

Thapar Institute of Engineering and Technology, Patiala

End Semester Examination, Dec. 2006.

Final Year Mechanical
ME- 015 Fluid Machines

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Dated: 9th Dec. 2006, 2.00-5.00 PM
Time: 3 Hour

Instructor: Chanpreet Singh
MM = 100

Note: Attempt any five questions.

- Q 1** A Centrifugal Pump delivers $0.1 \text{ m}^3/\text{s}$ discharge under a head of 30 m. The critical 8
(a) cavitation factor σ_c for the pump is 0.12. The pump is installed at a location where the barometric pressure is 96 kPa and the vapor pressure is 3 kPa. The friction in the intake pipe is 0.3 m. What is the maximum allowable elevation above the sump level where the pump can be installed?
- (b) Draw a layout of a reciprocating pump having air vessels on suction and discharge sides. 7
What are the advantages in using the air vessels?
- (c) Under which category, does a vane pump fall. By drawing a sketch, discuss the working of 5
the pump.
- Q2** A Centrifugal pump has impeller of 0.3 m diameter running at 960 rpm with an outlet angle 10
(a) of 28° . The velocity of flow of water through suction and discharge pipes is constant at 2 m/s. The static suction lift is 2.8 m. The energy losses in meters of water: in suction pipe, in impeller, and in volute casing are 0.61 m, 0.49 m and 0.88 m respectively. Calculate the pressure gage or vacuum readings at (i) Inlet to pump, (ii) Impeller outlet (iii) Pump outlet.
- (b) A Pelton Wheel is installed 400 m below the level of a lake. The jet diameter is 80 mm and 10
the penstock diameter is 0.6 m. Its length is 4 km and the friction factor, $f = 0.032$, in the formula $h_f = fLV^2/2gD$. The buckets deflect the jet through 165° and they run at 0.48 times the jet speed. The bucket friction reduces the velocity at outlet of the blades by 15 %. The velocity coefficient of nozzle K_v is 0.97. Find: The flow rate and the power developed. The mechanical efficiency is 90 %.
- (a) A Francis Turbine works under a head of 150 m and produces 175 MW at a speed of 136 10
rpm. The model analysis indicates an overall efficiency of 91 % and the hydraulic efficiency is 96 %. Calculate the specific speed and discharge of the turbine. Find suitable values for exit angles of guide vanes, vane angle of the runner, inlet and outlet angles of the runner, width of the wheel at inlet. The values of various parameters for slow and fast runners are as follows: Speed ratio, $K_u = 0.56, 0.7$; Ratio, $b_1 / D_1 = 0.2, 0.5$; Vane thickness coefficient, $K_1 = 0.92, 0.97$. Assume an axial discharge, no axial thrust produced and ratio $u_2/u_1 = 0.5$.
- (b) A Kaplan Turbine is provided with an elbow type draft tube with an inlet diameter of 2.6 m. 10
The inlet section is 1.6 m above the tail-race level. A vacuum gauge connected at this point shows a reading of 34 kN/m^2 . The efficiency of the draft tube is 80 %. Calculate the efficiency of the turbine if it develops 3000 kW under a head of 8.5 m

- Q 4** At a proposed site of hydroelectric power plant, the available discharge and head is 330 6
(a) m^3/s and 28 m respectively. The expected turbine efficiency and speed are 86 % and 250 rpm. Calculate the number of turbines required if (i) A Francis turbine with a specific speed of 260 is used (ii) A Kaplan turbine with a specific speed of 700 is used.
- (b) The following data is obtained from the main characteristics of a Kaplan Turbine of runner diameter 1m: $P_u = 30.6$, $Q_u = 108$ and $N_u = 63$. Estimate the runner diameter, the discharge and speed of a similar runner working under a head of 30 m and developing 2000 kW. 10
- (c) Differentiate between a centrifugal and a reciprocating pump in the terms of head developed, discharge and slip. 4
- Q 5** A double acting reciprocating pump has cylinder of 250 mm diameter and stroke of 500 8
(a) mm. The pump is required to deliver $0.1 \text{ m}^3/\text{s}$ at a head of 100 m. The friction losses are 1 m in suction pipe and 19 m in delivery pipe. The velocity of water in both the pipes is 1 m/s. and the overall efficiency is 85 %. The slip in the pump is 3 %. Determine speed of the pump and power required to drive it.
- (b) Discuss how the minimum number of buckets of Pelton Wheel are calculated. 6
- (c) Define the Euler head for a centrifugal pump. Describe the role of dynamic, static and diffusion heads in imparting energy to the fluid. 6
- Q6** A centrifugal pump impeller of outer diameter of 30 cm and an inner diameter of 15 cm. 10
(a) The pump runs at 1200 rpm. The impeller vanes are set back at 30° at the outlet. If the velocity of flow constant at 2 m/s. Find: (i) The velocity and direction of water at outlet. (ii) Head developed assuming a manometric efficiency of 85 %. (iii) Blade angle at inlet. (iv) The hydraulic efficiency if the slip factor for the pump is 0.94.
- (b) Define exit loss of a reaction turbine. How it can be reduced. 4
- (c) Assuming ratio of the length of the connecting rod to the crank radius to be large, find the effect of acceleration- retardation of piston on suction side indicator diagram of a reciprocating pump. How this diagram is modified with friction in the suction pipe. 6