

Serial No.

QUESTION BOOKLET

A

60157

CIVIL ENGINEERING (06)

Time Allowed : 3 Hours

[1 Hour for Objective

2 Hours for Subjective]

Maximum Marks : 200

[100 Marks for Objective

100 Marks for Subjective]

INSTRUCTIONS FOR CANDIDATES

1. This Question Booklet consists of **two** Parts (Objective and Subjective). Candidate has to attempt both the Parts.
2. **In Objective Part, there are 50 questions carrying 2 marks each. There is no negative marking for any wrong answer. In Subjective Part, four (4) questions should be answered in which Question No. 1 is compulsory.**
3. Please do not open this Question Booklet until you are told to do so.
4. Candidate must fill up the necessary information in the space provided on the OMR Answer Sheet before commencement of the test.
5. For marking the correct answer, darken one circle by **black or blue** ball-point pen only. Please do not mark on more than one circle. Darkening on more than one circle against an answer will be treated as wrong answer.
6. Do not detach any leaf from this Question Booklet. After the examination, hand over the OMR Answer Sheet to the Room Invigilator.
7. Possession and use of Calculator, Mobile Phone and Pager is prohibited in the Examination Hall.
8. Candidates are informed that evaluation of OMR Sheets will be done by Electronic Machine. So, they should shadow the bubbles of Roll No., Booklet Series and Booklet No. properly, otherwise Machine will not be able to evaluate it. Failure to comply this instruction will be sole responsibility of the candidates.

SEAL

PART—A
(Objective)

1. An aquifer confined at the top and at the bottom by impermeable layers is stratified into three layers as follows :

Layer	Thickness (m)	Permeability (m/day)
Top layer	4	30
Middle layer	2	10
Bottom layer	6	20

The transmissivity (m^2/day) of the aquifer is

- (A) 260
(B) 227
(C) 80
(D) 23
2. If it rains between 2 p.m. and 3 p.m. and the entire basin area just starts contributing water at 3 p.m. to the outlet, then the time of concentration will be

- (A) 15 minutes
(B) 20 minutes
(C) 30 minutes
(D) 60 minutes

3. If the base period of a 4-hour unit hydrograph is 48 hours, then the hydrograph of a storm of 8 hour, derived from this unit hydrograph, will be having a base period of

- (A) 44 hours
(B) 48 hours
(C) 52 hours
(D) 56 hours

4. A 4-hour rainfall in catchment of 250 km^2 produces rainfall depths of 6.2 cm and 5.0 cm in successive 2-hour unit periods. Assuming the ϕ index of the soil to be 1.2 cm/hour, the runoff volume in ha-m will be

- (A) 16
(B) 22
(C) 1600
(D) 2200

5. A 4-hour unit hydrograph of a drainage basin is triangular in form with a height of $50 \text{ m}^3/\text{sec}$ and a base of 15 hours. The area (in km^2) of the drainage basin is

- (A) 110
(B) 135
(C) 147
(D) 151

6. Match List-I with List-II and select the correct answer using the Code given below the Lists :

<i>List-I</i>	<i>List-II</i>
A. Unconfined aquifer	1. Insignificant yield
B. Confined aquifer	2. Impermeable of flow of water
C. Aquitard	3. Water-table aquifer
D. Aquiclude	4. Artesian aquifer

Code :

- (A) A B C D
1 2 3 4
- (B) A B C D
2 4 1 3
- (C) A B C D
3 4 1 2
- (D) A B C D
4 3 1 2

7. Match List-I with List-II and select the correct answer using the Code given below the Lists :

<i>List-I</i>	<i>List-II</i>
A. Horton formula	1. Evapotranspiration
B. Lysimeters	2. Ratio of lake evaporation to pan evaporation
C. Blaney-Criddle formula	3. Infiltration equation
D. Pan coefficient	4. Soil evaporation

Code :

- (A) A B C D
1 2 3 4
- (B) A B C D
2 4 1 3
- (C) A B C D
4 3 1 2
- (D) A B C D
3 4 1 2

8. The relationship among the duty D (in ha/cumec), the water depth Δ (in cm) and the base period B (in day) of irrigation water for a given crop is given by

(A) $D = \frac{864 B}{\Delta}$

(B) $D = \frac{8.64 B}{\Delta}$

(C) $D = \frac{864 \Delta}{B}$

(D) $D = \frac{8.64 \Delta}{B}$

9. Which one of the following is not a remedial measure for waterlogging?
- (A) Good drainage for irrigated land
 - (B) Conjunctive use of water in the basin
 - (C) Lining of canals and water-courses
 - (D) Contour bunding
10. An alluvial river has a dominant discharge of $1600 \text{ m}^3/\text{sec}$ and a bed slope of 1 in 5000. The approximate value of meander belt for this river would be
- (A) 0.06 km
 - (B) 0.6 km
 - (C) 6 km
 - (D) 60 km
11. If the peak load on a power plant having a capacity of 100 MW is 70 MW during a given week, and the energy produced is 5880000 kWh, the capacity factor for the plant for the week will be
- (A) 35%
 - (B) 50%
 - (C) 70%
 - (D) 80%
12. A tile drain is laid below a cropped land to remove excess irrigation water. The drainage coefficient of this drain is usually expressed as
- (A) centimeter of water depth removed from the drainage area per day
 - (B) m^3 of water removed per second
 - (C) percentage of applied water, which is intercepted by the drain
 - (D) hectares of the drainage area drained per second
13. The bottom portion of a concrete or a masonry gravity dam is usually stepped in order to
- (A) increase the overturning resistance of the dam
 - (B) increase the shear strength of the base of the dam
 - (C) decrease the shear stress at the base of the dam
 - (D) increase the retention capacity of the dam

14. A hydraulic structure is safe against sliding, when the magnitude of

- (A) the horizontal forces are more than the foundation friction resistance
- (B) the horizontal forces are less than the foundation friction resistance
- (C) the weight of structure is less than the uplift pressure
- (D) all of the above is more than the uplift pressure

15. Garret's diagrams are based on

- (A) Lacey's theory
- (B) Khosla's theory
- (C) Bligh's theory
- (D) Kennedy's theory

16. In Lacey's regime theory, the flow velocity is proportional to

- (A) $(Qf^2)^{1/2}$
- (B) Q/f^2
- (C) $(Qf^2)^{1/6}$
- (D) $(Qf)^{1/6}$

17. Which one of the following is not the requirement of an ideal regime condition in Lacey's regime theory?

- (A) The discharge in the channel is constant and the flow should be uniform
- (B) The channel flows through the same soil grade, as that of the sediment entering the channel from the headworks
- (C) The sediment grade and its amount entering the channel is constant
- (D) The silt grade should consist of clay-sized particles

18. Which of the following statements is incorrect?

- (A) Bligh's safe hydraulic gradient is the same as Khosla's safe exit gradient
- (B) The first streamline below a barrage section follows the bottom profile of the section
- (C) Equipotential lines are the lines joining the points of equal residual seepage head
- (D) Streamlines and equipotential lines intersect each other at right angles

19. The safety against any possible scour, on upstream or downstream side, of the pucca floor of hydraulic structure is usually ensured by laying
- (A) inverted filter
 - (B) toe wall
 - (C) rock toe
 - (D) stone apron
20. When the water level, standing against an earthen embankment, suddenly falls down, then there is eminent risk of sliding failure to the
- (A) upstream slope
 - (B) downstream slope
 - (C) Both (A) and (B)
 - (D) None of the above
21. If L is effective length of spillway crest and H is the total head over the spillway crest including velocity head, the discharge passing over an ogee spillway is given by
- (A) $CLH^{3/2}$
 - (B) $CHL^{3/2}$
 - (C) $CLH^{5/2}$
 - (D) $CLH^{1/2}$
22. Leaching is the process by which
- (A) water is excessively pumped from a waterlogged area
 - (B) excess salt in the soil is pushed down by standing water above the soil
 - (C) sodium ions are removed from irrigation water
 - (D) the soil structure and texture is improved by adding suitable chemicals
23. Which of the following Froude number ranges indicates a weak jump?
- (A) 1.0 to 1.7
 - (B) 1.7 to 2.5
 - (C) 2.5 to 4.5
 - (D) 4.5 to 9.0
24. Which of the following surface profiles represents the super-critical state of flow?
- (A) M_3 , H_2 and M_1
 - (B) M_2 , S_1 and M_3
 - (C) S_1 , S_2 and S_3
 - (D) S_2 , S_3 and C_3

25. A rectangular open channel carries a discharge of $18 \text{ m}^3/\text{s}$ when the depth of flow is 1.5 m and the bed slope is $1:1440$. What will be the discharge through the channel at the same depth, if the slope would have been $1:1000$?

- (A) $25.92 \text{ m}^3/\text{s}$
- (B) $15.00 \text{ m}^3/\text{s}$
- (C) $12.50 \text{ m}^3/\text{s}$
- (D) $10.42 \text{ m}^3/\text{s}$

26. Match List-I with List-II and select the correct answer using the Code given below the Lists :

<i>List-I</i>	<i>List-II</i>
(Flow regimes for gradually varied flow)	(Type of gradually varied flow profile)

- | | |
|--------------------|----------|
| A. $y_c > y_n > y$ | 1. C_1 |
| B. $y_c < y_n < y$ | 2. M_1 |
| C. $y_n > y > y_c$ | 3. S_3 |
| D. $y > y_c > y_n$ | 4. M_2 |
| | 5. S_1 |

y_n = normal depth
 y_c = critical depth
 y = depth of gradually varied flow]

Code :

- | | | | | |
|-----|---|---|---|---|
| (A) | A | B | C | D |
| | 1 | 2 | 3 | 4 |
| (B) | A | B | C | D |
| | 3 | 4 | 5 | 2 |
| (C) | A | B | C | D |
| | 3 | 2 | 4 | 5 |
| (D) | A | B | C | D |
| | 5 | 4 | 3 | 1 |

27. If specific energy in a triangular channel is E , critical depth in the channel will be given by

- (A) $0.33 E$
- (B) $0.67 E$
- (C) $0.75 E$
- (D) $0.80 E$

28. For the condition for maximum mean velocity of flow through an open channel of circular cross-section with diameter D , the depth of flow should be equal to

- (A) $0.95 D$
- (B) $0.81 D$
- (C) $0.30 D$
- (D) $0.29 D$

29. An irrigation canal has a steady discharge Q at a section where a cross-regulation (gate) is provided for control purposes. If the gate of the regulator, which is normally fully open, is suddenly lowered down to a half-open position, then a rapidly varied unsteady flow results both upstream and downstream of the gate. In such a case, it would take the form of

- (A) a positive surge moving u/s and a negative surge moving d/s
- (B) a positive surge moving d/s and a negative surge moving u/s
- (C) a positive surge moving u/s and a positive surge moving d/s
- (D) a negative surge moving u/s and a negative surge moving d/s

30. Given that, S_0 = slope of the channel bottom, S_e = slope of the energy line and F = Froude no., the equation of gradually varied flow is expressed as

- (A) $\frac{dy}{dx} = \frac{S_0 - S_e}{1 + F^2}$
- (B) $\frac{dy}{dx} = \frac{S_0 - S_e}{1 - F^2}$
- (C) $\frac{dy}{dx} = \frac{S_0 + S_e}{1 + F^2}$
- (D) $\frac{dy}{dx} = \frac{S_0 + S_e}{1 - F^2}$

31. In subcritical flow in a channel, Δz_m represents the maximum height of a hump that can be built without causing any change in the upstream water surface. If a hump of height $\Delta z < \Delta z_m$ is built, then

- (A) the upstream water surface will be lowered
- (B) the flow over the hump will be critical
- (C) the flow over the hump will be supercritical
- (D) the flow over the hump will be subcritical

32. For a triangular channel having a vertex angle of 120° , the critical depth for a discharge of $3.0 \text{ m}^3/\text{s}$ would be

- (A) 0.906 m
- (B) 1.982 m
- (C) 1.019 m
- (D) 2.352 m

33. Which of the following is the steepest gradient?
- (A) Ruling gradient
 (B) Limiting gradient
 (C) Exceptional gradient
 (D) Minimum gradient
34. For penetration test on bitumen, the penetrometer consists of a needle assembly with a total weight of
- (A) 5 gram
 (B) 10 gram
 (C) 100 gram
 (D) 200 gram
35. Which of the following properties is not considered while selecting good aggregate for road?
- (A) Toughness
 (B) Adhesiveness
 (C) Swelling
 (D) Ductility
36. If the velocity of moving vehicles on a road is 24 kmph, stopping distance is 19 m and the average length of vehicles is 6 m, the basic capacity of the lane is
- (A) 500 vehicles/hour
 (B) 750 vehicles/hour
 (C) 1000 vehicles/hour
 (D) 1250 vehicles/hour
37. RC-2, MC-2 and SC-2 correspond to
- (A) same viscosity
 (B) viscosity in increasing order from RC-2 to SC-2
 (C) viscosity in decreasing order from RC-2 to SC-2
 (D) None of the above
38. The cement concrete (with modulus of elasticity, $E = 3.0 \times 10^5 \text{ kg/cm}^2$ and Poisson's ratio, $\mu = 0.15$) is used for the construction of a pavement of 18 cm thickness. If the modulus of subgrade reaction is 6 kg/cm^3 , the radius of relative stiffness would be
- (A) 70.6 cm
 (B) 52.15 cm
 (C) 98.15 cm
 (D) 111.186 cm
39. If an ascending gradient of 1 in 50 meets a descending gradient of 1 in 50, the length of summit curve for a stopping sight distance of 80 m will be
- (A) 0
 (B) 64 m
 (C) 80 m
 (D) 60 m

40. Which one of the following pairs is not correctly matched?

- (A) Horizontal curves—Super-elevation
- (B) Origin and destination studies—Desire lines
- (C) Loss Angeles—Hardness of test aggregates
- (D) Soundness test—Purity of bitumen

41. Which of the following are claimed as advantageous in respect of aerobic sludge digestion as compared to anaerobic sludge digestion?

1. Production of a well-stabilized sludge with excellent dewatering propensity
2. Greater production of methane
3. Lower BOD concentration in supernatant liquor
4. Lesser operating cost
5. Lesser capital cost

Select the correct answer using the code given below :

Code :

- (A) 1, 2 and 4
- (B) 1, 3 and 5
- (C) 3, 4 and 5
- (D) 2, 3, 4 and 5

42. The short-circuiting occurring in a sedimentation tank is represented by

- (A) surface loading
- (B) displacement efficiency
- (C) recirculation ratio
- (D) detention time

43. A reactor, in which the surface area for growth of biofilm is provided by randomly packed solid forms, is called

- (A) activated sludge reactor
- (B) trickling filter
- (C) stabilization pond
- (D) None of the above

44. In water treatment, rapid gravity filters are adopted to remove

- (A) dissolved organic substances
- (B) dissolved solids and dissolved gases
- (C) floating solids and dissolved inorganic solids
- (D) bacteria and colloidal solids

45. For proper slow mixing in the flocculator of a water treatment plant, the temporal mean velocity gradient G needs to be of the order of

- (A) 5 s^{-1} to 10 s^{-1}
- (B) 20 s^{-1} to 80 s^{-1}
- (C) 100 s^{-1} to 200 s^{-1}
- (D) 250 s^{-1} to 350 s^{-1}

46. Strainer-type tube wells are unsuitable for

- (A) hard strata
- (B) fine sandy strata
- (C) coarse gravel
- (D) clayey strata

47. The commonly used material for water mains, which is strong, noncorrodible, very very durable (100 years or so), but heavy and brittle, is

- (A) steel
- (B) RCC
- (C) copper
- (D) cast iron

48. For internal water distribution system within building, the most suitable material amongst the following four is

- (A) steel pipe
- (B) CI pipe
- (C) RCC pipe
- (D) GI pipe

49. The working condition(s) in Imhoff tanks is/are

- (A) aerobic only
- (B) anaerobic only
- (C) aerobic in lower compartment and anaerobic in upper compartment
- (D) anaerobic in lower compartment and aerobic in upper compartment

50. Match List-I with List-II and select the correct answer using the code given below the Lists :

<i>List-I</i>	<i>List-II</i>
A. Soil pipe	1. Ventilating pipe
B. Intercepting tap	2. Wash basin
C. p-trap	3. Water closet waste
D. Cowl	4. House drainage

Code :

(A)	A	B	C	D
	3	4	1	2
(B)	A	B	C	D
	3	4	2	1
(C)	A	B	C	D
	4	3	2	1
(D)	A	B	C	D
	4	3	1	2

CIVIL ENGINEERING (06)

PART—B

(Subjective)

Full Marks : 100

Time : 2 hours

The figures in the margin indicate full marks for the questions

Candidates are required to answer **four** questions of which Question No. 1 is compulsory

1. Answer any *five* of the following questions : 5×5=25

- (a) What is meant by duty and delta of canal water? Derive a relationship between duty and delta for a given base period.
- (b) Explain the different methods of determining the average rainfall over a catchment due to a storm. Discuss the relative merits and demerits of the various methods in short.
- (c) Two reservoirs are connected by a pipe 120 m long and 100 mm in diameter followed by another pipe 60 m long and 50 mm in diameter. The total head loss between the reservoirs is 10.3 m. Given, $f = 0.03$, compute discharge neglecting minor losses.
- (d) Find the width of elementary gravity dam whose height is 100 m. Specific gravity of dam material is 2.2 and seepage coefficient at base $C = 0.8$.
- (e) For a BOD test, raw material (3.0 ml) was diluted to 300 ml (capacity of a BOD bottle). The diluted sewage was observed for its dissolved oxygen at the beginning and end of 5 days incubation at 20 °C. The respective values were 8.6 mg/l and 4.6 mg/l. Determine BOD of the raw sewage.
- (f) A two-lane road with design speed 80 kmph has horizontal curve of radius 480 m. Design the rate of superelevation for mixed traffic. By how much should the outer edges of the pavement be raised with respect to the centerline, if the pavement is rotated with respect to the centreline and the width of the pavement at the horizontal curve is 7.5 m?
- (g) The shear stress τ in open channel depends on depth of flow y , velocity v , density ρ , surface tension σ and acceleration due to gravity g . Using Buckingham's pi theorem, make out the dimensional analysis of the problem.

- (h) The maximum increase in temperature is expected to be 26 °C after the construction of a CC pavement. If the expansion joint gap is 2.2 cm, design the spacings between the expansion and construction joints. Assume plain cement concrete construction, thermal coefficient = 10×10^{-6} per °C, unit weight = 2400 kg/m³ allowable stress in torsion during initial period of curing = 0.8 kg/cm² and the coefficient of friction of interface = 1.4.

2. (a) Distinguish between the following :

- (i) Infiltration capacity and infiltration rate
- (ii) Actual and potential evapotranspirations
- (iii) Depression storage and interception

9

- (b) Two catchments A and B are considered meteorologically similar. Their catchment characteristics are given below :

Catchment A	Catchment B
$L = 30$ km	$L = 45$ km
$L_{Ca} = 15$ km	$L_{Ca} = 25$ km
$A = 250$ km ²	$A = 400$ km ²

For catchment A, a 2-hr unit hydrograph was developed and was found to have a peak discharge of 50 m³/s. The time to peak from the beginning of the rainfall excess in this unit hydrograph was 9.0 hr. Using Snyder's method, calculate the parameters of the unit hydrograph for catchment B.

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3. (a) A five-cylinder reciprocating pump raises the water level by 150 m and the theoretical discharge is 0.2 m³/s. The velocity in the delivery pipe is 2 m/s. Total head loss in pipes is 20 m. What is the input power if the efficiency of the pump is 0.87?
- (b) Two pipes of length 2500 m each and diameter of 80 cm and 60 cm respectively and connected in parallel. The friction factor for each pipe is $4f = 0.024$. Total flow is equal to 25.0 l/s. Find the discharge in each pipe.
- (c) A 5 m-wide rectangular channel carries 15 m³/s of water with a velocity of 6 m/s. State whether hydraulic jump is formed. If yes, compute height of the jump and power dissipated.

9

8

8

4. (a) On the basis of a detention period of 24 hrs, determine the size (assuming length to width ratio of around 2 and depth of waste water 1 m) of a septic tank required for 100 persons. The flow into the tank may be assumed at the rate of 70 lpcd. What will be the surface loading and weir loading of the tank? 12

- (b) The BOD rate constant (K) for a river's BOD assimilation was determined to be 2.0/day (base e). The BOD of this river after leaving a heavily populated town was determined to be 50 mg/l. Determine the distance after which the river's BOD would become 4 mg/l when the average velocity of the river was 1 m/s. What would have been K if this distance would have been 300 km and state what K manifests? 13

5. (a) Find the magnitude of Froud number after the hydraulic jump given the Froud number before the jump is $\sqrt{6}$. 8

- (b) A three-dimensional flow is given by

$$\vec{V} = (y^2 + z^2)i + (x^2 + z^2)j + (x^2 + y^2)k$$

Determine the component of acceleration at a point (2, 3, 4), where i, j, k are unit vectors. 8

- (c) Show that the normal depth of flow in a triangular channel having side slope $ZH : 1V$ is given by

$$y_n = 1.189 \left[\frac{Q_n}{\sqrt{S_0}} \right]^{3/8} \left[\frac{Z^2 + 1}{Z^5} \right]^{1/8} \quad 9$$

6. (a) The speeds of overtaking and overtaken vehicles are 80 kmph and 60 kmph respectively. If the acceleration of the overtaking vehicle is 2.5 kmph per sec, calculate the safe sight distance for (i) single-lane one-way traffic, (ii) three-lane both way traffic. Assume perception time of the driver is 2 sec. 12

- (b) A cement concrete pavement has a thickness of 18 cm and has two lanes of 7.2 m width with a longitudinal joint along the centre. Design the dimensions and spacing of the tie bar. Use the following data : 13

Allowable working stress in tension = 1400 kg/cm²

Unit weight of concrete = 2400 kg/m³

Coefficient of friction = 1.5

Allowable bond stress in deformed bar in concrete = 24.6 kg/cm²

7. (a) Differentiate between a slow sand filter and a rapid sand filter in respect of—

- (i) mechanisms of removal of impurities;
- (ii) cleaning process;
- (iii) effluence-quality;
- (iv) bed size in qualitative term.

8

(b) Show that if a plate $10\text{ m} \times 5\text{ m}$ is towed through a fluid so that the boundary layer is entirely laminar, the ratio of towing speeds such that drag force remains constant regardless of whether 10 m or 5 m side is in the flow direction is given by

$$\frac{U_{10m}}{U_{5m}} = 1.2598$$

If the boundary layer is entirely turbulent and Reynolds number is less than 10^7 , then show that

$$\frac{U_{10m}}{U_{5m}} = 1.08$$

10

(c) The velocity of distribution within the boundary layer is given by $\frac{u}{U} = \left(\frac{y}{\delta}\right)^{1/n}$. Obtain the ratio of displacement thickness to momentum thicknesses.

7

SPACE FOR ROUGH WORK

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SEAL