Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

V SEMESTER B. TECH (MECHANICAL ENGG.) END SEMESTER ONLINE EXAMINATIONS, FEBRUARY 2021

SUBJECT: TURBO MACHINES [MME 3154]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Write **Name, Registration number** and **Section** in each of the sheets used and **sign** in all the sheets.
- Write the **question number** clearly.
- Missing data may be suitably assumed.
- Take X = Last digit of your Registration number and Y = Sum of digits of your Registration number. Ex: If Registration number is 190909675, then X = 5, Y = 46.

Q1. A pumped storage hydroelectric power plant uses cheap off-peak-load electricity to pump sea water of density 1030 kg/m^3 to an artificial lake at an altitude of (500 + 2Y) ft. It is proposed to use a Francis turbine of dimensionless specific speed 0.9 to produce 5MW power to meet the peak load requirement. A 1/4th scale model of turbine is tested using normal water under a head of (10 + X) m. Find the speed of rotation and the flow rate for both model and prototype. Also, find the power output of the model. **05**

Q2. A petroleum refinery requires a pump to supply a liquid of specific gravity 0.9 and viscosity 0.012 Pa-s to a height of (20 + X) m at the rate of 10Y lit/s. A 1/8th scale model of the pump is tested using water (20ºC). The speed of rotation of the model is 2500 RPM. Assuming both model and prototype are (50 + Y) % efficient, find the flow rate, the head developed and the power consumed by the model. What is the specific speed of the pump? Also find the power required and speed of rotation of prototype. **05**

Q3. The mean blade diameter of an impulse turbine stage is (1 – 0.01X) m. The speed rotation is (2400 + Y) RPM. The nozzle is inclined at 20º to the plane of the runner wheel. Design (find inlet and exit blade angles) the turbine stage for a utilization factor of 0.88, blade speed ratio of 0.4 and zero axial thrust. Also find the specific work output from the stage and the bucket loss coefficient. **05**

Q4. A hydraulic reaction turbine of radial type works under a head of (50 + Y) m. The absolute velocity of water at inlet makes an angle of (16 + X)º with the **05**

tangential direction. Water exits the turbine in the radial direction. The meridional component of velocity is constant throughout and is (45 + Y)% of inlet relative velocity. The reaction head is equally shared by the centrifugal and the relative velocity head. Determine the runner blade angles, degree of reaction and the power output if the available flow rate is 0.1Y m^3/s.

Q5. An Air compressor has five stages of equal pressure ratio. The polytrophic index of compression process is found to be (1.2 + 0.01Y) and the exit temperature is (150 + X)ºC. Calculate the stage pressure ratio, stage efficiency, preheat factor and the power required to drive the compressor, if Y kg of air is compressed per minute. The conditions of air at entry are 1 bar and 27ºC. What would be the exit temperature if one more similar stage is added to the compressor? **05**

Q6. A farmer wants to buy a centrifugal pump to lift water from a well to the paddy fields. The water level in the well is (5 + 0.1X) m below the ground level. Specifications of the pump quoted by the seller are tip diameter 200 mm, tip width 12 mm, exit vane angle 32º, diameter of both suction and delivery pipes is 60 mm, speed of rotation (900 + 2Y) RPM. The manometric efficiency of the pump is 80%. Compute the flow rate through the pump assuming head loss in the suction pipe is 10% of the static suction head. If, in peak summer atmospheric temperature reaches to 40ºC and the water level in the well falls to 10 m below ground level, how can the farmer use the same pump to lift the water? Explain. **05**

Q7. Air enters a centrifugal compressor at stagnation temperature of (290 + X) K and pressure of 1 bar. The tip diameter of the impeller is 500 mm and the mean eye diameter is 100 mm. The compressor has radial blades at exit and the exit meridional component is Y m/s. The stagnation pressure of air increases to 2.2 bar when the compressor runs at 12000 RPM. What is the static, actual and isentropic temperature rise through the compressor? Find the total to total isentropic efficiency of the compressor and degree of reaction. **05**

Q8. A hydroelectric power-plant has an available head of (400 + Y) m and a flow rate of (5 + 0.1X) m^3/s. A double over-hung Pelton turbine is used for energy conversion. The specifications of the Pelton turbine are the speed of rotation 300 RPM, the coefficient of jet 0.97, the blade speed ratio 0.46, the bucket coefficient 0.85, the jet ratio 15. Find the specific speed of the turbine, number of jets required, diameter of jet, mean diameter of the runner. Assume the deflection angle of the jet over the bucket as 162°. **05**

Q9. An axial flow compressor stage draws air with a stagnation condition of 1 bar and (26 + X) º C. The work done factor of the compressor stage is 0.86 and the mass flow rate is 12 kg/s. The total to total efficiency is (45 + Y)% and the total pressure ratio is (1.2 + X/Y). Assuming 50% reaction stages with a flow coefficient of 0.52 and ratio $\Delta Cu / U = 0.3$. Find the rotor blade angle at inlet and exit as well as mean rotor speed. Find also the pressure coefficient and power input. **05**

Q10. The nozzle of an impulse steam turbine having efficiency of 96% is inclined **05**

at (15 + X)° to the plane of rotor which revolves at (8000 + 5Y) RPM. The rotor tip diameter is 960 mm and the blade height is 80 mm. Steam enters the nozzle in the dry saturated condition with an enthalpy of 2750 kJ/kg and exits the turbine into the condenser with an enthalpy of 2400 kJ/kg. Assuming the coefficient of velocity for the equiangular rotor blades as 0.92, find the specific power output, the rotor efficiency, the stage efficiency and utilization factor.