*Ex/BESUS/AM-405/ 06*

B.E. (EE) Part-II 4th Semester Examination, 2006

# Hydraulics and Hydraulic Machines (AM-405)

Time : 3 hours Full Marks : 100

*Use separate answerscript for each half.*
*Answer SIX questions, taking THREE from each half.*
*The questions are of equal value.*
*Assume g = 9.807 m/s$^2$*

## FIRST HALF

1. (a) Show that in a Pelton wheel where the buckets deflect the water through (180 - 6), the hydraulic efficiency of the wheel is given by $rj_h = [2Ky\ (V - u)(l + cosd)\ u]/v^2$ where 9 is the blade angle at exit, u is the velocity of the wheel at pitch radius, V is the velocity of jet and $K_v$ is the co-efficient of velocity. Proceed further to establish that the best bucket speed for maximum efficiency is equal to one half of the jet velocity.

(b) A double jet Pelton wheel is supplied with water at 700 litres /sec under an effective head of 200m at the base of nozzle at 300 rpm. If the jet is deflected by the bucket through 165 degrees, find the (i) size of the jet and mean diameter of wheel (ii) power developed and hydraulic efficiency of turbine (iii) angle at which the jet leaves the bucket and (iv) specific speed of the turbine. Given, overall efficiency =85%; speed ratio = 0.46; co-efficient of nozzle velocity = 0.98 and friction factor = 0.9 to allow for losses due to bucket friction.

2. (a) List the differences between an impulse turbine and a reaction turbine and site examples for each case.
(b) The following data refers to the nmner of a Kaplan turbine which yields 8850 KW at the turbine shaft: net head available 5.5 m, speed ratio 2.1, flow ratio 0.67 and overall efficiency 85%. Assuming that the hub diameter of the wheel is 0.35 times the outside diameter, work out the runner diameter and its total rotational speed.
(c) A conical draft tube of 5 m length has a diameter of 2 m at its top. Water discharges through it with a flow rate of 20m$^3$/s and 1.2 m/s velocity at outlet. The pressure head at the top is 5.8 m of water (vacuum) and atmospheric pressure equals 10.3 m of water. Neglecting friction loss, calculate the length of tube immersed in water.

3.(a) What do you mean by specific speed of a turbine? Derive an general expression of specific speed of a turbine and state clearly the assumptions made. Hence prove that the specific speed of a Francis runner is $988.5AT_U\ JK\ n\ K\ f\ rj_0$, where $K_u$ = speed ratio; $K$ = vane thickness co-efficient; $n$ = width to diameter ratio; $Kf$= flow ratio; and $r\backslash_0$ - overall efficiency.
(b) In a hydroelectric generating plant there are four similar turbines of total output 220,000 KW. Each turbine is 90% efficient and runs at 100 rpm under a head of 65 m. It is proposed to test the model of the above turbines in a laboratory where discharge is 400 litres / s under a head of 4 m. Work out the size (scale ratio) of the model. Also calculate the model speed and power expected from the model.

4 (a) Derive an expression for manometric head of a centrifugal pump. Find the minimum speed required for delivering liquid by a centrifugal pump.
(b) What is priming of a centrifugal pump and explain its importance? Why can the suction lift of a pump not exceed a certain limit?
(c ) A three stage centrifugal pump has impellers 30 cm diameter and 1.5 cm width at outlet. The velocity of water at inlet is radial, the vanes are curved back at an angle of 30 degree to the tangent at outlet and occupy 8 % of the outlet area. While running at 1000 rpm, the pump delivers 40 litres / s with 85 % manometric efficiency and 75 % overall efficiency. Calculate the head generated by the pump and input power.

5 (a) Derive an expression for acceleration head impressed on the flow in case of a reciprocating pump. Assume the piston has simple harmonic motion. Explain the functions of air vessels fitted to the suction and delivery pipes of a reciprocating pump. Explain the term negative slip as used in connection with the working of a reciprocating pump. Why and when negative slip occurs?
(b) A single acting reciprocating pump has a stroke length of 15 cm, the suction pipe is 7 m long and the rati of suction pipe diameter to plunger diameter is $^3A$. The water level in the sump is 2.5 m below the level of the pump cylinder and the pipe connecting sump and pump cylinder is 7.5 cm diameter. If the crank is running at 75 rpm, determine the pressure head on the piston at the beginning, mid and end of suction stoke. Take friction co-efficient = 0.1.

## SECOND HALF

6. (a) Define the following terms: i) Surface Tension, ii) Non-newtonian Fluid, iii) Capillarity, iv) Bulk Modulus of Elasticity.

(b) A hydraulic lift used for lifting automobiles has 20 cm diameter ram which slides in a 20.016 cm diameter concentric cylinder. The annular space between the cylinder and ram is filled with a lubricating oil of kinematic viscosity 3.5 stokes and relative density 0.85. If the 3.2 m long ram travels axially at a speed of 15 cm/s, estimate the frictional resistance experienced by the ram.

7. (a) Prove that the pressure at a point in a static fluid is the same in all directions.

(b) A trapezoidal plate of parallel sides *a* and *2a* and height h is immersed vertically in water with its side of length *a* horizontal and topmost. The top edge is at a depth *y* below the water surface. Determine the total force on one side of the plate and the location of the centre of pressure.

8. (a) Derive Euler's Equation of motion along a streamline mentioning clearly the assumptions used at the places where each assumption is used. Hence derive Bernoulli's Equation mentioning the additional assumption needed.

(b) A 2 m long pipeline tapers uniformly from 10 cm diameter to 20 cm diameter at its upper end. The pipe centre-line slopes upwards at an angle of 30 degree to the horizontal and the flow direction is from smaller to bigger cross-section. If pressure gauges installed at the lower and upper ends of the pipeline read 200 KPa and 230 KPa respectively, determine the flow rate and the fuid pressure at the mid-length of the pipeline. Neglect friction loss.

9. (a) Derive an expression for the head loss when a horizontal pipe abruptly expands into a concentric larger diameter pipe mentioning clearly any assumption used. Also derive an expression for the loss in piezometric head.

(b) What do you mean by minor or localised losses? A 5 cm diameter pipe takes off abruptly from a large tank and runs 8m, then expands abruptly to 10 cm diameter and runs 45 m, and next discharges directly into the open air with a velocity of 1.5 m/s. Compute the necessary height of water in the tank surface above the point of discharge. Take friction factor 0.02 in Darcy-Weisbach equation.

10. (a) Derive the formula for discharge over a triangular weir.

(b) A horizontal venturimeter with 30 cm diameter inlet and 10 cm throat is used for measuring the flow of water through a pipeline. If the pressure in the pipe is 1.5 KPa and the vacuum pressure at the throat is 40 cm of mercury, calculate the discharge assuming 5 per cent of the differential head is lost between the pipe main and throat section. Also make calculations for the discharge coefficient. Take specific weight of water to be $10KN/m^3$.