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Name.....

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FOURTH SEMESTER B.TECH. (ENGINEERING) (09 SCHEME) DEGREE EXAMINATION, APRIL 2015

ME 09 405/PTME 09 404—FLUID MACHINERY

Time : Three Hours

Maximum : 70 Marks

Part A

Answer **all** *questions.*

1. Write the Euler's energy equation in its final form as applicable to fluid machines, and explain the contribution of each term from the fundamentals.
2. "The suction height of turbine above tail race level is limited by cavitation"–justify the statement.
3. What are operating and main characteristics curves ?
4. Specify the factors which reduce the mechanical efficiency of centrifugal pump.
5. How is pumping action developed in a gear pump ?

(5 × 2 = 10 marks)

Part B

Answer any **four** *questions.*

6. A jet of water having a velocity of 30 m/s impinges on a series of vanes with a velocity of 15 m/s. The jet makes an angle of 30° to the direction of vanes when entering and leaving at an angle of 120° Sketch the complete velocity triangles at the entrance and the exit. Also determine the work done by jet on vanes.
7. A Pelton wheel of 1.2 m mean bucket diameter works under a head of 650 m. The jet deflection is 165° and its relative velocity is reduced over the buckets by 15% due to friction. If the water is to leave the bucket without any whirl, determine :
   (a) rotational speed of the wheel ;
   (b) ratio of bucket speed to jet velocity ; and
   (c) efficiency of the wheel.

   Take coefficient of velocity, $C_v = 0.97$.
8. A conical draft tube has inlet and outlet diameters of 60 cm and 90 cm respectively. The tube is 6 m long and 1.5 m of its bottom length lies immersed in tail water. Water flows downwards and its velocity at entry to the tube is estimated to be 6 m/s, presuming that friction loss between the top and bottom tube is 15% of the velocity head at entry, work out the pressure head at entry to the draft tube.

Turn over

9. Show that the pressure rise across the impeller of a centrifugal pump is given by

$$\frac{1}{2g}\left[V_{f1}^2 + V_2^2 \operatorname{cosec}^2 \varphi\right].$$

Where V_{f1} and V_{f2} are velocities of flow at inlet and outlet. V_2 tangential velocity of impeller at outlet and (φ vane angle at outlet.

10. A multistage centrifugal pump is to be installed to lift water through a head of 80 m at the rate of 0.1 m^3/s, The pump is coupled to an electric motor running at 1000 rev/min. Make calculations for the head developed per stage and the required number of stages; the required impeller diameter if the speed ratio based on the impeller diameter is 0.9; and the power required. [Assume $\eta_0 = 0.75$ and N_s (for each impeller) = 30.

11. A single acting reciprocating pump has a plunger diameter 20 cm and stroke length 30 cm. It draws water from a sump 3,5 m below the centre of pump cylinder. Find the least diameter of suction pipe if it is 6 m long. The pump runs at 50 rpm with simple harmonic motion and separation occurs at 2.5 m of water absolute pressure. Barometric pressure = 10.3 m of water.

(4 × 5 = 20 marks)

Part C

Answer **all** *questions.*

12. (a) A sprinkler with unequal arms separated by 70 cm and jets of 0.8 cm^2 facing in the same direction. A flow of 1.5 lps enters (40 cm from one arm) the assembly normal to the rotating arm. Assuming no friction, Calculate:

(i) its speed of rotation ; and

(ii) what torque is required to hold it from rotating ?

Or

(b) Discharge Q of a centrifugal pump can be assumed to be dependent on density of liquid ρ, viscosity of liquid μ, pressure p, impeller diameter D and speed N rpm. Using Buckingham's -π method, show with the usual notations that, $Q = ND^3 \varphi\left(\frac{gH}{N^2D^2}, \frac{\mu}{ND^{20}}\right)$.

13. (a) The three jet Pelton wheel turbine is required to generate 10,000 kW, when the net head at the nozzle is 400 m. The exit blade angle is 165° and the reduction in relative velocity while passing through the bucket is 5%. Assuming that the total efficiency of the wheel is 80%, coefficient of nozzle velocity is 0.98. and the speed ratio is 0.46. Find the following :—

(a) the diameter of Jet ;

(b) total flow in cumecs ; and

(c) the force exerted by a jet on the buckets.

If the jet ratio is not to be less than 10, find the speed of the wheel for a frequency of 50 Hertz, and the corresponding wheel diameter.

Or

(b) A Francis turbine runner is to be designed for the following data :—

Net head	=	50 m
Shaft power	=	400 kW
Speed	=	450 rpm
Hydraulic efficiency	=	85%
Overall efficiency	=	85%
Flow ratio	=	0.15
Breadth to diameter ratio	=	0.1

Assume the inner diameter as one-half the outer diameter. The velocity of flow is constant throughout. The discharge is radial. Neglect vane thickness.

14. (a) Water enters radially through a centrifugal pump whose impeller has a diameter of 30 cm and breadth 15 cm; the corresponding dimensions at the outer periphery are 60 cm and 7.5 cm. The blades are curved back at 30° to the tangent at exit and the discharge is 225 litres per second. If the rotational speed of the impeller is 1200 rpm and the pump delivers water to a height of 115 m, calculate :

(a) the theoretical head developed and the manometric efficiency,

(b) the pressure rise across the impeller assuming losses equal to 10 percent of velocity head at exit ;

(c) the vane angle at inlet ; and

(d) the power required to drive the pump assuming an overall efficiency.

Or

(b) The outer diameter of an impeller of a centrifugal pump is 300 mm and outlet width 40 mm. The pump is running at 900 rpm and is working against a total head of 12 m. The vanes are set back at an angle of 35° and the manometric efficiency is 75%. Determine the following :—

(a) velocity of flow at outlet ;

(b) velocity of water leaving the vane ;

(c) angle made by the absolute velocity at the outlet with the direction of motion at outlet ; and

(d) discharge.

15. (a) Estimate the power required to drive a DARP and the quantity of water delivered under the following conditions :—

Head of water excluding friction = 16m

Diameter and length of main pipe = 1m and 2000m respectively

Diameter of cylinder and length of stroke = 75 cm and 150 cm respectively

Positive slip = 4%; Mechanical efficiency = 80% and pump speed = 25 rpm

Neglect all losses except friction and take pipe coefficient f = 0.01 in the Darcy's equation.

Or

(b) Show that the work saved in overcoming friction in the pipelines by fitting air vessels is 84.8% for a Single Acting Reciprocating. Pump and 39.2% for Double Acting Reciprocating Pump.

(4 × 10 = 40 marks)