

Heaven's Light is Our Guide  
**DEPARTMENT OF CIVIL ENGINEERING**  
**RAJSHAHI UNIVERSITY OF ENGINEERING & TECHNOLOGY**  
 B.Sc. Engineering Third Year Odd Semester Examination, 2016  
**CE-3121**  
**Engineering Hydraulics**

Full marks: 72

Time: 3 Hours

Rawibol Islam  
CE-140022

- N.B:- (i) Answer any SIX questions, taking THREE from each section.  
 (ii) Figure in the margin indicate full marks.  
 (iii) Use separate answer script for each section.  
 (iv) Assume reasonable value for any data missing.

**SECTION-A**

- Q.1(a) What do you mean by open channel flow? Write the differences of it with pipe flow. 4.00  
 (b) The velocity distribution in a wide open channel may be approximated by the equation  $u = 0.4 + \frac{0.6y}{h}$ . Find  $U$  5.00  
 $\alpha$  and  $\beta$  if  $h = 3$  m.  
 Q.1(c) Explain the term Celerity. How you would confirm by observation that whether the flow channel will be Super 3.00  
 Critical or Sub-critical?  
 Q.2(a) Prove that for a given discharge, specific force will be minimum for Critical state of flow 5.00  
 (b) Derive Chezy's formula for uniform flow,  $U = \sqrt{RS}$  where the symbols bear their usual meanings. 4.00  
 (c) Define specific energy. Draw a specific energy curve and show critical depth, alternate depths sub-critical and 3.00  
 super critical flow region.  
 Q.3(a) Prove that the loss of energy in a hydraulic jump is  $\Delta E = \frac{(y_2 - y_1)^3}{4y_1 y_2}$ , where the symbols indicate usual meanings. 5.00  
 (b) What is critical tractive force? Show that unit tractive force in a wide open channel is  $\tau_0 = \omega y S$  where symbols 3.00  
 have their usual meaning.  
 (c) Write four conditions for a trapezoidal channel section of most efficient section. Prove that  $\frac{b+2nd}{2} = d\sqrt{n^2 + 1}$  4.00  
 where symbols have their usual meaning.  
 Q.4(a) Explain why  $H_f$  and  $A_f$  profiles are not fractionally. 3.00  
 (b) Sketch the possible flow profile for the following and mention the name of profile. (i) Profile of stream below a 4.50  
 sluice gate. (ii) Profile behind a dam in a natural channel. (iii) Profile of a flow behind a dam in a steep   
 channel.  
 (c) Deduce the dynamic equation for a gradually varied flow in the following form:  $\frac{dy}{dx} = S_0 \frac{1 - (u_n/k)^2}{1 - (y/y_c)^2}$ , where the 4.50  
 symbols having usual meanings.

**SECTION-B**

- Q.5(a) Deduce the continuity equation for unsteady flow in the form of  $\frac{\partial \rho}{\partial x} + T \frac{\partial y}{\partial t} = 0$  where the symbols indicate 4.00  
 usual meanings.  
 (b) Compute the conveyance and velocity distribution co-efficient at peak flow in a natural stream channel 5.00  
 consisting of a main section and an overflowed side section. The data obtained at the peak flow stage one as   
 given below  

Sub section	$A, m^2$	$V, m$	$n$	$\alpha$	$\beta$
Main section	5320	205	0.035	1.12	1.05
Side section	5670	468	0.046	1.10	1.04

  
 (c) Write practical applications of hydraulic jump. 3.00  
 Q.6(a) Derive the equation for the force exerted by fluid jet on a stationary flat plate, when plate is normal to the jet. 5.00  
 (b) A jet of water having a velocity of 45 m/s impinges without shock a series of vanes moving at 15 m/s, the 6.00  
 direction of motion of the vanes being inclined at  $20^\circ$  to that of the jet. The relative velocity at outlet is 0.9 of   
 that at inlet and the absolute velocity of the water at exit is to be normal to the motion of the vanes. Find (i)   
 vane angles at entrance and exit (ii) work done on vanes per unit weight of water supplied by the jet; and (iii)   
 the hydraulic efficiency.  
 (c) Define the following term-(i) Manometric efficiency (ii) Mechanical efficiency (iii) Overall efficiency. 3.00  
 Q.7(a) Explain with neat sketches the working principle of a reciprocating pump. 4.00  
 (b) What is an indicator diagram of a reciprocating pump? Explain with diagram the effect of acceleration and 4.00  
 friction on both suction and delivery stroke  
 (c) For a pump with no air vessel, stroke length = 30cm, piston diameter = 12.5 cm, suction pipe diameter = 7.5 4.00  
 cm, length of suction pipe = 3m and suction head = 3m. Separation not be assumed to occur when the absolute   
 pressure head in the cylinder fall below 2.5m of water. Calculate the maximum speed at which the pump may   
 be run if separation is to be avoided.  
 Q.8(a) What is meant by priming of a pump? What are the different priming arrangements employed for small and big 4.00  
 priming unit?  
 (b) A centrifugal pump 1.5m diameter runs at 220 rpm and 1800 liters of water per second. The angle which 5.00  
 makes the vane at exit with the tangent to the impeller is  $25^\circ$ . Assuming radial entry and velocities of flow   
 throughout is 2.5 m/sec. Determine the power required to drive the pump. If manometric efficiency of the   
 pump is 65 percent find the average lift of the pump.  
 (c) Write short notes on the following and also give necessary sketches (i) Differential Hydraulic accumulator 3.00  
 (ii) Hydraulic lift.

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**CE 321**  
**Engineering Hydraulics**

Full marks: 70

Time: 3 Hours

- N.B:-
- (i) Answer any SIX questions, taking THREE from each section.
  - (ii) Figure in the margin indicate full marks.
  - (iii) Use separate answer script for each section.

$$dA = T dy$$

$$T = \frac{dA}{dy}$$

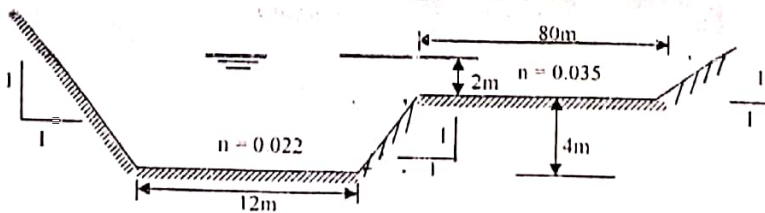
$$\frac{\partial A}{\partial y}$$

**SECTION-A**

- Q.1 (a) Define open channel flow. 'Open channel flow is more complicated than pipe flow' explain why? 3.67
- (b) State continuity equation for unsteady flow in open channel and show that  $\frac{\partial Q}{\partial x} + T \frac{\partial y}{\partial t} = 0$  is the basic equation of continuity for unsteady flow in open channel. Where symbols have their usual meaning. 4.00
- (c) The following pressures were measured on a wall. Find the force per unit length of the wall in excess of the hydrostatic value. 4.00
- |                                  |   |    |     |     |     |                    |
|----------------------------------|---|----|-----|-----|-----|--------------------|
| Distance below free surface (mm) | 0 | 50 | 100 | 150 | 200 | 250 (base of wall) |
| Pressure of water (mm)           | 0 | 51 | 104 | 159 | 216 | 275                |

- Q.2 (a) What is channel transition? Write the functions of channel transition. Show the variation of  $y_1$  and  $y_2$  in subcritical and super critical flow over a hump. 4.00
- (b) Find the critical depth for a specific energy head of 1.5 m in a trapezoidal channel 2.0 m bottom width and side slope of 1:1 and show also  $\frac{Ac^3}{T_c} = \frac{Q^2}{g}$ .
- (c) A low dam 5 ft high having a broad horizontal crest built with a rectangular channel 20ft wide. Assuming that a depth of 2.5ft measured on the crest is the critical depth. Compute the discharge and depth of flow upstream from the dam.

- Q.3 (a) Name and discuss the factors affecting Manning's roughness coefficient. 3.67
- (b) What are the different conditions for critical state of flow through open channel? 3.00
- (c) The cross section of the river may be idealized as shown in figure below. Find the discharge carried by the river if  $s = 2 \times 10^{-4}$ . 5.00



- (a) Name and discuss the factors to be considered in the design of channel. What do you know about critical tractive force? Show that tractive force ratio 3.00
- (b)  $K = \sqrt{1 - \frac{\sin^2 \phi}{\sin^2 \theta}}$  where symbols indicate usual meaning. 4.67
- (c) Design a canal to carry  $50 \text{ m}^3/\text{s}$  of clear water through 3.00 mm gravel (Angle of repose =  $31^\circ$ ) on a slope of  $10^{-4}$ . The canal is to be trapezoidal in shape having side slopes of 2H:1V. The average temperature =  $20^\circ\text{C}$   $\nu = 10^{-6} \text{ m}^2/\text{s}$ , given  $\tau'_c = 0.0485$ . Use the methods of Shield's analysis. 4.00

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SECTION-B



- Q.5 (a) Name and sketch the possible water surface profile in the following cases.
- (i) Flow from a sluice gate located on a horizontal floor to a steep slope, which is followed by an adverse slope.
  - (ii) Flow from a mild slope to a milder slope followed by a steep slope
- (b) Explain why H1 and A1 profiles are not practically possible. 3.00
- (c) Water is flowing under the sluice gate in a horizontal rectangular channel that is 6ft wide. The depth  $y_0$  and  $y_1$  are 65 ft and 1 ft respectively. What will be the horsepower lost in the hydraulic jump if energy loss for flow under the sluice gate is neglected. 4.67
- Q.6 (a) What do you mean by the term 'jet of water'? Derive an expression for the force of jet impinging on a moving curved vane. 4.00
- (b) A jet of water moving at 60 m/s is deflected by a vane moving at 25 m/s in a direction at  $30^\circ$  to the direction of the jet, the water leaves to blade normally to the motion of the vanes. Draw inlet and outlet triangle of velocities and find the vane angles for no shock at entry and exit. Take relative velocity at outlet to be 0.85 of relative velocity at inlet. 5.00
- (c) Write short notes on hydraulic intensifier and hydraulic jump. 2.67
- Q.7 (a) Explain the static head and Monometric head of a centrifugal pump with necessary sketching. 3.67
- (b) Write short notes on (i) Hydraulic lift (ii) Hydraulic Accumulator 3.00
- (c) Write down the comparison between the centrifugal and reciprocating pump. 3.00
- (d) Water is to be pumped out of a deep well under a total head of 95m. A number of identical pumps of design speed 1000 r.p.m and specific speed 900 r.p.m with a rated capacity of 150 litres/sec are available. How many pumps will be needed and how should they be connected? 2.00
- Q.8 (a) What is an indicator diagram of a reciprocating pump? Explain with diagram the effect of friction on both suction and delivery stroke. 3.00
- (b) Explain briefly the reasons for placing air vessels in the delivery pipe of a reciprocating pump. 2.67
- (c) A single acting reciprocating pump has a plunger of 80 mm diameter and a stroke of length 150 mm. It takes its supply of water from a sump 3m below the pump through a pipe 4.5m long and 30 mm diameter. It delivers water to a tank 12m above the pump through a pipe 25mm diameter and 15m long. If separation occurs at  $78.48 \text{ kN/m}^2$  below atmospheric pressure, find the maximum speed at which the pump may be operated without separation, assume the plunger to have simple harmonic motion. 6.00

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**CE 321**  
**Engineering Hydraulics**

Full marks: 70

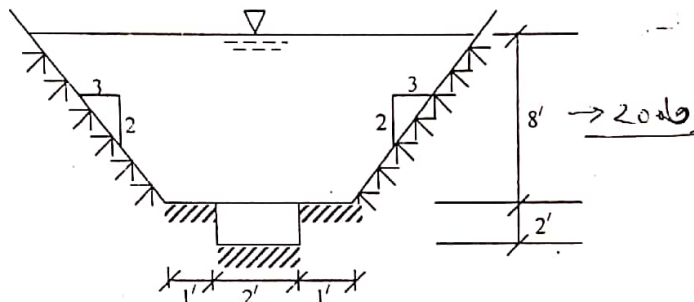
Time: 3 Hours

- N.B:- (i) Answer any **SIX** questions, taking **THREE** from each section.  
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 (iv) Assume reasonable value for any data missing.

**RAKIBUL ISLAM**  
**CE'140022**

**SECTION-A**

- Q.1(a) What do you mean by state of flow? How open channel flow are classified according state of flow. Discuss briefly. 2.67
- (b) Distinguish between canal, chute and flume. Compute the hydraulic radius, hydraulic depth and section factor of the channel section shown in figure below. 4.00

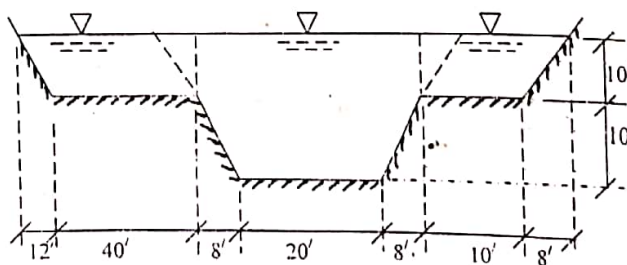


- (c) Velocity distribution in a semi-circular channel of diameter  $2R_0$  follows the law of  $\frac{u}{U_0} = \left(\frac{y}{R_0}\right)^{1/2}$  in which  $y$  is the distance normal to the surface at which the velocity is  $u$  and  $U_0$  is the velocity at the centre of the semi-circle. If  $R_0 = 2$  m and  $U_0 = 2$  m/sec, find  $U$ ,  $\alpha$  and  $\beta$ . Where symbols indicate usual meaning. 5.00

- Q.2(a) Draw a specific energy curve and show the following on the curve. (i) Alternate depth (ii) Critical depth (iii) Sub-critical and super critical flow region. 2.67
- (b) Prove the statement that at critical state of flow the specific force is a minimum for the given discharge. 4.00
- (c) A rectangular channel 8 ft wide, carrying 100 cfs at a depth of 0.5 ft is connected by a straight wall transition of a channel 10 ft wide, flowing at a depth of 4 ft. Determine the flow profile in the transition if the frictional loss through the transition is negligible. If a hydraulic jump occurs in the transition how can it be eliminated? 5.00

- Q.3(a) Using the Chezy's formula, show that the general equation for the hydraulic exponent  $N$  is  $N = \frac{V}{A} \left( 3T - R \frac{dA}{dy} \right)$ . Where symbols indicate usual meaning. 2.67

- (b) Using Manning's formula, show that the depth for a maximum discharge and velocity in a circular conduit are respectively  $0.938d_0$  and  $0.81d_0$ . 4.00
- (c) A channel consists of a main section and two side sections shown in figure below. Compute the total discharge, assuming that the main section and the two side sections are separated by (a) vertical division line and (b) extended sides of the main channel. Given,  $n = 0.015$  for main channel,  $n = 0.030$  for side channels and  $S = 0.001$ . 5.00



- Q.4(a) Explain why a uniform flow can not occur (i) in a frictionless channel and (ii) in a horizontal channel. 2.67
- (b) What is meant by critical tractive force and how can it be determined? Write three conditions for most efficient trapezoidal section and prove any one of them. 4.00
- (c) Design a canal to carry 50 m<sup>3</sup>/s of clear water through 300 mm gravel (angle of repose = 31°) on a slope of 10<sup>-4</sup>. The canal is to be trapezoidal in shape having side slope of 2H:1V. The average temperature = 20°C. ( $\nu = 10^{-6}$  m<sup>2</sup>/s). 5.00

## SECTION-B

- Q.5(a) Deduce the dynamic equation of gradually varied flow, where symbols indicate their usual meaning. 8.00
- (b) Sketch the possible flow profiles in the following serial arrangement of channel. The flow is from left to right  
 (i) mild-steep (ii) mild- free overfall (iii) reservoir- mild (iv) reservoir- steep 3.67
- Q.6(a) Classify the hydraulic jumps in horizontal rectangular channels according to USBR. 3.00
- (b) Write short notes on (i) Differential Hydraulic Accumulator (ii) Hydraulic Lift. 5.00
- (c) Water flows in a horizontal rectangular channel 6 m wide at a depth of 0.52 m and a velocity of 15.2 m/s. If a hydraulic jump forms in this channel, determine (i) the type of jump (ii) the downstream depth needed to form the jump (iii) the downstream froude number (iv) the efficiency of the jump (v) the relative height of the jump. 5.00
- Q.7(a) Show that the efficiency of a free jet striking normally as series of flat plates mounted on the periphery of a wheel never exceeds 50%. 6.67
- (b) A jet of water having a velocity of 45 m/s impinges without shock a series of vanes moving at 15 m/s. the direction of motion of the vanes being inclined at  $20^\circ$  to that of the jet. The relative velocity at outlet is 0.9 of that at inlet and the absolute velocity of the water at exit is to be normal to motion of the vanes. Find, (i) vane angles at entrance and exit (ii) work done on vanes per unit weight of water supplied by the jet and (iii) the hydraulic efficiency. 4.00
- Q.8(a) Describe the working principle of a centrifugal pump with sketching. 4.00
- (b) Find the saving in work done against friction in the delivery pipe of a single acting reciprocating pump by fitting with an air vessel is 84.8%. 3.67
- (c) A single acting reciprocating pump has a plunger of diameter 250 mm and stroke of 350 mm. If the speed of the pump is 60 r.p.m. and it delivers 16.5 litres per second of water against a suction head of 5 m and a delivery head of 20 m. Find the theoretical discharge, the slip, the percentage slip of the pump and the power required to drive the pump.

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**DEPARTMENT OF CIVIL ENGINEERING**  
**RAJSHAHI UNIVERSITY OF ENGINEERING & TECHNOLOGY**  
 B.Sc. Engineering Third Year Fifth Semester Examination, 2013

**CE 321**  
**Engineering Hydraulics**

Full marks: 70

Time: 3 Hours

- N.B:-
- (i) Answer any **SIX** questions, taking **THREE** from each section.
  - (ii) Figures in the margin indicate full marks.
  - (iii) Use separate answer script for each section.
  - (iv) Assume reasonable value for any data missing.

**SECTION-A**

- Q.1 (a) 'Open channel flow is more complicated than pipe flow' explain why? 2.67  
 (b) What is the hydrostatic law of pressure distribution? Discuss with suitable sketches the pressure distribution in a channel section. 4.00  
 (c) Compute the conveyance and velocity distribution co-efficient at peak flow in a natural stream channel consisting of a main section and an overflowed side section. The data obtained at the peak flow stage are as given below. 5.00

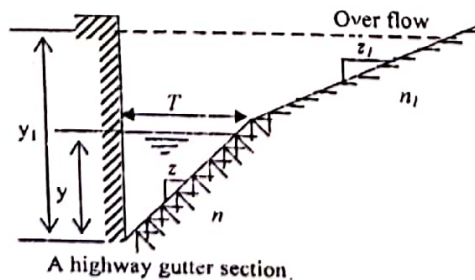
Sub section	A, ft <sup>2</sup>	P, ft	n	$\alpha$	$\beta$
Main section	5320	205	0.035	1.12	1.05
Side section	5670	408	0.040	1.10	1.04

- Q.2 (a) Deduce continuity equation for unsteady flow in form of  $\frac{\partial Q}{\partial X} + T \frac{\partial y}{\partial t} = 0$ . Where symbols have their usual meaning. 2.67

- (b) Prove that Froude number for critical state of flow,  $F = \frac{v}{\sqrt{gD \cos \theta / \alpha}}$  Where symbols indicate their usual meaning. 4.00

- (c) Applying the momentum principles and the continuity equations to the analysis of a submerged hydraulic jump which occurs at the sluice outlet in a rectangular channel. Prove that  $\frac{y_2}{y_1} = \sqrt{1 + 2F_1^2 (1 - \frac{y_2}{y_1})}$ , where  $y_1$  is the submerged depth,  $y_1$  is the height of the sluice gate opening,  $y_2$  is the tail-water depth and  $F_1^2 = \frac{q^2}{gy_1^3}$ ,  $q$  being the discharge per unit width of the channel. Neglect the channel bed friction  $F_f$ . 5.00

- Q.3 (a) A uniform flow can not be occur (i) in a friction less channel, (ii) in a horizontal channel, explain why? 3.00  
 (b) What are the factors affecting Manning's roughness co-efficient? Discuss briefly. 3.6  
 (c) Compute the discharge in an overflowed highway gutter as shown in figure below, having a depth of flow of 3in. and a longitudinal slope of 0.03. The gutter is made of concrete with  $n = 0.017$  and has a triangular section with a vertical curb side, a sloped side of  $z = 12$  and a top width of  $T = 2$  ft. The overflowed soil aggregate pavement has a cross slope of  $z_1 = 24$  and  $n_1 = 0.02$ . 5.00



Handwritten calculations:  
 $by + by$   
 $(b + 2y) \cdot 2$   
 $= b + 2y$   
 $2 + 2y$   
 $6 + 2y$

- Q.4 (a) What is critical tractive force? Show that unit tractive force in channel section is  $\tau_0 = \omega RS$ , where symbols indicate their usual meaning. 2.6  
 (b) Write the name of the factors to be considered in the design of open channel. Show that the tractive force ratio is a function only of the inclination of the sloping side and the angle of repose of the material forming the channel body. 4.0  
 (c) Design the section of a canal to carry a discharge of 200 cfs through a land of erodible soils with  $n = 0.020$  and  $s = 0.0010$ . Assume other necessary data and use your own judgment. 5.0

SECTION-B

- Q.5(a) What is an indicator diagram of a reciprocating pump? Explain with diagram the effect of accelerations and frictions on both suction and delivery stroke. 2.67
- (b) Define slip of a reciprocating pump? Why negative slip occur? 3.00
- (c) A single acting reciprocating pump has a plunger of 8 cm diameter and 15 cm of stroke length. It takes its supply of water from a sump of 4 m below the pump through a pipe 5 m long and 3 cm diameter. If separation occur at  $0.8 \text{ kg/cm}^2$  below the atmospheric pressure. Find the speed at which the pump may be operated without separation. 5.00
- Q.6(a) What is meant by hydraulic jump? Mention some practical applications of hydraulic jump. 2.67
- (b) Write down the condition of gradually varied flow and differentiate it with rapidly varied flow. 3.00
- (c) Write short note on (i) hydraulic accumulator and (ii) hydraulic intensifier. 2.00
- (d) Prove that the energy loss in a hydraulic jump is  $\Delta E' = \frac{(y_2 - y_1)^3}{4y_1y_2}$ , where symbols indicate usual meanings. 4.00
- Q.7(a) Write down the comparison between the centrifugal and reciprocating pump. 3.67
- (b) Determine the minimum speed required to commence the flow for centrifugal pump. 3.00
- (c) Define specific speed of a centrifugal pump and mention its purposes. Derive an expression for finding the specific speed for centrifugal pump. 5.00
- Q.8(a) A jet of water 5 cm in diameter having a velocity of 20 m/s strikes normally on flat smooth plate. Determine the thrust on the plate: (i) If the plate is at rest and (ii) If the plate is moving in the same direction as the jet with the velocity of 8 m/s. 5.67
- (b) Show that the efficiency of a free jet striking normally as a series of flat plates mounted on the periphery of a wheel never exceed 50%. 6.00

$$F = \frac{w a v^2}{g}$$

$$F = \frac{w a (v-u)^2}{g}$$

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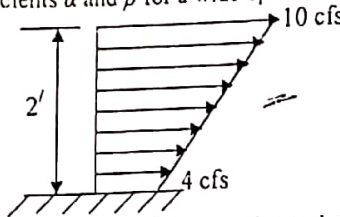
**CE 321**  
**Engineering Hydraulics**

Time: 3 Hours

- (i) Answer SIX questions, taking THREE from each section.  
 (ii) Figure in the margin indicates full marks.  
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 (iv) Assume reasonable value for any data not given.

**SECTION-A**

- Q.1(a) Sketch the possible flow for the following and mention the type of profile: (i) the profile in a stream below a sluice (ii) the profile behind a dam in a natural river. 4.00  
 (b) "The best hydraulic section is not necessarily the most economic section" - why? 2.67  
 (c) Determine the velocity distribution coefficients  $\alpha$  and  $\beta$  for a wide open flow with velocity distribution shown in figure below. 5.00



*Ahsan voh*

- Q.2(a) What are the types of open channel flow? Describe spatially varied flow with neat sketches. 3.67  
 (b) Deduce the equation of continuity for unsteady flow in open channel. 3.00  
 (c) The following pressures were measured on a wall. Find the force per unit length of the wall, pressure co-efficient at base of the wall and force in excess of the hydrostatic value. 5.00

Distance below free surface, mm	Pressure of water, mm
0	0
50	51
100	104
150	154
200	216
250 (Base of the wall)	275

- Q.3(a) Write the applications of hydraulic jump. 2.67  
 (b) Show that the energy loss in a horizontal hydraulic jump is  $\Delta E = (y_2 - y_1)^3 / 4y_1y_2$ , where symbols indicate usual meaning. 4.00  
 (c) A trapezoidal channel has side slope of 2 vertical to 3 horizontal. It is discharging water at the rate of 20 cumecs with a bed slope 1 in 2000. Design the channel for its best form. Using Manning's formula. Take,  $n = 0.01$ . 5.00
- Q.4(a) What is critical tractive force? Deduce the relationship and show that the tractive force ratio is a function of the inclination of sloping side and of the angle of repose of the material forming channel body. 3.00  
 (b) Design a trapezoidal channel laid on a slope of 0.0016 and carrying a discharge of 400 cfs. The channel is excavated in earth containing fine non-cohesive particle, 50% of which are larger than 1mm in diameter. The water is clear. If the side slopes are assumed as 1 on 1.5. 5.00  
 (c) What are the conditions for most efficient triangular, rectangular and trapezoidal section of an open channel? Deduce a mathematical relationship for a condition of most efficient trapezoidal section in open channel. 3.67

**SECTION-B**

- Q.5(a) Define the terms: (i) open channel flow and (ii) pipe flow. Also, write the differences between them. 4.00  
 (b) Derive an expression for the discharge through a channel by Chezy's formula. 4.67  
 (c) What are the functions of channel transition? 3.00
- Q.6(a) What is an indicator diagram of a reciprocating pump? What useful information does it give? Discuss briefly. 2.67  
 (b) Define 'Separation' in a reciprocating pump and explain how it can be avoided? 2.00  
 (c) The work saved by fitting an air vessel on a single acting reciprocating pump is more than in a double acting reciprocating pump, why? Explain briefly. 3.60  
 (d) A double acting reciprocating pump runs at 90 r.p.m. The diameter and stroke are 100 mm and 250 mm respectively. The suction pipe is of 100 mm diameter and 5 m long. Calculate the maximum permissible lift assuming no air vessel is fitted and separation occurs at 2 m of water absolute. 4.00
- Q.7(a) What is a centrifugal pump? On what principle does it work? Discuss with sketches. 2.67  
 (b) A centrifugal pump of 1.5 metre diameter runs at 220 rpm and pumps 1800 litres of water per second. The angle which the vane makes at exit with the tangent to the impeller is  $25^\circ$ . Assuming radial entry and velocity of flow throughout as 2.5 m/sec. Determine the power required to drive the pump. If manometric efficiency of the pump is 65 percent, find the average lift of the pump. 5.00  
 (c) What do you understand by the term multistage pump? Determine the least stages for a multi-stage pump to deliver 60 litres of water per second against a total head of 210 metres and speed 1450 rpm. The speed is not to exceed 670 rpm. 4.00
- Q.8(a) Write short notes on "Hydraulic accumulator". 2.00  
 (b) Derive an expression for the force of jet impinging on a stationary curved vane at its centre. 5.00  
 (c) A jet of water 5 cm in dia. having a velocity of 15 m/sec strikes normally in flat smooth plate. Determine the thrust on the plate: (i) if the plate is at rest and (ii) if the plate is moving with velocity 8 m/sec in the same direction of the striking jet. 4.67

Full marks: 70

Time: 3 Hours

- N.B:-**
- (i) Answer any SIX questions, taking THREE from each section.
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**SECTION-A**

- Q.1(a) State why the velocity distribution coefficient  $\alpha$  and  $\beta$  are used in open channel flow. 2.67
- (b) State whether the following open channel flows are steady or unsteady and gradually varied, rapidly varied or spatially varied. 3.00
- (i) Flood flow in a river  $u = 5.0 \sqrt{h}$
- (ii) Flow upstream of a hydraulic jump
- (iii) Tidal flow in an estuary.
- (c) In a wide channel the velocity varies along a vertical as  $u = 1 + \frac{2z}{h}$ , where  $h$  is the depth of flow and  $u$  is the velocity at a distance  $z$  from the channel bottom. 6.00
- (i) compute the discharge per unit width.
- (ii) determine the state of flow, and
- (iii) compute the numerical values of  $\alpha$  and  $\beta$ , if  $h = 5m$ .
- Q.2(a) Show that the C1 and C3 profiles are horizontal or approximately horizontal. 2.67
- (b) Sketch the possible flow profiles in the following serial arrangement of channels. The flow is from left to right. 4.00
- (i) mild-sloper mild-sloper (ii) critical-adverse-horizontal.
- (c) What is the difference between backwater curve and drawdown curve? State the assumption regarding the frictional losses in gradually varied flow and by this virtue how do you compute the friction slopes and friction losses in gradually varied flow? 5.00
- Q.3(a) Write down the condition of gradually varied flow and differentiate it with rapidly varied flow. 2.67
- (b) Derive a relationship between the initial depth and sequent depth of a hydraulic jump on a horizontal floor in a rectangular channel. 4.50
- (c) A uniform flow of 300 cfs occurs at a depth of 5 ft in a long rectangular channel 10 ft wide. Compute the minimum height of a flat top hump that can be build on the floor of the channel in order to produce a critical depth. What will result if the hump is lower or higher than the computed minimum height? 4.50
- Q.4(a) What are the functions of channel transition? 2.67
- (b) Write the applications of hydraulic jump. What are the different types of hydraulic jump show with diagram? 3.00
- (c) Design a trapezoidal channel laid on a slope of 0.0016 and carrying a discharge of 400 cfs. The channel is to be excavated in earth containing non-colloidal coarse gravel and pebbles 25% of which is 1.25 inch over diameter. Manning's roughness  $n = 0.025$ , angle of repose  $\theta = 33.5^\circ$  and side slope  $\phi = 26.5^\circ$  6.00

**SECTION - B**

- Q.5(a) Classify the hydraulic jumps in horizontal rectangular channels according to USBR. 3.67
- (b) Write short notes on: (i) Hydraulic accumulator (ii) Hydraulic intensifier. 4.00
- (c) An accumulator has a ram 0.3m in diameter and 9m lift, and is loaded with 1000kN total weight. If packing friction accounts for 1% of the total force on the ram, determine the power being delivered to the machine if the ram falls through its full range in 3 minutes, and if at the same time the pumps are delivered 1360 litres per minute. 4.00
- Q.6(a) Explain why reciprocating pumps are ideally suitable for grouting operation in dam foundation? Explain why centrifugal pumps are not suitable. 2.67
- (b) What is an air vessel? Evaluate the effect of air vessel on the work done. 3.00
- (c) A single acting reciprocating pump running at 60 rpm has a plunger diameter of 25 cm and a stroke of 50 cm. The delivery pipe is 10 cm diameter and 50 cm long. If the motion of the pump is simple harmonic, find the horse power required to overcome the friction of the delivery pipe when (i) no air vessel is fitted (ii) a large air vessel is fitted at the centre line of the pump. Assume  $f = 0.001$ . 6.00
- Q.7(a) Write down the comparison between the centrifugal and reciprocating pump. 3.67
- (b) Determine the minimum speed required to commence the flow for centrifugal pump. 3.00
- (c) Find the power required to drive centrifugal pump which delivers 10 litres of water per second to a height of 20m through a 150mm diameter and 100m long pipe line. The overall efficiency of the pump is 70% and Darcy's  $f = 0.06$  for the pipe line. Assume inlet losses in suction pipe equal to 0.33m. 5.00
- Q.8(a) Prove that the force exerted by a jet in its direction of flow, on a semi-circular vane is twice that exerted on a flat plate, both plates being fixed in position. 5.00
- (b) State some practical applications of hydraulic jump. 1.67
- (c) A Jet of water having a velocity of 45 m/s impinges without shock a series of vanes moving at 15 m/s, the direction of motion of the vanes being inclined at  $20^\circ$  to that of the jet. The relative velocity at outlet is 0.7 of that at inlet, and the absolute velocity of the water at exit is to be normal to motion of the vanes. Find: (i) vane angles at entrance and exit (ii) work done on vanes per unit weight of water supplied by the jet and (iii) the hydraulic efficiency. 5.00