Ollscoil na hÉireann, Gaillimh GX 692

WINTER EXAMINATION 2000

SECOND CIVIL ENGINEERING EXAMINATION

ELEMENTARY HYDRAULICS (EH201)

Examiners: Prof. P.E. O'Connell
Prof. C. Cunnane
Mr. A.M. Cawley

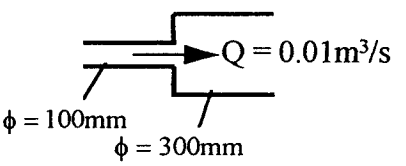
Time allowed: **Three Hours**.

Attempt Question 1 and three other questions

1. Compulsory (40 Marks)

(i) Distinguish between uniform and steady flow.

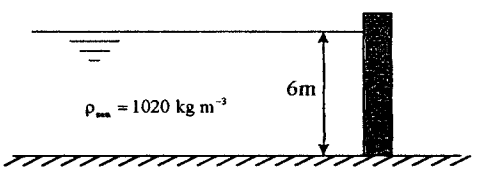
(ii) Determine the shock loss for the sudden expansion shown in the accompanying diagram.



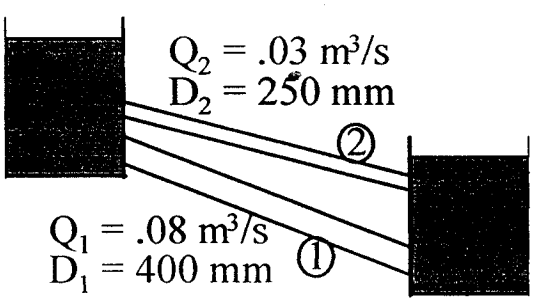
(iii) A fluid flows uniformly at 8 m^3/s in rectangular open channel of width 4m. If its wetted cross-sectional area is 4 m^2 and the channel roughness coefficient n = 0.035, determine the bed slope and the Froude Number.

(iv) A fluid has specific gravity 0.87 and a kinematic viscosity of 463 mm^2/s. Determine the dynamic viscosity of the fluid.

(v) Determine the moment per unit width exerted by seawater ($\rho_{sea} = 1020\,kgm^{-3}$) on a vertical sea wall about its base (see accompanying diagram for details).



(vi) Two Reservoirs are connected by two pipelines of equal length as shown in the accompanying diagram. If the friction factor for pipeline 1 is f_1 = 0.02, compute the friction factor f_2 for pipeline 2.

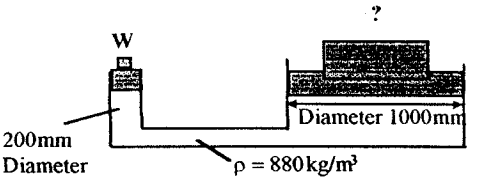


(vii) Water of density 1000 kgm^{-3} and surface tension 0.07 N/m rises in a capillary tube of diameter 1mm by an amount H. Is H equal to 2.8mm, 28mm, 280mm or none of these?

(viii) The pressure difference between the inlet and outlet pipe of a pump is 34kPa. Determine the energy head provided by the pump if both inlet and outlet pipe diameters are equal.

Q1 Continued on next page

(ix) If a force W = 40N is applied to a hydraulic jack described in the accompanying diagram, determine the load that this force will support.



(x) Compute the (i) mass flux, (ii) momentum flux and (iii) energy flux of water flowing full at 2 cumec in a 1m square culvert.

2. (a) Outline the similarities and differences between pipe flow and open channel flow

(5 marks)

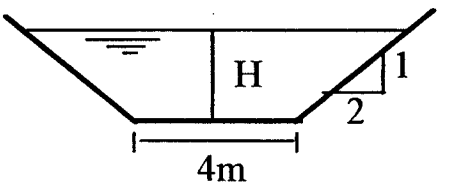
(b) Define the term hydraulic grade line. Prove that the hydraulic grade line coincides with the liquid surface in open channel flow.

(3 marks)

(c) The following measurements of uniform flow depth, H, and discharge Q, were made in a uniform open channel of trapezoidal cross-section (as shown in the accompanying diagram). The longitudinal slope of the channel is 1 in 500. Stating clearly the logic underlying your analysis, determine whether these observations are in agreement or not with the theory underlying the Manning equation.

H (m)	**0.25**	**0.50**	**0.75**	**1.0**	**1.25**	**1.5**
Q (m3/s)	**1.25**	**4.12**	**8.35**	**14.21**	**21.68**	**30.10**

If they do support the theory determine a suitable value of the Manning roughness coefficient n.



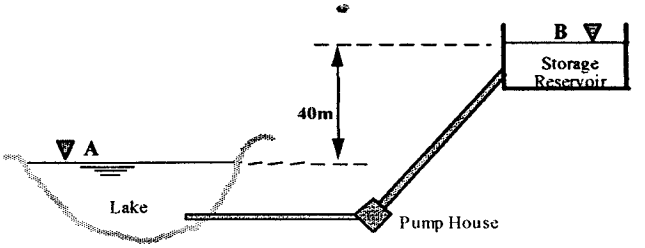
(12 marks)

3. Lake A is connected to a storage reservoir B by a 1.2km pipeline of diameter 350mm and friction factor $f = 0.016$. Two identical centrifugal pumps are available having a pump characteristic described as follows

H(m)	60.0	56.0	50.0	43.0	36.0	27.0	17.0
Q(m^3/s)	0.00	0.05	0.10	0.15	0.20	0.25	0.30

Ignoring shock losses determine the rate in (m^3/s) at which water is pumped from A to B when the two pumps are arranged

(a) in parallel, and
(b) in series.



In each case find the cost of pumping 6,000 m^3 of water from the lake to the storage reservoir if the combined motor/pump power efficiency is 72% and electricity costs £0.05 per kWhr.

(20 marks)

4. Analyse the water distribution network illustrated in the accompanying diagram, determining:

(i) The individual discharge in each pipe,

(ii) The gauge pressure at B, and

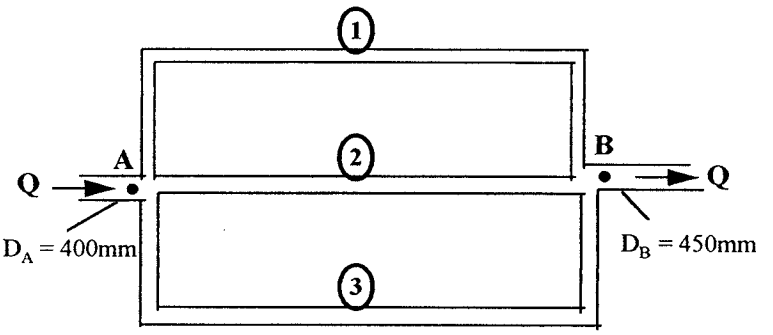
(iii) The piezometric head and total energy head at B,

given that the total discharge entering the network at A is $Q = 0.12\ m^3/s$, the gauge pressure at A is 300 kPa, the pipe elevation at A, Z_A = 35m O.D. and the pipe elevation at B, Z_B = 31m O.D. In your calculations you may neglect minor losses and assume f = 0.024 is fixed for all pipes. The relevant dimensions are detailed in the accompanying diagram.

$L_1 = 1000$ m
$L_2 = 750$ m
$L_3 = 1000$m

$D_1 = 200$mm
$D_2 = 150$mm
$D_3 = 200$mm

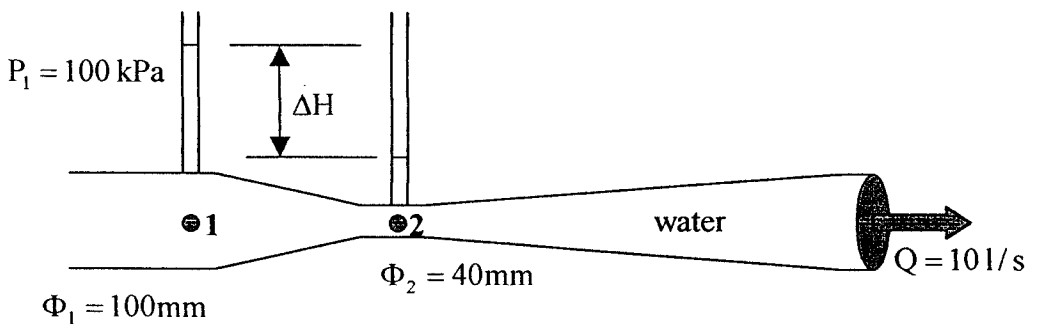
$f_1 = f_2 = f_3 = 0.024$



$Q = 0.12\ m^3/s$; $P_A = 300$ kPa; $Z_A = 35$m & $Z_B = 31$m

(20 marks)

5. (a) Using Bernoulli's Equation derive the discharge relationship for the horizontal Venturi Meter shown below. Describe all assumptions made in your derivation.



(8 marks)

(b) Explain why a drop in pressure occurs between sections 1 and 2.

(2 marks)

(c) Calculate the pressure P_2 at the throat of the Venturi meter if Q = 12 l/s and $C_d = 0.97$.

(6 marks)

(d) Describe any other flow measuring device used in pipeline systems. Outline briefly the fundamental theory on which it is based.

(4 marks)

6 (a) State and prove Archimides' Principle.

(6 marks)

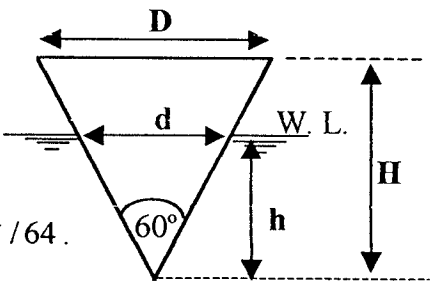
(b) In the context of vessel stability explain with the aid of suitable diagrams what you understand by the following terms:

(i) stable, (ii) unstable, (iii) metacentre, and (iv) centre of buoyancy.

(4 marks)

(c) If a right solid cone, with an apex angle of 60°, is of density k relative to that of the liguid in which it floats with its apex downwards, determine what range of the ratio k is compatible with stable equilibrium.

Where,
G the centre of gravity of the cone is located 3H/4 above the apex of the cone,
V = volume of entire cone = $\pi D^2 H/12$
I = second moment of area at the water line (W.L.) = $\pi d^4/64$.



(10 marks)

7. (a) Define what is meant by a control volume. State the bulk flow equation of fluid mechanics with reference to such a control volume.

(4 marks)

(b) Describe the fundamental laws of physics that govern fluid motion.

(6 marks)

(c) Describe how you would calculate the pipe friction factor *f* for
(i) laminar flow, and
(ii) turbulent flow

(6 marks)

(d) In the context of fluid flow define briefly (i) Potential head, (ii) Kinetic energy head, (iii) Pressure head and (iv) Piezometric head.

(4 marks)

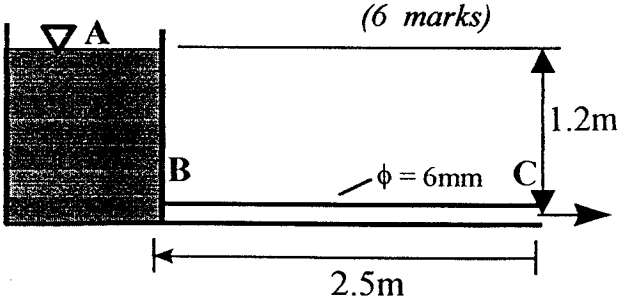
8. (a) Explain what viscosity of a fluid is and why it is important in fluid flow. What is a Newtonian Fluid?

(4 marks)

(b) Describe the principle involved in any one method of measuring liquid viscosity.

(6 marks)

(c) Steady laminar flow occurs in the horizontal pipe BC of length 2.5m and diameter 6mm. The pressures at A and C are atmospheric. If the density of the fluid is 870kgm^{-3} and the fluid velocity in the pipe is 0.01 ms^{-1}, calculate the dynamic and kinematic viscosities of the fluid, clearly indicating their respective units.



(10 marks)