(32)

Name of the Program: M. Sc./PhD in Mechanical Engineering
Semester: Summer

Date: 17 May, 2024
Time: 10:00 am – 01:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination — **Summer Semester : 2022 - 2023**
Course Number: MCE 6119 — **Full Marks: 150**
Course Title: Turbomachines — **Time : 3.0 Hours**

There are **06 (Six)** questions. Answer **all** questions. The symbols have their usual meanings.

1. The impeller of a centrifugal pump has outlet diameter of 0.370 m, runs at 800 rpm, and delivers 30 l/s of water. The radial velocity at the impeller exit is 2.5 m/s. The difference between the water levels at the overhead tank and the pump is 14 m. The power required to drive the pump is 8 hp, its mechanical and volumetric effectiveness being 0.96 and 0.97, respectively. The impeller vanes are backward curved with an exit angle of 45^0. (25)
   Calculate
   a. ideal head developed with no slip and no hydraulic losses and
   b. the hydraulic efficiency.
2. A centrifugal pump delivers water at the rate of 8.5 m^3/min against a head of 10 m. It has an impeller of 50 cm outer diameter and 25 cm inner diameter. Vanes are set back at outlet at an angle of 45^0, and impeller is running at 500 rpm. The constant velocity of flow is 2 m/s. (25)
   Determine –
   a. the manometric efficiency,
   b. vane angle at inlet, and
   c. minimum starting speed of the pump.
3. A Pelton wheel develops 12,900 kW at 425 rpm under a head of 505 m. The efficiency of the machine is 84%. (25)
   Find-
   a. discharge of the turbine,
   b. diameter of the wheel, and
   c. diameter of the nozzle.
   Assume Cv = 0.98, and ratio of bucket speed to jet speed = 0.46.

4. A Kaplan turbine produces 16000 kW under a head of 20 m, while running at 166 rpm. The diameter of the runner is 4.2 m while the hub diameter is 2 m, the discharge being 120 m^3/s. (25)

Calculate –

a. the turbine efficiency,
b. specific speed,
c. the speed ratio based on the tip diameter of the blade, and
d. the flow ratio.

5. Consider a convergent–divergent nozzle in which steam enters at 0.8 MPa and leaves the nozzle at 0.15 MPa. Assuming isentropic expansion and index n = 1.135, find the ratio of cross-sectional area, the area at the exit, and the area at the throat for choked conditions (i. e. , for maximum mass flow). (25)

6. In an impulse turbine, the velocity of steam at the exit from the nozzle is 700 m/s and the nozzles are inclined at 22^0 to the blades, whose tips are both 34^0. If the relative velocity of steam to the blade is reduced by 10% while passing through the blade ring, calculate the blade speed, end thrust on the shaft, and efficiency when the turbine develops 1600 kW. (25)

Table 13 Water at Saturation Temperature

Saturation Temperature T			Saturation Pressure $P \times 10^{-5}$ (N/m^2)	Specific volume of Vapor $v_g(m^3/kg)$	Enthalpy		
					h_f (KJ/kg)	h_g (KJ/kg) $\times 0.430 =$ (Btu/lb_m)	h_{fg} (KJ/kg)
°F	K	°C	$\times 1.450 \times 10^{-4}$ = (psi)	$\times 16.02$ = (ft^3/lb_m)	$\times 0.430$ = (Btu/lb_m)	$\times 0.430$ = (Btu/lb_m)	$\times 0.430$ = (Btu/lb_m)
32	273	0	0.0061	206.3	−0.04	2501	2501
60	283	10	0.0122	106.4	41.99	2519	2477
68	293	20	0.0233	57.833	83.86	2537	2453
86	303	30	0.0424	32.929	125.66	2555	2430
104	313	40	0.0737	19.548	167.45	2574	2406
122	323	50	0.1233	12.048	209.26	2591	2382
140	333	60	0.1991	7.680	251.09	2609	2358
158	343	70	0.3116	5.047	292.97	2626	2333
176	353	80	0.4735	3.410	334.92	2643	2308
194	363	90	0.7010	2.362	376.94	2660	2283
212	373	100	1.0132	1.673	419.06	2676	2257
248	393	120	1.9854	0.892	503.7	2706	2202
284	413	140	3.6136	0.508	589.1	2734	2144
320	433	160	6.1804	0.306	675.5	2757	2082
356	453	180	10.027	0.193	763.1	2777	2014
392	473	200	15.551	0.127	852.4	2791	1939
428	493	220	23.201	0.0860	943.7	2799	1856
464	513	240	33.480	0.0596	1037.6	2801	1764
500	533	260	46.940	0.0421	1135.0	2795	1660
536	553	280	64.191	0.0301	1237.0	2778	1541
572	573	300	85.917	0.0216	1345.4	2748	1403

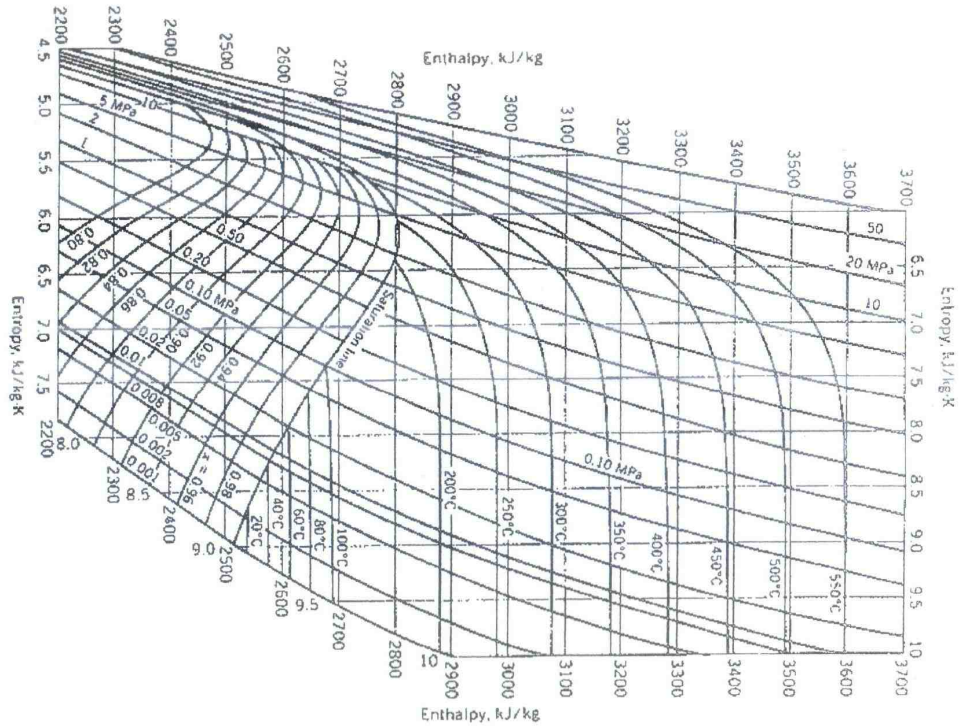

Figure A.2 Enthalpy-Entropy Diagram for Water