Total number of printed pages – 8

B. Tech

BENG 1208

Third Semester Examination – 2007

FLUID MECHANICS AND HYDRAULIC MACHINES

Full Marks – 70

Time – 3 Hours

Answer Question No. 1 which is compulsory and any ***five*** *from the remaining.*

The figures in the right-hand margin indicate marks.

1. Answer the following questions in brief and to the point : 2×10

   (i) With the help of a neat sketch, discuss Newton's law of viscosity.

   (ii) Discuss about atmospheric pressure, absolute pressure, gauge pressure and

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vacuum pressure with the help of a sketch.

(iii) Discuss metacentre and metacentric height of a floating body. State the position of metacentre, center of gravity and center of buoyancy for different type of equilibrium.

(iv) In a three dimensional incompressible fluid flow, the flow field is given by expression $V=(x^2+y^2z^3)\,i-(xy+yz+zx)\,j+(w)\,k$. Find the w component of velocity so that the case is possible for a steady incompressible fluid flow.

(v) Bernoulli's theorem is based on which principle ? Give its statement. Name three devices where Bernoulli's equation is applied.

(vi) Draw velocity triangle diagram at inlet and outlet for a jet striking tangentially at the

inlet tip of an unsymmetrical moving curved vane. Consider three possible cases of velocity diagram at outlet. No discussion.

(vii) Define hydraulic efficiency (η_h) and mechanical efficiency (η_m) and overall efficiency (η_o) for a hydraulic turbine. Show that $\eta_o = \eta_h \times \eta_m$.

(viii) What is runway speed for a hydraulic turbine ? Find out a situation when it occurs ? How it is helpful in design of rotating components of turbine ?

(ix) Where draft tubes are used ? Write two functions of draft tubes.

(x) Relate percentage of slip with coefficient of discharge as in case of a reciprocating pump. Discuss a situation when negative slip occurs.

2. (a) Two horizontal plates are placed 12.5 mm apart, the space between them being filled with oil having viscosity 14 poise. Calculate the shear stress in the oil if the upper plate moved with a velocity 2.5 m/sec. 3

(b) An isosceles triangular plate of base 1.5 m and height 2 m lies immersed in oil of sp. gravity 0.9 with the apex downward. The base of the triangle is 1 m below the free surface and parallel to it. Calculate the total pressure on the plate and depth of center of pressure. 7

3. (a) Briefly discuss the stream lines, path lines and streak lines with example of each. 3

(b) Show that for a one dimensional frictionless steady flow of a compressible fluid in an infinitesimal stream tube is

$d\rho/\rho + dA/A + dV/V = 0$ and from it deduce the continuity equation for an incompressible flow. 7

4. In a laboratory experiment, the test rig fitted with a venturimeter lying vertical with (d/D) ratio 0.6 fitted in a 10 cm diameter pipe. The venturi is 20 cm above the inlet. The meter has a coefficient of discharge of 0.92 . Determine (a) pressure difference as recorded by gauges fitted at inlet and at throat, (b) pressure difference on a vertical mercury manometer when a liquid of specific gravity 0.8 flow through the meter at the rate of 50 liters per second. 10

5. (a) Show that for a Pelton wheel turbine blade, the hydraulic efficiency is maximum and 100% when the angle of deflection is 180°. Use velocity diagram. 7

(b) Sketch and label the theoretical indicator diagram for a reciprocating pump. Superimpose the practical indicator diagram taking the effect of acceleration and friction in the suction and delivery side. 3

6. The following data refer to a Pelton wheel turbine :

Generator out put = 4000 kW

Effective head = 300 m

Coefficient of velocity of nozzle = 0.97

Speed ratio = 0.45

Jet ratio = 12

Over all efficiency = 86%

Generator efficiency = 96%

Number of poles = 32

Determine (a) Quantity of water required/sec, (b) Size of jet, (c) Mean diameter of runner (Revised), (d) Synchronous speed of wheel (e) Specific speed of turbine. 10

7. (a) Define and derive for specific speed of hydraulic turbines. 3

(b) The center line of a centrifugal pump is 2.5 m above the level of water in sump and the static lift is 32.5 m. The loss of head due to friction in suction and delivery pipes are 1 m and 8 m respectively. The diameters of suction and delivery pipes are 12 cm each. The diameter and width of impeller at outlet are 30 cm and 1.8 cm respectively and the vanes are set back at an angle 30° with tangent to the wheel. The speed of pump is 1800 rpm, mechanical efficiency = 75 % and manometric efficiency = 80%. Determine the rate of flow and power required to drive the pump. Assume radial entry. 7

8. A single acting reciprocating pump has a plunger of 100 mm diameter and a stroke

length of 200 mm. The center of the pump is 3 m above the water level in the sump and 20 m below the water level in a tank to which water is delivered by the pump. The diameter and length of the suction pipe are 50 mm and 5 m while of delivery pipe are 40 mm and 30 m respectively. Determine (a) maximum speed at which the pump run without separation if separation occurs at 7.35 N/cm^2 below atmosphere. (use indicator diagram), (b) Power required to drive the pump neglecting friction and slip of the pump. 10