CBCS SCHEME

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BME502

Fifth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025
Turbo Machines

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		Module – 1	M	L	C
Q.1	a.	Define Turbo machine and explain parts of turbomachine with neat sketch.	7	L1	CO1
	b.	What is specific speed of a pump? Derive an expression for the same?	6	L2	CO1
	c.	Tests on a turbine runner 1.25 m in diameter at 30 m head gave the following results : Power developed 736 kW, Speed 180 rpm, Discharge 2.7 m^3/s. Find the diameter, speed and discharge of a runner to operate at 45 m head and gave 1472 kW power at the same efficiency. What is the specific speed of both the turbines?	7	L3	CO1
		OR			
Q.2	a.	With reference to expansion process, define the following and write the corresponding relations: (i) Total-to-Total efficiency. (ii) Static-to-Static efficiency.	4	L1	CO1
	b.	Show that for a compressor polytropic efficiency is given by, $$\eta_P = \frac{\frac{x-1}{x}\ln\left[\frac{P_2}{P_1}\right]}{\ln\left[\frac{T_2}{T_1}\right]}$$ Where P_1 and P_2 are pressure at inlet and outlet of compressor respectively. Where as T_1, T_2 are temperatures at inlet and outlet of compressor respectively.	8	L2	CO1
	c.	A 9 stage centrifugal compressor has overall stage pressure ratio 2.82. Air enters the compressor at 1 bar and 15 °C. The efficiency of the compressor is 88%. Determine the following : (i) Pressure ratio of each stage (ii) Polytropic efficiency (iii) Preheat factor	8	L3	CO1
		Module – 2			
Q.3	a.	Derive an alternate form of Euler's turbine equation and explain the significance of each energy components.	8	L2	CO2
	b.	For an axial flow compressor, show that $$R = \frac{V_f}{2U}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \times \tan\beta_2}\right]$$ Where V_f velocity of flow, U-blade speed β_1, β_2 are blade angles at inlet and outlet respectively.	7	L2	CO2
	c.	The velocity of steam in a Delavar turbine at the inlet is 1200 m/s. The nozzle angle at the inlet is 22° and rotor blades are equiangular. Assume relative velocities of the steam at inlet and outlet to be equal and tangential speed of the rotor is 400 m/s. Determine (i) Blade angles at inlet and outlet. (ii) Power developed if mass flow rate is 1 kg/s.	5	L3	CO2

		OR			
Q.4	**a.**	Show that maximum utilization factor, where ϕ is the speed ratio, α_1 is Guide angle at inlet. $\in_{max} = \dfrac{2\phi\cos\alpha_1}{1+2R\phi\cos\alpha_1}$.	8	L2	CO2
	b.	Define utilization factor and degree of reaction also show that utilization factor, $\in = \dfrac{V_1^2 - V_2^2}{V_1^2 - RV_2^2}$?	7	L2	CO2
	c.	The impeller of a centrifugal pump has an outer diameter of 1.5 m. It lifty water at a rate of 2000 kg/s. The blade is making an angle of 145° with the direction of motion at outlet and the speed being 300 rpm. Radial velocity of flow is 3 m/s. Find the power required to drive the impeller.	5	L3	CO2
		Module – 3			
Q.5	**a.**	What is compounding? Name different methods of compounding and explain with neat sketch any one of the method of compounding.	6	L1	CO3
	b.	Prove that in 50% reaction turbine maximum blade efficiency, $\eta_{b\,max} = \dfrac{2\cos^2\alpha_1}{1+\cos^2\alpha_1}$ Where α_1 is nozzle exit angle.	7	L2	CO3
	c.	A signle stage impulse turbine has diameter of 1.5 m and running at 3000 rpm. The nozzle angle is 20°. Speed ratio is 0.45. Ratio of relative velocity at the outlet to that at inlet is 0.9. The outlet angle of blade is 3° less than inlet angle. Steam flow rate is 6 kg/s. Draw the velocity diagrams and find the following : (i) Blade angle (ii) Power developed (iii) Axial thrust	7	L3	CO3
		OR			
Q.6	**a.**	In a Curtis stage with two rows of moving blades, the rotors are equiangular. The first rotor has an angle of 29° each while second rotor has an angle of 32° each. The velocity of steam at the exit of nozzle is 530 m/s and blade coefficients are 0.9 in the first, 0.95 in the stator and in the second rotor. If the absolute velocity at the stage exit should be axial, find (i) Mean blade speed (ii) The rotor efficiency (iii) Power output for a flow rate of 32 kg/s.	9	L3	CO3
	b.	Define the following terms related to reaction steam turbine and write their relations : (i) Blade efficiency (ii) Stage efficiency	4	L1	CO3
	c.	The following data refers to a stage of reaction turbine: Rotor diameter = 1.5 m, Speed ratio = 0.72, Outlet blade angle 20°, Rotor speed = 3000 rpm, Determine (i) Blade efficiency (ii) Percentage increase in blade efficiency and the rotor speed, if the rotor is designed to run at the best theoretical speed.	7	L3	CO3
		Module – 4			
Q.7	**a.**	With reference to Hydraulic turbines, define (i) Hydraulic efficiency (ii) Mechanical efficiency (iii) Overall efficiency (iv) Volumetric efficiency.	4	L1	CO4

	b.	Show that maximum hydraulic efficiency in a Pelton wheel $\eta_{H\,max} = \dfrac{1 + C_b \cos\beta_2}{2}$. Where C_b – blade velocity coefficient and β_2 is blade angle at exist.	7	L2	CO4
	c.	A Pelton turbine has a water supply of 5 m^3/s at a head of 256 m and runs at 500 rpm. Assume a turbine efficiency of 0.85, a coefficient of velocity for nozzle as 0.985 and a speed ratio of 0.46. Calculate (i) Power output (ii) Specific speed (iii) Number of Jets (iv) Jet diameter (v) Diameter of wheel (vi) Number of cups (vii) Cup dimensions.	9	L3	CO4
		OR			
Q.8	a.	Explain the construction and working of Kaplan turbine with neat sketch.	6	L1	CO4
	b.	The following data is given for a Francis turbine. Net head = 70 m, Speed – 600 rpm, Shaft power = 370 kW, $\eta_C = 0.80$, $\eta_H = 0.95$, flow ratio = 0.25, Breadth ratio = 0.1, Outer diameter of the runner is = 2 times inner diameter of runner. The thickness of vanes occupy 10% of circumferential area of the runner. Velocity of flow is constant and discharge is radial at outlet? Determine (i) Guide blade angle. (ii) Runner angle at inlet and outlet. (iii) Diameter of the runner at inlet and outlet. (iv) Width of the wheel at inlet.	7	L3	CO4
	c.	Define draft tube efficiency. Derive an expression for inlet pressure head of draft tube and its efficiency.	7	L2	CO4
		Module – 5			
Q.9	a.	Define the following terminologies related to centrifugal pump : (i) Suction head (ii) Delivery head (iii) Static head (iv) Manometric head (v) Manometric efficiency (vi) Mechanical efficiency. (vii) Overall efficiency.	7	L1	CO5
	b.	Derive an expression for H-Q characteristic curve for a centrifugal pump. Discuss the H-Q curve for forward, radial and backward curved vanes.	8	L2	CO5
	c.	A single stage centrifugal pump with a impeller diameter of 30 cm rotates at 2000 rpm and lifts 3 m^3/s water to a height of 30 m with a manometric efficiency of 75%. Find the number of stages and diameter of each impeller of a multistage pump to lift 5 m^3/s of water to a height of 200 m when rotating at 1500 rpm.	5	L3	CO5
		OR			
Q.10	a.	With neat sketch, explain slip, slip coefficient and slip factor.	6	L1	CO5
	b.	Explain the phenomenon of surging and stalling.	4	L1	CO5

	c.	A single sided centrifugal air compressor running at a speed of 16500 rpm produced a pressure ratio of 4 : 1. The hub diameter at the eye of the compressor is 16 cm. Inlet of air to the rotor is axial and equal to 120 m/s. The stagnation temperature and pressure at inlet are 25 °C and 1 bar. The mass flow rate is 8.3 kg/s and the total head isentropic efficiency is 78%. The pressure coefficient is 0.7. Determine (i) Eye tip diameter (ii) Blade angle at eye root and eye tip. (iii) Impeller tip diameter. (iv) Shaft power input to the compressor if the mechanical efficiency is 97%.	10	L3	CO5

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