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

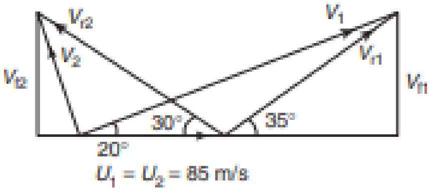
Autonomous Institute Affiliated to VTU

June 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.

			CO	PO	Marks
		UNIT - I			
1	a)	Define the turbomachine and with necessary assumptions derive the Euler equation.	*CO1*	*PO1*	**10**
	b)	The velocity triangles at the inlet and outlet are given in Fig. (1). State with reasons the following: (i) Whether the machine is radial flow type or axial flow type; (ii) Whether the machine is work-producing type or work-absorbing type; (iii) Specific work W; (iv) Power per unit flow rate; and (v) Utilization factor. Assume Vr_2=0.98 Vr_1  Fig. (1)	*CO1*	*PO1*	**10**
		OR			
2	a)	With the help of velocity triangles obtain the maximum work done and maximum hydraulic efficiency expressions for a Pelton wheel.	*CO1*	*PO1*	**10**
	b)	A Francis turbine is to be designed for the flow rate of 2 m^3/s available at a project site at a net head of 10 m of water. The expected overall efficiency is 80%. The speed coefficient (or speed ratio) and the flow coefficient can be assumed as 0.8 and 0.6, respectively. The hydraulic losses in the turbine are 15% of available energy. Design the turbine rotor, with the salient dimensions and angles, to run at 300 rpm. The water leaves the rotor without any whirl component.	*CO1*	*PO2*	**10**
		UNIT - II			
3	a)	Define the following terms related to centrifugal compressor: (i) Work done factor; (ii) Slip; (iii) Choking; (iv) Surging; and (v) Pre-whirl	*CO2*	*PO1*	**10**

		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 the 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 k Pa and 300 K.	*CO2*	*PO2*	**10**
			OR			
	4	a)	Deduce the work done relation from Euler equation and pressure developed expression for a rotor in the compressor.	*CO2*	*PO1*	**10**
		b)	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 75^0 . The speed is 10000 rpm and the velocity of flow is constant at 120 m/s. If the blade width at the intake is 6 cm, calculate (i) specific work, (ii) exit pressure, (iii) mass flow rate; and (iv) power required to drive the compressor if the overall efficiency can be assumed as 0.7	*CO2*	*PO2*	**10**
			UNIT - III			
	5	a)	What is cavitation? Discuss its formation and effects	*CO2*	*PO1*	**06**
		b)	Draw the head versus discharge general trend curve for two pumps which are arranged in series and parallel respectively	*CO2*	*PO1*	**04**
		c)	The outlet diameter of the impeller of a centrifugal pump is restricted to 25 cm and width at the outlet to 1.5 cm. The blade angle at the outlet is 60o. The drive to the pump is from a motor at 1440 rpm. Find the number of identical stages required to pump water to a water tube boiler, operating at 4 MPa. The capacity of the boiler is 60 kg/s. The hydraulic efficiency of the pump is 80%. The entry of water to the impeller is radial, without any whirl component and the flow component remains constant in the impeller. If the overall efficiency of the setup is 75%, find the power of the motor to drive the pump.	*CO2*	*PO2*	**10**
			OR			
	6	a)	Draw the inlet and exit velocity triangles for the centrifugal pump with all notations.	*CO2*	*PO1*	**02**
		b)	Define manometric efficiency, MSL and NPSH used in the analysis of centrifugal pump and obtain their relations.	*CO2*	*PO1*	**09**
		c)	The power input to a centrifugal pump is 50 kW at the shaft while running the pump at 1440 rpm. The impeller tip diameter is 30 cm and the blade width at the tip is 1.5 cm. The water flow rate is 110 liter/s (0.11 m^3/s). The vacuum gauge reading at the suction flange is –20 cm of mercury and at delivery flange; the pressure gauge reading is 370 kPa. The blade outlet angle is 65^0. A 2% slip may be assumed. Calculate the (i) theoretical head, (ii) ideal head, (iii) hydraulic	*CO2*	*PO2*	**09**

			efficiency, (iv) mechanical efficiency, (v) overall efficiency, and (vi) specific speed of the pump. Assume radial entry and constant flow velocity.			
			UNIT - IV			
	7	a)	Show that the decrease in the available energy when heat is transferred through a finite temperature difference.	*CO3*	*PO1*	**08**
		b)	What is 'Second Law Efficiency'? How it is different from First law efficiency?	*CO3*	*PO1*	**04**
		c)	By burning a fuel, the rate of heat release is 500 kW at 2000 K. What would be the first law and the second law efficiencies if,(i) energy is absorbed in a metallurgical furnace at the rate of 480 kW at 1000 K, (ii) energy is absorbed at the rate of 450 kW for generation of steam at 500 K, and (iii) energy is absorbed in a chemical process at the rate of 300 kW at 320 K? Take T0=300 K, (iv) Had the energy absorption rate been equal to 450 kW in all these three cases, what would have been the second law efficiencies?	*CO3*	*PO1*	**08**
			OR			
	8	a)	Prove the statement on a quality of energy, 'The available exergy of a fluid at a higher temperature is more than at a lower temperature and decreases as the temperature decreases.'	*CO3*	*PO1*	**08**
		b)	Write the expression for exergy balance equation for the closed system with all the abbreviations.	*CO3*	*PO1*	**02**
		c)	Air expands through a turbine from 500 kPa, 520 0C to 100 kPa 300C. During the expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 200C. Neglecting the K.E. and P.E. changes, determine per kg of air (i) the decrease in availability, (ii) the maximum work, and (iii) the irreversibility. For air, cp = 1.005 kJ/kg K, h = C_p T.	*CO3*	*PO1*	**10**
			UNIT - V			
	9	a)	Draw the P-V and T-S diagram for dual combustion cycle	*CO4*	*PO1*	**02**
		b)	Show that the thermal efficiency of Otto cycle is, $\eta_{th,\,Otto} = 1 - \frac{1}{r^{k-1}}$ where r- compression ratio; k= ratio of specific heats	*CO4*	*PO1*	**10**
		c)	In a gas turbine plant working on Brayton cycle, the air at inlet is 27°C, 0.1 MPa. The pressure ratio is 6.25 and the maximum temperature is 800°C. The turbine and compressor efficiencies are each 80%. Find compressor work, turbine work, heat supplied, cycle efficiency and turbine exhaust temperature. Mass of air may be considered as 1 kg.	*CO4*	*PO1*	**08**
			OR			

	10	a)	Discuss the combustion stages in C.I Engines with the help of p-θ diagram.	*CO4*	*PO1*	**08**
		b)	List any 2 salient features of detonation in SI engines.	*CO4*	*PO1*	**02**
		c)	In a test of an oil engine under full load condition, the following results were obtained. IP = 33 kW; Brake power = 27 kW; Fuel used = 8 kg/h; Rate of flow of water through gas calorimeter = 12 kg/min; Cooling water flow rate = 7 kg/min; Calorific value of fuel = 43 MJ/kg; Inlet temperature of cooling water = 15 ^{0}C; Outlet temperature of cooling water = 75 ^{0}C; Inlet temperature of water to exhaust = 150C; gas calorimeter Outlet temperature of water to exhaust = 55 ^{0}C; gas calorimeter final temperature of the exhaust gases = 80^{0}C; Room temperature = 17 ^{0}C; Air-fuel ratio on mass basis = 20 Mean specific heat of exhaust gas = 1 kJ/kg K; Specific heat of water = 4.18 J/kg K. Draw up a heat balance sheet and estimate the thermal and mechanical efficiencies.	*CO4*	*PO2*	**10**

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