UNIVERSITY OF LONDON

B.Sc. (ENGINEERING) EXAMINATION 1964

PART III

for Internal and External Students

(23) MECHANICS OF FLUIDS AND SURVEYING I

Mechanics of Fluids

Tuesday 16 June: 10 to 1

Answer THREE questions from Section A and TWO from Section B. The total number of marks obtainable in either section is the same.
The examiners attach considerable importance to the descriptive parts of the question.

Section A

Answer THREE questions.

1. Describe the purpose for which the following are used in large hydraulic structures:
(*a*) Stoplogs
(*b*) Taintor or radial gates
(*c*) Drum gates
(*d*) Stilling basins.
Sketch carefully hydraulic structures which will include the above items.
Sketch the pressure distribution on the upstream face of a Taintor gate when the gate is impounding water but is partially open and water is discharging freely below the gate. Explain how you would attempt to calculate the force exerted by the water on the gate under these conditions.

2. Derive, by dimensional analysis, an equation relating the drag to the vertical settling speed of particles falling freely in a viscous liquid.
Perspex grains, density 1·2 gm cm^{-3} and diameter 0·5 mm settle freely at 1 cm sec^{-1} in water of viscosity 0·013 gm cm^{-1} sec^{-1}. Calculate, for dynamical similarity, the size and corresponding settling speed of geometrically similar particles of sand of density 2·65 gm cm^{-3} in water of viscosity 0·01 gm cm^{-1} sec^{-1}.

RP 64/128/28/350 **Turn over**

3. The axial velocity distribution of the flow in a wide rectangular channel can be expressed in the form:

$$u = 5{\cdot}75 \sqrt{\frac{\tau}{\rho}} \log_{10} \frac{33y}{k}$$

where u is the axial velocity distant y from the bed, τ the shear stress, ρ the fluid density and k the roughness size.
It is found experimentally that the mean velocity occurs at a height above the bed of 0·4 d where d is the total depth of the stream. Show that this result may also be inferred by integration assuming the above law.

4. A very long wide rectangular channel has a constant bed slope of 1 in 2000 and Chézy's C is 100 $ft^{1/2}\ sec^{-1}$. A flood wave of stable form is passing down the channel at constant velocity. The flow is at a normal depth of 4·5 ft for the full length of the channel upstream of the wave front and the gravity and frictional forces are in balance. The depth of flow downstream of the wave front is that due to the original normal depth flow of 15 ft^3/s per foot width. Estimate the time taken for the wave to travel 5 miles along the channel. (*Do not* treat the wave as a surge.)

5. It is proposed to install a water turbine to develop 24 500 horse power with an overall efficiency of 90 per cent when running at 100 rev/min in a situation where the net head for the turbine is 40 ft. The linear velocity of the runner vanes at the maximum periphery is to be 100 ft/s and at the minimum periphery 36 ft/s. Discharge from the runner is to be axial. Decide on the type of turbine to be installed and estimate the runner leading dimensions and vane angles. Assume a hydraulic efficiency at all points on the vanes of 85 per cent. Sketch the general arrangement of the turbine.

Section B

Answer TWO questions.

6. In a hydro-electric scheme a low-pressure penstock 7 ft diameter and 3220 ft long with $f = 0{\cdot}005$ connects the reservoir to a simple surge tower 20 ft diameter from the base of which the high-pressure penstock feeds the turbines. There is not to be less than 10 ft depth of water in the surge tower after the turbine gates are suddenly completely opened to the steady full-load flow of 423 ft^3/s. Estimate the distance below reservoir water level for the low-pressure penstock connection to the base of the tower. (Intervals of 9 seconds are suggested for a step-by-step integration.)

7. The simplified characteristics of the hydrographs of inflow and outflow for storm flow passing through a reservoir are as given below, the points being joined by straight lines.

Time (hours)	0	6	8	9	11	12	20
Inflow (1000 ft^3/s)	0	5		2·5		0·5	0
Outflow (1000 ft^3/s)	0		2·4	2·5	2·4		1

Plot the estimated curves of reservoir storage against time and reservoir storage against outflow rate.
Sketch more typical hydrographs than those indicated by the straight lines of the above problem.

8. Discuss the method of successive approximation as applied to networks of pipes:

(*a*) when the pipes intersect at a common junction box and

(*b*) when the pipes form a ring main.

ABCD is a horizontal ring main, 4 ft^3/s of water being supplied to the ring at A and 1 ft^3/s being withdrawn at C. In the formula, head loss $= KQ^2$, pipes AB and DC have $K = 1$, AD and BC having $K = 2$. The rate of discharge from B to C along BC is 2 ft^3/s. Calculate the possible rates of supply to or withdrawal from the ring main at the junctions B and D for these conditions.

9. A wide canal has Chézy's C equal to 100 $ft^{1/2}\ sec^{-1}$, a bed slope of 1 in 1000 and a water flow rate of 25 ft^3/s per foot width. A dam spillway, with a flow rate per unit width of $3\ H^{3/2}$, is built across the canal causing the depth of water at a point 4500 ft upstream of the spillway to be 4·5 ft. Deduce which type of free surface curve will occur and sketch it carefully. Estimate the height of the spillway crest above the bed of the canal.

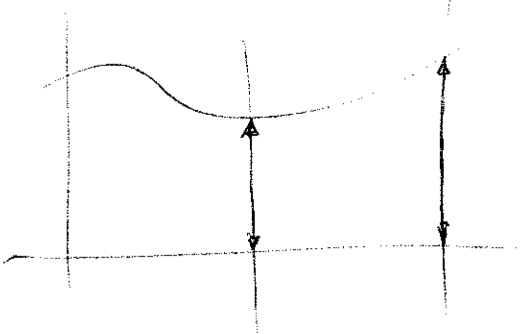
J. ALLEN

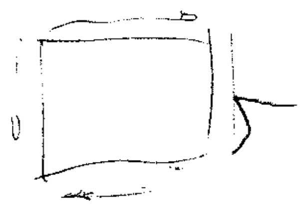
D. W. HENDERSON

$$\frac{dH}{dL} = \frac{s - i}{1 - \frac{v^2 b}{g a}}$$

$$\Delta H = \frac{\Delta Q}{\Sigma \frac{Q}{nH}}$$

$$\Delta Q = \frac{\Delta H}{\Sigma \frac{2H}{Q}}$$





$$D = \phi \rho v^2 D^2 \phi\left(\frac{\rho v d}{\mu}\right)$$