**Bengal Engineering and Science University, Shibpur**
**B.E. (Civil) 3rd Semester Examination, 2011 (held in December 2011)**

Subject: Hydraulics –I | Code No. AM302
Time 3 hours | Full Marks: 70

(i) Answer any **six** questions taking **three** from each half
(ii) All questions in **second half** carry equal marks

## First Half

1(a). The power $P$ required by a pump is a function of discharge $Q$, energy developed per unit mass, $gH$ (where $H$ is the head developed and $g$ is the acceleration due to gravity), viscosity $\mu$ and mass density $\rho$ of the fluid, speed of rotation $N$ and impeller diameter $D$. Obtain the relevant dimensionless parameters. (5)
(b) A flow meter when tested in the laboratory gives a pressure drop of 100KN/m$^2$ for a discharge of 0.10 m$^3$/s in a 150mm diameter pipe. If a geometrically similar model is tested in a 600mm diameter pipe under identical conditions of fluid, determine the corresponding discharge and pressure drop in the model. (6)

2(a). From first principle derive the expression for pressure drop in a pipe for laminar flow condition. (5)
(b) To determine the viscosity of benzene, an experiment was conducted using capillary tube viscometer. The data obtained were: capillary tube diameter ($D$) = 2mm; length of tube ($l$) = 0.5m; head loss ($h_f$) = 0.2m; voleme collected ( $\forall$ ) = 189cc; time of collection ($t$) = 100s; mass density of benzene ( $\rho$ ) = 860 kg/m$^3$. Determine the dynamic viscosity of benzene. (6)

3(a). Explain the distinction between hydraulically rough and smooth pipe. (3)
(b) Derive the expression for head loss due to sudden expansion. (4)
(c) Oil of specific gravity 0.85 and viscosity 0.05 poise flows through a 20cm diameter pipe at the rate of 75 litres /s. Find the head loss due to friction for a 2000 m length of pipe. Also calculate the power required to maintain this flow. (4)

4(a). Fitting an external mouthpiece running full increases discharge compared to a plane orifice. Explain. (2)
(b)Determine the discharge in a pipe of 200mm diameter which suddenly expands to 400mm diameter due to which hydraulic grade line rises by 10mm at the expansion. (5)
(c) An old water supply distribution pipe 25cm diameter of a city is to be replaced by two parallel pipes of smaller diameter having equal lengths and identical friction factor values to supply same discharge. Find the new diameter required. (4)

5(a) A sharp edged weir is in the form of a symmetrical trapezium. The horizontal base is 10cm wide, the top is 50cm wide and the depth is 30cm. Estimate the rate of flow when the upstream water surface is 25cm above the weir crest. Assume coefficient of discharge as 0.6 for both rectangular and triangular portions. (4)
(b) Find the throat diameter of a venturimeter, when fitted to a horizontal main 10cm diameter having discharge of 20 litres/s. Pressure gauges inserted at the entrance and throat indicate pressures 158 KPa and 82 KPa, respectively. Take $C_d$ = 0.95. (4)
If instead of pressure gauges, the entrance and throat of the meter are connected to the two limbs of a U-tube mercury manometer, determine the reading in cm of differential mercury column. (3)

## Second Half

6. A 150 mm diameter shaft rotates at 1500 r.p.m. in a 200 mm long journal bearing with 150.4 mm internal diameter, the uniform annular space between the journal and the shaft being filled with an oil of dynamic viscosity 0.08 Pa s. Calculate the power dissipated as heat.

7a) Deducing the formula you use, calculate the capillary depression of mercury at 20° C (contact angle = 140°) to be expected in a 2.5 mm diameter glass tube. The surface tension of mercury at 20° C is 0.4541 N/m.

b) An open tank contains water upto a depth of 2 m and above it there is an oil of specific gravity 0.9 for a depth of 1 m. Find the pressure intensity at (i) the interface of two liquids, (ii) at the bottom of the tank. Also determine the height from the bottom of the tank to which the liquid will rise if a piezometer tube is fitted near the bottom.

8.a) A velocity field is given by $\mathbf{V} = Ax\,\mathbf{i} - Ay\,\mathbf{j}$, where V is the velocity vector in xy-plane in m/sec unit, x, y are in 'm', and $A = 0.3\ sec^{-1}$. i and j are unit vectors in x- and y- directions respectively. Find (a) equation of streamlines in xy-Plane, and (b) velocity of a particle at (2,8). Also sketch the streamlines and identify the flow pattern.

b) The velocity distribution for certain flow through a pipe of radius 'a' is given by,

$$u = u_{max} ( 1 - r/a)^{1/7}$$

where, 'u' is the velocity at any radius 'r' from the axis of the pipe and '$u_{max}$' is the maximum velocity at the axis. Determine 'Average Velocity' and 'Kinetic Energy Correction Factor'.

9. State and explain different types of equilibrium possible for a floating body.

Show that a homogeneous right circular cone of vertex angle '2A' cannot float in stable equilibrium with its axis vertical and vertex downwards unless its density relative to that of the liquid in which it floats is greater than $Cos^6A$.

10. What is 'centre of pressure'? Show that the moment of hydrostatic pressure force about the horizontal centroidal axis of a plane surface kept immersed in a liquid is independent of its depth of submergence.

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 'h' below the free water surface. Determine the total force due to hydrostatic pressure on one side of the surface and the location of its centre of pressure.