M.E. (Water Resources & Hydraulic Engineering) (6 Semester) Exam., 2025

(1st Year 2nd Semester)

HYDRAULIC STRUCTURE AND HYDEL POWER ENGINEERING

(Paper V)

Time : Three Hours | Full Marks : 100

Answer any ***four*** questions.

1. a) Why do fluctuations occur from day-to-day or hour-to-hour in the supply and demand of turbines? How do you cater to the same?

   b) Explain diversion canal plants, addressing their principles, advantages, disadvantages, components, and examples.

   c) Differentiate between conventional hydro plants and depression power plants

   d) During a low water week, a river has an average daily flow of 36 cumec with a fluctuation during the day requiring a pondage capacity of approximately 20% of the daily discharge. A hydroelectric plant is to be located on the river, which will operate 5 days a week, 24 hours a day, but will supply power at a varying rate such that the daily load factor is 60%, corresponding to which the pondage required is equal to 0.2 times the mean flow to the turbine. On Saturdays and Sundays, all the flow is ponded for use on the rest of the days. If the effective head on the turbines when the pond is full is to be 25 m and the maximum allowable fluctuation in pond level is 1 m, find (i) the surface area of the pond to satisfy all the operating conditions, and (ii) the weekly output at the switch board in kWh. Assume turbine efficiency 85% and generator efficiency 95%.

   2+5+5+13 = 25

2. a) What is the economical diameter of a penstock? How can you determine it analytically?

   b) Typical weekly and daily releases of water from an upstream reservoir on a river are given below. Estimate the pondage capacity to operate a run-of-river plant at a downstream location so that a steady uniform power output is available from the plant.

   Weekly Release Pattern

Day	*Average daily release rate, m^3/s*
Sunday	20
Monday	37
Tuesday	50
Wednesday	60

Thursday	50
Friday	40
Saturday	30

Daily Release Pattern

Time	*Volume released, %*
12 MN – 6 AM	5
6 AM – 12 Noon	35
12 Noon – 6 PM	50
6 PM – 12 MN	10

c) The following data gives the average monthly flow in cumec in a dry year and it is intended to use it for designing a hydropower plant : July 17.0, Aug. 18.4, Sept. 17.6, Oct. 13.6, Nov. 13.3, Dec. 11.3, Jan. 9.9, Feb. 9.6, Mar. 8.5, Apr. 11.8, May 12.7, June 14.2. Assuming the net head on the turbine as 91.5 m and efficiency 80% draw the flow duration and power duration curves.

5+9+11 = 25

3. a) Define plant factor.

b) The water turbine of a hydel storage scheme has an output of 7000 kW when working under a head of 25 m and with an overall efficiency of 80%. The inflow in the reservoir during a year is as given below:

Month	J	F	M	A	M	J	J	A	S	O	N	D
Inflow (10^6 m^3)	102	110	90	81	72	87	120	90	93	100	105	96

Find (i) the minimum capacity of the reservoir to satisfy the uniform demand of water, (ii) the total quantity of water wasted during the year. Use a graphical or analytical method. Assume that the reservoir is full at the beginning of January.

c) What are the difficulties in tidal power generation?

d) Explain with sketches the Double-Cycle Systems for tidal power generation. What are the advantages and disadvantages of this method?

2+13+3+7 = 25

4. a) Develop the general equations of area-elevation & capacity-elevation curve of a Reservoir site by statistical methods.

   b) What is the classification of stilling basins according to their purpose and the corresponding Froude number ranges?

   c) A rectangular broad-crested weir with a length of 1.2 m, width of 1 m, and height of 50 cm is proposed for measuring flow in a channel. What range of flow rate can be accurately measured using this weir length? [Use value of Coefficient of Discharge (C_d) = 0.9] (12)

7+6+12=25

5. a) Discuss the different flow regimes that occur in culverts by providing a brief description of each regime, the governing flow equations.

   b) Establish the governing discharge equation given below for calculation of Type II flow in culvert when the entrance is submerged but the outlet is not submerged and the normal depth of flow in the culvert is larger than the height of culvert.

$$Q = A.\sqrt{\frac{2g\,\Delta h}{\frac{fL}{4R}+K_e+1}}$$

   Where, Δh = Difference between Head Water & Tail Water

   K_e= Entrance loss coefficient

   R= Hydraulic Radius

   f = Friction factor

   L= Length of Culvert

   (c) A culvert under a roadway is to be design to accommodate a 100-year beak flow rate of 2.49 m^3/s. The invert elevation at the culvert inlet is 289.56m. The invert elevation at the outlet is 288.65m and the length of the culvert is to be 22.9m. The channel d/s of the culvert has a rectangular cross section with a bottom width of 1.5 m. a slope of 4%, and a Manning's n of 0.045. The paved roadway crossing the culvert has a length of 15.2 m and an elevation of 291.08 m, and a width of 18.3 m Considering a circular reinforced concrete pipe (RCP) culvert with a diameter of 610 mm and a conventional square-edge inlet and head wall, determine the depth of water flowing over the road way, and the flow rate over the roadway, and the flow rate through the Culvert.

4+6+15=25

6. a) Deduce an expression of flow over a sharp-crested and Broad-crested weirs in an open channel for rectangular section, considering the flow across a horizontal width.

   b) Water flows under a vertical gate into a 3.2 m wide rectangular channel, where flow rate and the depth of flow are 5 m^3/s & 1.2 m respectively. Estimate the minimum gate opening to prevent the formation of a hydraulic jump. What energy loss (in kW) can be expected in a hydraulic jump?

13+12=25

7. The maximum design discharge over a spillway is 250 m^3/s, and the spillway and stilling basin are 10 m wide. The reservoir behind the spillway has a water-surface elevation of 60 m, and the river water surface elevation downstream of the stilling basin is 30 m. Assuming a 12% loss of hydraulic head in the flow down the spillway, find the elevation of the floor of the stilling basin so that the hydraulic jump forms in the basin. Design the stilling basin.

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8. a) What are the different types of stilling basins, and what are the criteria for their selection?"
   b) Estimate the length of the concrete apron (S0 = 0.015) for a stilling basin downstream from an overflow spillway. The spillway crest is 10 m in length and 4 m in height. If the discharge is 115 m3/s and n equals 0.025, should a type-II basin be used for this situation?

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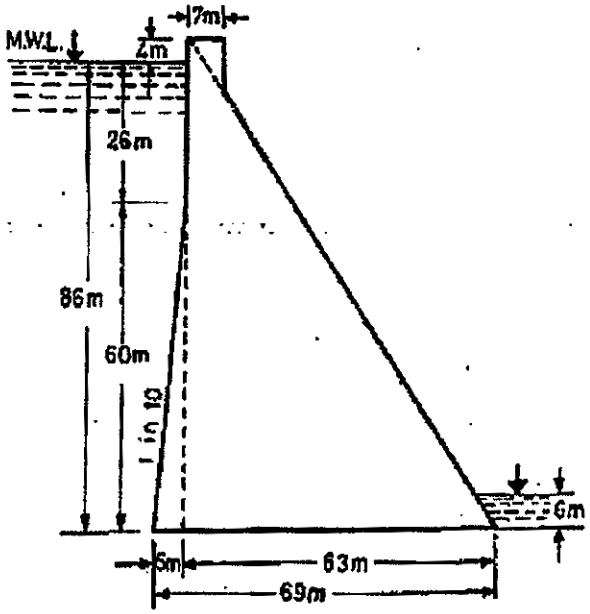
9. a) Explain in details various forces causing instability in gravity dam.

   b) Below figure shows the section of gravity damn built of concrete examine the stability of the section at the base. The earthquake force may be taken as equivalent to 0.1 g for horizontal force and 0.05 g what vertical forces. the uplift may be taken as equal to the hydrostatic pressure at the either ends and is constructed to act over 60% of the area of the section. A tail water depth of 6 m is assumed to be present when reservoir is full and there is no tailwater when the reservoir is empty. Also indicate the values of various kind of stresses that are developed at heel and toe. Assume unit weight of concrete as 24 kN/m^3 and unit weigh of water =10 kN/m^3



5+20=25