U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

January / February 2025 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 23ME5PCTFE / 22ME5PCTFE **Max Marks: 100**
Course: Thermal and Fluids Engineering

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	CO	PO	Marks
1	a)	Discuss the basis of classification of turbomachines based on direction of the energy transfer and fluid flow direction. Provide at least two examples for each type of turbomachine. Highlight the significance of dimensionless parameters in comparing turbomachine performance.	CO1	PO1	**06**
	b)	A pump operates under the following conditions: Inlet velocity triangle: Axial velocity V_1=10 m/s, Blade angle at the inlet $\beta_1=30^o$. Outlet velocity triangle: Axial velocity V_2=10 m/s, Blade angle at the outlet $\beta_2=60^o$. Rotor diameter at inlet and outlet is d=0.5 m. Rotor speed is 300 rpm. Using the Euler equation for turbomachines, calculate: i) The tangential component of velocity (V_{w1}, V_{w2}). ii) The specific work done on the fluid by the pump. (Assume the axial velocity remains constant, and there are no losses.)	CO2	PO2	**07**
	c)	A turbine operates with the following parameters: Inlet velocity triangle: Axial velocity V_1=15 m/s, Tangential velocity at the inlet V_{w1}=20 m/s. Outlet velocity triangle: Axial velocity V_2=15 m/s, Tangential velocity at the outlet V_{w2}=5m/s. If the rotor diameter at inlet and outlet is d=1.0 m and the rotor speed is 150 rpm. Calculate: i) The specific energy transfer per unit mass of the fluid using the Euler equation. ii) The specific speed of the turbine, given the flow rate is Q=1.5 m^3/s and the head developed is H=10 m.	CO2	PO2	**07**
		OR			
2	a)	Classify hydraulic turbines based on the type of energy at the inlet, direction of flow, and head available. Explain the working principles of impulse and reaction turbines, providing suitable examples for each. Highlight the significance of efficiency in hydraulic turbines.	CO1	PO1	**07**
	b)	A Pelton wheel operates with the following parameters: Net Head: 50 m, Jet velocity: 30 m/s, blade velocity: u=12 m/s, deflection angle of the jet: $\theta=165^o$, if the flow rate is Q=0.2 m^3/s. Assume relative velocity at the exit as 0.85 times the relative velocity at	CO2	PO2	**07**

			inlet. Calculate: i) The power developed by the Pelton wheel. ii) The hydraulic efficiency of the turbine.			
		c)	A Francis turbine operates under the Head of 30 m, with a flow rate: Q=1.5 m^3/s and an hydraulic efficiency of 85%. Calculate: i) The power output of the turbine. ii) The specific speed of the turbine, given the rotational speed N=150 rpm.	*CO1*	*PO2*	**06**
			UNIT - II			
	3	a)	Discuss the effect of the blade discharge angle on energy transfer and head coefficient. Define surging and choking in centrifugal compressors.	*CO1*	*PO1*	**06**
		b)	A centrifugal compressor operates with the following conditions: Inlet blade velocity is u_1=80 m/s, outlet blade velocity is u_2=120 m/s, If the flow velocity at the inlet and outlet is 50m/s. If the blade angle at the outlet: $\beta_2=30^o$. Flow is radial at the inlet and mass flow rate is 0.5 kg/s. Using the velocity triangles, calculate: i) The tangential velocity at inlet and exit. ii) The energy transfer per unit mass of air using the Euler equation and Power required.	*CO2*	*PO2*	**07**
		c)	A centrifugal compressor with a mass flow rate of 2 kg/s with a overall pressure ratio: $P_{02}/P_{01}=4$. If the inlet total temperature is 300 K, Isentropic efficiency: η_s=85% and assuming air as an ideal gas (γ=1.4, R=287 J/kg-K), calculate: i) The isentropic work of compression. ii) The actual work required by the compressor and the temperature after compression.	*CO2*	*PO2*	**07**
			OR			
	4	a)	Explain the need for pre-whirl vanes in centrifugal compressors and how they address compressibility effects.	*CO1*	*PO1*	**04**
		b)	The diameter ratio of the impeller of a centrifugal compressor is 2 and the pressure ratio is 4. At a speed of 12000 rpm, the flow rate is 10 m^3/s of free air. The isentropic efficiency of the compressor is 84%. The blades are radial at the outlet and entry is radial at the inlet. The velocity of flow remains constant at 60 m/s through the impeller. Calculate i) power input to the machine, ii) the impeller diameters at the inlet and outlet, and iii) the blade angle at the inlet. The suction is from the atmosphere at 100 kPa and 300 K.	*CO2*	*PO2*	**07**
		c)	The impeller of a centrifugal compressor has the inlet and outlet diameters of 0.3 and 0.6 m, respectively. The intake is from the atmosphere at 100 kPa and 300 K, without any whirl component. The outlet blade angle is 75o. The speed is 10000 rpm and the velocity of flow is 120 m/s. If the blade width at the intake is 60 mm and overall efficiency as 0.7 calculate, i) specific work and ii) exit pressure.	*CO2*	*PO2*	**09**
			UNIT - III			
	5	a)	Define Net Positive Suction Head (NPSH) and explain the concept of NPSH mathematically.	*CO3*	*PO1*	**05**
		b)	A centrifugal pump operates with the suction head of 2 m and the	*CO3*	*PO2*	**05**

			delivery head of 20 m. If the losses in suction and delivery are of 1 m each and suction pressure is 20 kPa and the discharge through the pump is 0.01 m^3/s. Determine: i) The manometric head. ii) The power required by the pump, if its overall efficiency is 75%			
		c)	The blade angles at the inlet and outlet of the impeller of a centrifugal pump are 55^o and 75^o, and the corresponding diameters are 30 mm and 60 mm respectively. The blade width at the outlet is 7.5 mm. The speed is 1500 rpm. The entry of water is radial without any whirl component. The flow component of fluid velocity remains constant and the hydraulic efficiency is 0.85. Draw the velocity triangles and calculate, i) the specific work, ii) flow rate, iii) power required to drive the pump, and iv) manometric head.	*CO2*	*PO2*	**10**
			OR			
	6	a)	Define and explain the following efficiencies and discuss the factors affecting each efficiency. i) Manometric efficiency ii) Hydraulic efficiency iii) Volumetric efficiency	*CO3*	*PO1*	**06**
		b)	A centrifugal pump has its impeller with inlet and outlet diameters of 35 cm and 70 cm respectively. It is used in a setup with a manometric head of 28 m. Determine the minimum starting speed. If the manometric head is increased to 35 m for the same pump, comment on the starting speed obtained with the earlier value.	*CO3*	*PO2*	**06**
		c)	A centrifugal pump is driven by an induction motor at 960 rpm. The flow rate of water is 50 litres/sec against a head of 10 m. The flow velocity is constant at 6.5 m/s through the impeller. The blades are radial at the outlet and the losses are estimated as 15% of the output. Assume that water enters the rotor at $\alpha_1 = 90^o$. Calculate; i) tip diameter of the impeller, ii) width of the blades at the outlet, iii) fluid delivery angle iv) power and v) specific speed.	*CO2*	*PO2*	**08**
			UNIT - IV			
	7	a)	Explain the concept of availability and exergy. Discuss the exergy balance equation for steady-flow systems.	*CO3*	*PO1*	**06**
		b)	A heat engine operates with the following parameters: Inlet temperature: T_1=600 K, Outlet temperature: T_2=300 K. If the heat input: Q_{in}=500 kJ and the ambient temperature: T_0=300 K. The engine is operating at steady state. Calculate: i) The exergy input to the engine. ii) The exergy destruction in the engine.	*CO3*	*PO2*	**06**
		c)	A system operates at steady state with the inlet temperature of 400 K and outlet temperature is 250 K. The system undergoes an isothermal process at ambient temperature T_o=300 K . If the mass flow rate is 1.5 kg/s. Given the specific heat capacity of the fluid C_p=1 kJ/kg K, calculate: i) The exergy lost during the process. ii) The second law efficiency of the system.	*CO3*	*PO2*	**08**

			OR			
	8	a)	Explain the concept of dead state. Discuss the significance of second law efficiency.	*CO3*	*PO1*	**06**
		b)	A 15 kg of water is heated in an insulated tank by a churning process from 300 K to 340 K. If the surrounding temperature is 300 K, find the loss in availability for the process.	*CO3*	*PO2*	**06**
		c)	A closed system contains 2 kg of air during an adiabatic expansion process there occurs a change in its pressure from 500 kPa to 100 kPa and in its temperature from 350 K to 320 K. if the volume doubles during the process make calculations for maximum work, the change in availability and irreversibility. Take for air C_v = 0.718 kJ/kg K and R = 0.287 kJ/kg-K. The surrounding conditions may be assumed to be 100 kPa and 300 K.	*CO3*	*PO2*	**08**
			UNIT - V			
	9	a)	Explain the working principle Brayton Cycle with the help of p-V and T-S diagrams.	*CO4*	*PO1*	**06**
		b)	Derive an expression thermal efficiency of the Otto cycle.	*CO4*	*PO1*	**08**
		c)	In an air-standard Diesel cycle, the following data is provided: Compression ratio: 18, Cut-off ratio: 2.5, Maximum temperature: 2200 K and the inlet temperature: 300 K. Specific heat ratio γ=1.4. Calculate: i) The efficiency of the Diesel cycle. ii) The work output per cycle if the gas mass is 0.025 kg.	*CO4*	*PO2*	**06**
			OR			
	10	a)	Tabulate the differences between the combustion processes in a Spark Ignition (SI) engine and a Compression Ignition (CI) engine.	*CO4*	*PO1*	**06**
		b)	**A** 4-stroke SI engine has the following specifications: Bore diameter = 80 mm, Stroke = 100 mm. The engine runs at 2400 rpm and consumes about 1 kg of air and 5 kg of fuel per hour. If the calorific value of the fuel is 42,000 kJ/kg and generates 30 kW of power. If the exhaust temperature is 800 K rejecting heat to ambient at 300 K, while the specific heat of exhaust gases is 2.1 kJ/kg-K. Calculate: i) The brake thermal efficiency of the engine. ii) The heat lost to the exhaust gases per hour.	*CO4*	*PO2*	**07**
		c)	In a Morse test conducted on a multi-cylinder petrol engine, the following data was obtained: The engine consists of 4 cylinders, each with a displacement volume of 0.0005 m^3.The engine is tested at a speed of 1500 rpm, and the load on each cylinder is measured to be as follows: • Cylinder 1: 4.5 kW • Cylinder 2: 4.7 kW • Cylinder 3: 4.6 kW • Cylinder 4: 4.4 kW Calculate: i) The total power developed by the engine during the Morse test. ii) The indicated power per cylinder. iii) Mechanical Efficiency	*CO4*	*PO2*	**07**

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