pressure ratio and power required to drive the compressor. (iv) The rotor air angles at the root section. **(5)**

3A. An aircraft centrifugal radial compressor impeller rotates at 9000 rpm. If the impeller tip diameter of 0.914 m and $\alpha_2 = 20^0$, calculate the following for operation in standard sea level at atmospheric conditions: U_2, C_{W2}, C_{r2} and C_2. **(2)**

3B. With the help of neat digrams explain all the aerodynamic losses of turbomachinery components. **(3)**

3C. The following design data apply to an aircraft double sided centrifugal compressor. Impeller eye tip diameter 0.28m, Impeller eye root diameter 0.14m, Impeller tip diameter 0.48m, mass flow of air 10 kg/sec, Inlet stagnation temp 290 K, Inlet stagnation pressure 1 bar, Air enters axially with the velocity 145 m/sec, slip factor 0.89, power input factor 1.03, Rotational speed 15,000 rpm. Calculate (i) Impeller vane angles at the eye tip to eye root (2M) (ii) Power input (1M) (iii) The maximum mach number at the eye (1M). **(5)**

4A. With the help of neat diagrams discuss different types of centrifugal compressor blades **(2)**

4B. A single stage axial flow gas turbine has the following design data. Mean blade speed 340 m/sec, stator exit angle 15^0, axial velocity (constant) 105 m/sec, turbine inlet temperature 900^0 C, Turbine outlet temperature 670^0 C, Degree of reaction 50 %, Calculate the enthalpy drop per stage and number stages required **(3)**

4C. The following aircraft engine design data particulars related to a single stage turbine of free vortex design are: Inlet temp 1100 K, Inlet pressure 4 bar, Mass flow 20 Kg/sec, axial velocity at stator exit 250 m/sec, blade speed 300 m/sec, stator angle at mean diameter 25^0, rotational speed 240 rps, ratio of tip to radius 1.4, the gas leaves the stage in an axial direction, find: (i) The total throat area of the nozzle (ii) The stator efflux angle at root to tip (iii) The workdone on turbine blades. Take $C_{P_{gas}} = 1147$ J/Kg.K and $\gamma_{gas} = 1.333$. **(5)**

5A. Write a short note on different types of fuels used in aviation sector. **(2)**

5B. Air leaves the fan with a radial velocity 110 m/sec, makes an angle of 25^0 with an axial direction. The fan tip speed is 475 m/sec. Fan efficiency is 0.80 and mechanical efficiency 0.96, Neglect power input factor and assume $\gamma = 1.4$, $T_{01} = 298$ K and mass flow rate is 3 kg/sec. Find: (i) Slip factor (ii) Overall pressure ratio (iii) Power required to drive the fan. **(3)**

5C. Air enters axially in a centrifugal fan at a stagnation temperature 20^0 C and is compressed from 1 to 4.5 bars. The fan has 19 radial vanes and rotates at 17,000 rpm. The isentropic efficiency of the fan is 0.84 and the work input factor is 1.04. Determine the overall diameter and power required to drive the fan when the mass flow is 2.5 kg/sec. **(5)**