ROYAL CIVIL SERVICE COMMISSION
BHUTAN CIVIL SERVICE EXAMINATION (BCSE) 2023
EXAMINATION CATEGORY: TECHNICAL

PAPER III: SUBJECT SPECIALISATION PAPER FOR WATER ENGINEERING

Date : October 7, 2023
Total Marks : 100
Writing Time : 150 minutes (2.5 hours)
Reading Time : 15 minutes (prior to writing time)

GENERAL INSTRUCTIONS:

1. Write your Registration Number clearly and correctly on the Answer Booklet.
2. The first 15 minutes is to check the number of pages of Question Paper, printing errors, clarify doubts and to read the instructions. You are NOT permitted to write during this time.
3. This paper consists of **TWO SECTIONS**, namely SECTION A & SECTION B:
   - **SECTION A** has two parts: Part I - 30 Multiple Choice Questions
     Part II - 4 Short Answer Questions
   - **SECTION B** consists of **SIX** questions and answer only **FIVE** of them.
4. All answers should be written on the Answer Booklet provided to you. Candidates are not allowed to write anything on the question paper. If required, ask for additional Answer Booklet.
5. All answers should be written with correct numbering of Section, Part and Question Number in the Answer Booklet provided to you. Note that any answer written without indicating the Section, Part and Question Number will NOT be evaluated and no marks will be awarded.
6. Begin each Section and Part on a fresh page of the Answer Booklet.
7. You are not permitted to tear off any sheet(s) of the Answer Booklet as well as the Question Paper.
8. Use of any other paper including paper for rough work is not permitted.
9. **You must hand over the Answer Booklet to the Invigilator before leaving the examination hall.**
10. This paper has **8 printed pages**, including this instruction page.

GOOD LUCK

SECTION A

PART I: Multiple Choice Questions [30 marks]

Choose the correct answer and write down the letter of your chosen answer in the Answer Booklet against the question number e.g. 31 (d). Each question carries ONE mark. Any double writing, smudgy answers or writing more than one choice shall not be evaluated.

1. What percentage of the world's water is potable?
   a) less than 3%
   b) about 15%
   c) about 25%
   d) more than half

2. Which goal out of the 17 Sustainable Development Goals (SDGs) mentions "Ensure availability and sustainable management of water and sanitation for all"?
   a) SDG 17
   b) SDG 6
   c) SDG 13
   d) SDG 7

3. The field of hydrology deals with:
   a) flood water
   b) river water
   c) rainwater
   d) surface and ground water

4. Runoff is measured in:
   a) cubic meters
   b) cubic meters per sec
   c) cubic meters per minute
   d) cubic meters per hour

5. The runoff is affected by:
   a) rain intensity and duration
   b) rain distribution
   c) soil moisture
   d) all of the above

6. Pick up the correct equation from the following:
   a) Run off = Surface run off + Ground water flow
   b) Run off = Surface run off - Ground water flow
   c) Run off = Surface run off / Ground water flow
   d) Run off = Surface run off x Ground water flow

7. In Bhutan, rainfall is recorded by:
   a) National Environment Commission
   b) National Biodiversity Center
   c) National Center for Hydrology and Meteorology
   d) Ministry of Works and Human Settlement

8. A hyetograph is a graphical representation of:
   a) rainfall intensity and time
   b) discharge and time
   c) cumulative rainfall and time
   d) rainfall depth and time

9. A hydrograph is a graphical representation of:
   a) rain fall
   b) discharge flowing in the river
   c) surface runoff
   d) all of the above

10. For determination of average annual precipitation in a catchment basin, the best method is:
   a) Thiessen's mean method
   b) Arithmetical method
   c) Isohyetal method
   d) none of the above

11. The average mean velocity of a stream having depth *h* may be obtained by taking the readings of a current meter at a depth of:
   a) 0.1 *h* and 0.9 *h*
   b) 0.2 *h* and 0.8 *h*
   c) 0.3 *h* and 0.7 *h*
   d) 0.4 *h* and 0.6 *h*

12. The time required by rainwater to reach the outlet of the drainage basin is generally called:
   a) time of concentration
   b) duration of rainfall
   c) time of overland flow
   d) detention time

13. The following is **NOT** a geological factor governing the occurrence of groundwater.
   a) porosity of the soil
   b) permeability of the soil
   c) elasticity of the soil
   d) transmissibility of the soil

14. The quantity of water available from an infiltration gallery depends upon the:
   a) the yield of the aquifer source
   b) size of gallery
   c) the efficiency of the drain pipes
   d) all of the above

15. If the grain size of soil increases,
   a) water supply in well increases
   b) specific retention decreases
   c) surface area decreases
   d) all of the above

16. Sharp crested weirs are generally used for:
    a) small flows
    b) large flows
    c) streams carrying high sediment loads
    d) rivers carrying floating debris

17. Per capita demand of water is calculated in liters:
    a) per person per year
    b) per person per month
    c) per person per day
    d) none of the above

18. Per capita water demand is defined as the liters of water consumed daily by each person over a period of:
    a) 24 hours
    b) one month
    c) one year
    d) 10 years

19. Generally, the multiplying (peak) factor that is applied to compute the maximum daily water demand in relation to the average per capita daily demand is:
    a) 1.5
    b) 1.8
    c) 2.0
    d) 2.7

20. As per the Bhutan Drinking Water Quality Standard 2016, water is microbiologically safe if *E.coli* (in CFU/100ml sample) is within the following permissible limit :
    a) 0
    b) 1 - 5
    c) 6 - 10
    d) none of the above

21. In Water Supply Engineering “meters water column” is frequently used as a unit of pressure (head) expressed as “mwc’’ or “cm-wc”.
    10 m water column (mwc) is equivalent to:
    a) 0.1 bar
    b) 1 bar
    c) 10 bar
    d) 100 bar

22. The distribution system in a typical urban water supply is designed on the basis of::
    a) average daily demand
    b) peak hourly demand
    c) maximum daily demand + fire demand
    d) greater of (b) and (c)

23. In a hydraulic system, there are Elevation Head, Pressure Head, and Velocity Head.
    The Total Energy Head in a hydraulic system is equal to:
    a) Elevation Head - Pressure Head + Velocity Head
    b) Elevation Head - Pressure Head - Velocity Head
    c) Elevation Head + Pressure Head - Velocity Head
    d) Elevation Head + Pressure Head + Velocity Head

24. The Hydraulic Grade Line (HGL) is a graph of the pressure head _____ the pipe centerline.
    a) along
    b) below
    c) above
    d) near

25. The energy loss due to viscosity and friction along the straight length of the pipeline is called _____ and accounts for most of the pressure drop.
    a) major loss
    b) minor loss
    c) apparent loss
    d) physical loss

26. As the water flows through valves, bends, and other tube fittings, there are additional losses due to turbulence which is called _____ losses.
    a) major
    b) minor
    c) apparent
    d) physical

27. Pressure pipes are exclusively used for carrying water supplies because:
    a) such pipes can go up and down the hills and valleys thus requiring a lesser length
    b) such pipes are closed and hence not exposed to pollution
    c) since water runs under pressure, pollution from the outside surrounding cannot enter even if some joints are loose
    d) all of the above

28. Water hammer pressures can be reduced by using:
    a) critically closing time valves
    b) fast closing valves
    c) slow closing valves
    d) none of the above

29. Air valves are special kinds of valves that are generally placed at the _____ along the pipeline.
    a) summit
    b) bottom
    c) middle
    d) none of the above

30. Check valves are installed:
    a) on the delivery side of the pump
    b) at the interface connection between the treated water and raw water
    c) both (a) and (b)
    d) neither (a) nor (b)

PART II – Short Answer Questions [20 marks]

This part has 4 Short Answer Questions. Answer ALL the questions. Each question carries 5 marks.

1. Explain with neat sketches various types of aquifers.

2. Which factors should be considered while selecting a site for a stream gauging station?

3. Explain uplift pressure on hydraulic structures. How are hydraulic structures designed to make it safe from uplift pressure?

4. List down the strategies/activities/techniques to address reservoir sedimentation. Which five strategies/activities/techniques would you propose to avoid reservoir sedimentation in Bhutan?

SECTION B [50 marks]

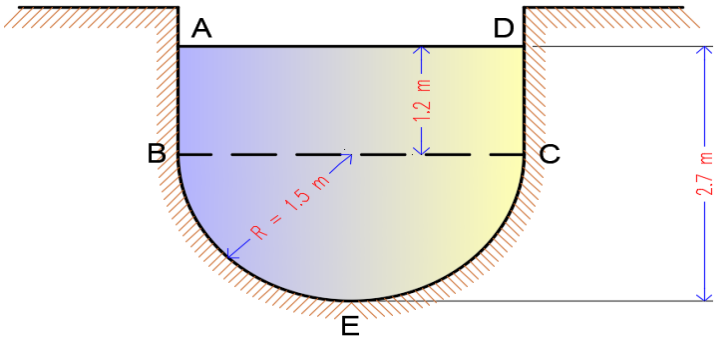
There are 6 Questions in this Section. Choose 5 Questions out of 6 Questions. Each Question carries 10 marks. Refer to the diagram and list of formulas given at the end of the Section.

1. Explain the stream flow measurement by velocity-area method. How can it be used to estimate stream flow in Bhutan? What corrections are needed to estimate flow by velocity-area method?

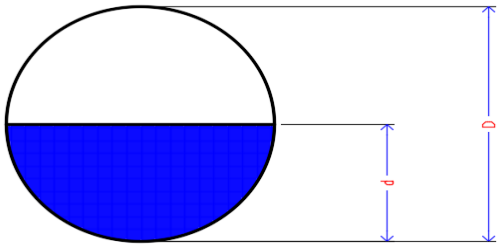
2. The leakage in a water distribution system was 20 m^3/h at the average pressure of 50 m. Given $L = K P^{1.5}$, where L = Leakage, P = Pressure
   a) What will be the leakage at the average pressure of 40 m?
   b) What should be the average pressure in the above distribution system to reduce the leakage to 10 m^3/h?
   c) List the causes of high water losses in a distribution system.

3. Answer the following questions:
   a) What should be the production capacity in m^3/h of a treatment facility that has to supply a city with 300,000 people with an average quantity of 130 lpcd?
   b) If the population of the city is increasing geometrically at the rate of 2% per year, estimate the increase in the production capacity of the treatment plant required after 15 years for the following scenarios:
      (i) The average total per capita water demand remains constant (130 lpcd)
      (ii) The average total per capita water demand increases linearly 1% per year

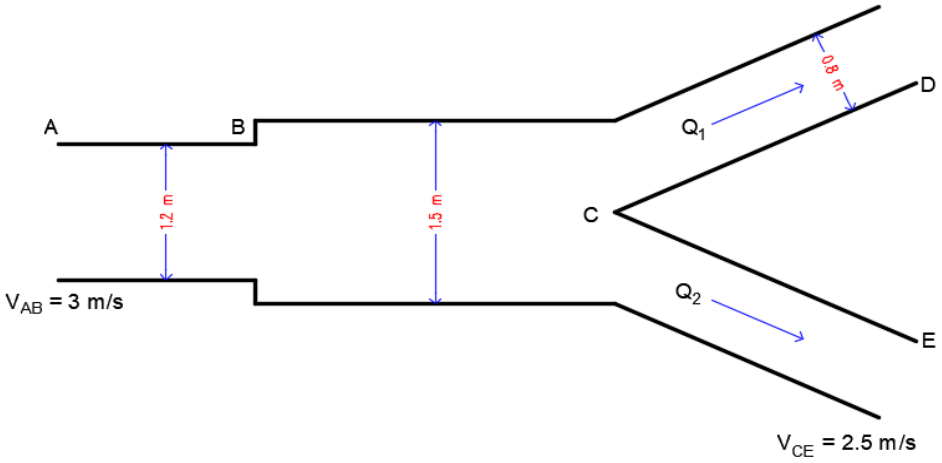
4. Determine the discharge of water through the channel shown in the diagram below. Take the value of Chezy's constant as 60 and slope of the bed as 1 in 2000.



5. Find the diameter of a circular sewer pipe (refer diagram below) which is laid at a slope of 1 in 8000 and carries a discharge of 800 l/s when flowing half full. Take the value of Manning's N as 0.02



6. Water flows through Pipe AB of 1.20 m diameter at 3.00 m/s and then passes through Pipe BC of 1.50 m diameter. At point C, the pipe branches into two pipes. Branch Pipe CD is 0.80 m in diameter and carries one-third of the flow in Pipe AB. The flow velocity in branch Pipe CE is 2.50 m/s. Find the volume rate of flow in Pipe AB, the velocity in Pipe BC, the velocity in Pipe CD and the diameter of Pipe CE in meters (Refer the following diagram).



FORMULAE

$Q = AC\sqrt{mi}$ { C = Chezy's constant, m = hydraulic mean depth, i = slope }

Hydraulic mean depth, $m = \frac{A}{P}$ { A = area of flow, P = wetted perimeter }

$C = \frac{1}{N} m^{\frac{1}{6}}$ { N = Manning's n value }

Average daily demand (ADD) = P x q (lpcd)

Maximum daily demand (MDD)= 1.8 x P x q (lpcd)

Maximum hourly demand of the maximum day = 1.5 x MDD { P = population, q = per capita water demand }

Geometric Increase, $P_n = P_o (1 + r)^n$

Linear Increase, $P_n = P_0 (1 + rn)$ { r = rate of change, n = number of years }

Principle of continuity of flow, $Q_1 = Q_2 = v \times A$

TASHI DELEK