SECTION A

Q1. (a) A straight 20 cm diameter pipeline 4 km long is laid between two reservoirs having a difference of levels of 40 m. To increase the capacity of the system, an additional 2 km long, 20 cm diameter pipe is laid parallel from the upper reservoir to the mid-point of the original pipe. Find the increase in discharge due to installation of the new pipe. 12

Assume f as 0·00625.

(b) What is cavitation ? How does it affect the performance of hydraulic machines ? Also mention the significance of Thoma cavitation number. 12

(c) A well is pumping near a barrier boundary at a rate of 0·04 m^3/s from a confined aquifer 20 m thick. The hydraulic conductivity of the aquifer is $3{\cdot}5 \times 10^{-4}$ m/s and its storativity is 3×10^{-5}. Determine the drawdown in the observation well after 15 hours of continuous pumping. What is the fraction of the drawdown attributable to the impermeable barrier boundary ? 12

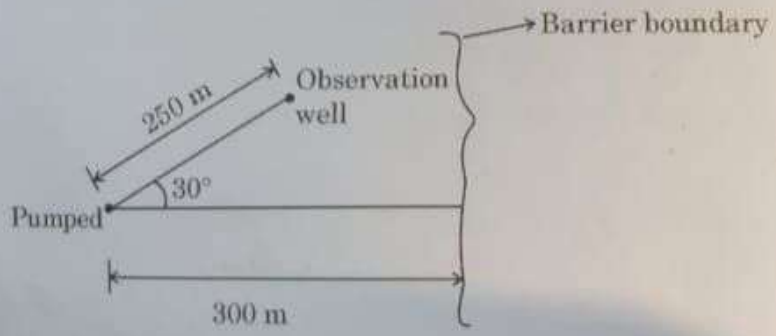


Table : Values of W(u) for Various Values of u

u	1·0	2·0	3·0	4·0	5·0	6·0	7·0	8·0	9·0
$\times 1$	0·219	0·049	0·013	0·0038	0·0011	0·00036	0·00012	0·000038	0·000012
$\times 10^{-1}$	1·82	1·22	0·91	0·70	0·56	0·45	0·37	0·31	0·26
$\times 10^{-2}$	4·04	3·35	2·96	2·68	2·47	2·30	2·15	2·03	1·92
$\times 10^{-3}$	6·33	5·64	5·23	4·95	4·73	4·54	4·39	4·26	4·14
$\times 10^{-4}$	8·63	7·94	7·53	7·25	7·02	6·84	6·69	6·55	6·44
$\times 10^{-5}$	10·94	10·24	9·84	9·55	9·33	9·14	8·99	8·86	8·74
$\times 10^{-6}$	13·24	12·55	12·14	11·85	11·63	11·45	11·29	11·16	11·04
$\times 10^{-7}$	15·54	14·85	14·44	14·15	13·93	13·75	13·60	13·46	13·34
$\times 10^{-8}$	17·84	17·15	16·74	16·46	16·23	16·05	15·90	15·76	15·65
$\times 10^{-9}$	20·15	19·45	19·05	18·76	18·54	18·35	18·20	18·07	17·95
$\times 10^{-10}$	22·45	21·76	21·35	21·06	20·84	20·66	20·50	20·37	20·25
$\times 10^{-11}$	24·75	24·06	23·65	23·36	23·14	22·96	22·81	22·67	22·55
$\times 10^{-12}$	27·05	26·36	25·96	25·67	25·44	25·26	25·11	24·97	24·86
$\times 10^{-13}$	29·36	28·66	28·26	27·97	27·75	27·56	27·41	27·28	27·16
$\times 10^{-14}$	31·66	30·97	30·56	30·27	30·05	29·87	29·71	29·58	29·46
$\times 10^{-15}$	33·96	33·27	32·86	32·58	32·35	32·17	32·02	31·88	31·76

(d) What do you mean by Environmental Lapse Rate (ELR) and Adiabatic Lapse Rate (ALR) ? How and in what manner do the environmental lapse rate and adiabatic lapse rate affect the dispersion of an air pollutant into the atmosphere ? Explain clearly. *12*

(e) A community of 50,000 people uses a 12 ha landfill site that can be filled to an average depth of 20 m. If the municipal solid waste is generated at the rate of 25 N per person per day, and its compacted unit weight in the fill is 8 kN/m^3 and the municipal solid waste to cover ratio is 4 : 1, what is the anticipated useful life of the landfill site ? *12*

Q2. (a) A centrifugal pump having outer diameter equal to two times the inner diameter and running at 1200 rpm, works against a total head of 75 m. The velocity of flow through the impeller is constant and equal to 3·0 m/s. The vanes are set back at an angle of 30° at the outlet. If the outlet diameter of the impeller is 600 mm and width at the outlet is 50 mm, determine the following :

(i) Vane angle at the inlet

(ii) Work done per second by the impeller

(iii) Manometric efficiency

(iv) Loss of head at inlet to impeller when the discharge is reduced by 40% with changing the speed

(b) A gravity dam is 18 m high, in triangular shape. The specific gravity of the dam material is 2·25. Find the minimum safe width of the dam. Use uplift factor K as 0·45. Also calculate the principal and shear stress at the toe of the dam. Consider safety against sliding when the reservoir is full. 20

(c) A wastewater treatment plant produces 900 kg of dry solids per day at a moisture content of 96 percent. The solids are 70 percent volatile with a specific gravity of 1·0 and 30 percent non-volatile with a specific gravity of 2·5. What would be the sludge volume under the following conditions :

(i) After digestion process, which reduces volatile solids content by 50 percent and decreases the moisture content to 91 percent.

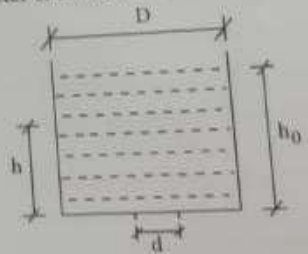
(ii) After dewatering process to 72 percent moisture. 20

Q3. (a) Design a sewer to serve a population of 50,000 with per capita water supply of 150 litres per day. Assume that the sewer should run 0·7 times full at the maximum discharge. The slope available for the sewer to be laid is 1 in 500 and the sewer should be designed with a peaking factor of 3·0. Assume Manning's rugosity coefficient value (N) = 0·012. Also perform check for self-cleansing velocity. The following table may be used if required : 25

Proportionate depth	Proportionate velocity	Proportionate discharge
0·20	0·615	0·088
0·30	0·776	0·196

(b) An open tank of diameter D containing water to depth h_0 is emptied by a smooth orifice at the bottom. Derive an expression for the time taken to reduce the height to h.

Also deduce the expression for time if d << D. Then estimate the time if D is 0·5 m, diameter of orifice is 0·025 m with water level as 0·5 m. 20



(Orifice)

(c) State Buckingham's π-theorem. Write the procedure for selecting the repeating variables. 15

(a) A rectangular channel of 5 m width discharges water at 2 m^3/s into a 5 m wide apron with 1/3500 slope at a velocity of 6 m/s. Determine the height of hydraulic jump and energy loss.

(b) A 20 cm diameter well fully penetrates a confined aquifer of thickness 35 m when the well is pumped at a rate of 200 litres/minute. The steady state drawdown in two observation wells located at 10 m and 100 m distance from the pumping well are found to be 3·5 m and 0·05 m, respectively. Calculate the permeability and transmissivity of the aquifer.

(c) A drinking water treatment plant has a circular sedimentation basin to treat 13 million litres of river water per day. After storms occur upstream, the river often carries 0·010 mm silt particles with an average density of 2300 kg/m^3, and the silt must be removed before the water can be used. The sedimentation basin is 3·5 m deep and 21·0 m in diameter. The water is at 15°C. Answer the following :

(i) What is the hydraulic detention time of the basin ?

(ii) Will the sedimentation basin (clarifier) remove all of the silt particles from the river water ? Justify your answer with appropriate calculations.

(Take density of water (ρ) = 999·1 kg/m^3 and viscosity of water (μ) = 0·00114 kg/m.s at 15°C)

(d) Explain the Hardy Cross method used for pipe network analysis in the water distribution system. Also derive the expression to apply correction to assumed flow successively for each pipe loop in the network.

$h_L = kQ^n$

$\frac{dh_L}{dQ} = nkQ^{n-1} \Rightarrow \frac{\Delta h}{nkQ^{n-1}} = \Delta Q$

SECTION B

Q5. (a) The following two sizes of sampling tubes are available in the market :

Parameters	Sampling Tube 1	Sampling Tube 2
Outer Dia (mm)	75	50
Inner Dia (mm)	72	35
Length (mm)	600	600

To obtain undisturbed soil sample from borehole, which sampling tube needs to be selected and why ? 12

(b) An infinite dry sandy slope is just stable at a slope angle of 35°. Unit weight of sand = 20 kN/m^3. In monsoon, water starts flowing through the sand down the slope. At what inclination of slope will it be stable in such condition ? 12

(c) What do you mean by spot speed, running speed, space-mean speed and time-mean speed ? Explain them with appropriate examples. Also discuss the main purposes of spot speed studies. 12

(d) What is meant by crossing ? What are the essential requirements of a good crossing ? Discuss various types of crossings in use in Indian Railways. 12

(e) The top point P of a tower having reduced level of 200 m was sighted using the theodolite from two stations A and B which were 100 m apart and were on the same side of the tower. All the three points A, B and P were in the same plane. The angles of elevation of point P from instrument stations A and B were 10°30′ and 16°20′ respectively. The horizontal axis of instrument at point A was 2·5 m below the horizontal axis of instrument at point B and 1·5 m above the base of the tower. Calculate the

(i) horizontal distance between point A and the top of the tower.

(ii) height of the tower.

(iii) reduced level of station A, if the height of instrument at A was 1·5 m. 12

(c) Dust, gravel and intact pieces of rock are produced during rock coring with core advance of 2 m. The lengths of the rock pieces are 150 mm, 200 mm, 80 mm, 300 mm, 60 mm, 250 mm, 120 mm, 170 mm, 80 mm, 210 mm and 75 mm.

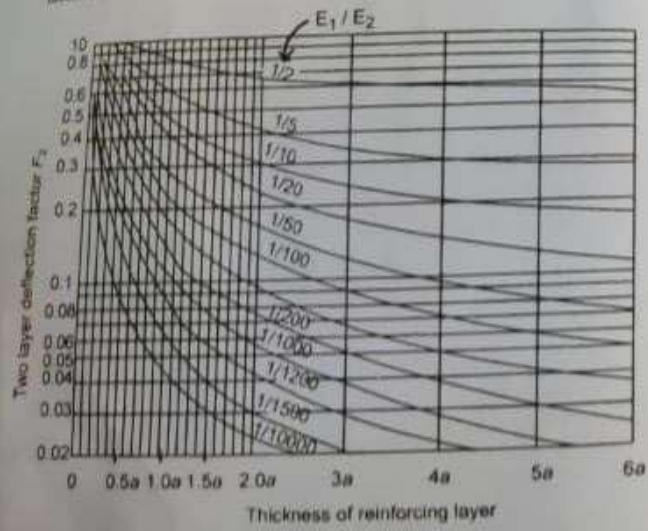
Calculate RQD and comment on the rock quality based on RQD. 8

(b) A 5 m high rigid vertical retaining wall has to retain a dry backfill of cohesionless sand with the following properties :

Void ratio (e) = 0·74, specific gravity of soil (G) = 2·68, Poisson's ratio of soil (μ) = 0·4.

The wall needs to be designed for no lateral movement condition of earth pressure. In monsoon, the dry backfill becomes fully submerged with water table at the top of the backfill surface. Estimate the percentage change in the total lateral thrust acting on the wall during monsoon. 12

(c) Plate bearing tests were conducted with 30 cm diameter plate on soil subgrade and over 15 cm base course. The pressure yielded at 0·25 cm deflection is 1·25 kg/cm^2 and 5 kg/cm^2 for subgrade and base course respectively. Design the thickness of flexible pavement for a wheel load of 4080 kg with tyre pressure of 4·5 kg/cm^2. Take rigidity factor 1·11. 20



(d) (i) Briefly explain the working principle of Global Positioning System (GPS). Write any three advantages and any three limitations of GPS in surveying. 10

(ii) A city of site 25 km × 50 km is to be surveyed for aerial photogrammetry using camera having focal length of 150 mm mounted on an airplane flying at the height of 1500 m above the ground level. The longitudinal and side lap will be 80% and 30% respectively. The size of the photograph will be 250 mm × 250 mm. It is planned to set the exposure interval of camera at 10 seconds. 10

Calculate the following :

(I) The number of photographs required to cover the area.

(II) The flying speed of the airplane.

(III) The total time required to capture the photographs.

Q7. (a) A 400 m radius curve is introduced between straight portions of a Broad Gauge (BG) railway line intersecting to form a deflection angle of 50 degrees. The speed for determining the equilibrium cant is fixed at 100 kmph and the maximum sectional speed is 120 kmph. Determine the equilibrium cant, the maximum permisaible speed (considering the cant deficiency, cant excess) and desirable length of transition curve. The maximum permissible cant and cant deficiency are 165 mm and 100 mm respectively. Cant excess is restricted to 75 mm. The lowest speed of any train can be taken as 50 kmph. 20

(b) A pile group with 12 piles, each having a diameter of 0·5 m and 30 m long, supports a raft foundation. The piles are arranged in 3 rows and spaced at 1·25 m c/c. The properties of the foundation soil are as follows :

$\gamma' = 11$ kN/m^3, $C_u = 40$ kN/m^2, $\phi = 0°$

Take $\alpha = 0{\cdot}85$ and F.S. = 2·5. 20

Determine the capacity of the pile group.

(c) An oedometer test on a 2 cm thick clay sample took 15 minutes time to attain 50% consolidation under a loading with double drainage condition. How many days will it take in the field to achieve the same degree of consolidation for the same clay soil 4 m thick ? Consider similar loading and drainage conditions for laboratory and field. 10

(d) List and briefly discuss the geological factors affecting the construction of high speed rail project. 10

Q5. (a) Two different contractors carried out plate load test at the same site location as per IS code. Details are as follows :

Parameters	Contractor 1	Contractor 2
Size of plate	45 cm × 45 cm	75 cm × 75 cm
Load	100 kN	175 kN
Settlement at above load	10 mm	10 mm

Estimate the maximum load which a footing of size 3 m × 3 m can carry at the settlement of 10 mm at the same site location. Consider the depths of both tests and that of proposed footing are same. 10

(b) A twenty-storeyed building carries a load of 10 kN/m^2 at each floor level. A fully compensated (buoyant) raft foundation is proposed for such building at a soft clay soil site with unit weight of clay as 15 kN/m^3. Find the depth at which the raft foundation needs to be placed. 10

(c) (i) What are the different types of resolutions in Remote Sensing ? Briefly explain the significance of each resolution in the field of Civil Engineering. 10

(ii) Two points A and B were selected 80 m apart from each other for testing permanent adjustment of a dumpy level using two peg test. Following staff readings were observed at both the points while keeping dumpy level at two different locations :

Instrument Location	Staff Reading (in m)	
	A	B
Midway between A and B	1·430	1·780
At P (10 m from A and 70 m from B)	1·500	1·950

Calculate the following : 10

(I) Level difference between point A and point B

(II) Inclination of line of sight, if any

(III) Corrected staff readings at point A and point B when dumpy level was set at P and having no error in its permanent adjustment

(d) The design speed of a highway is 80 km/h. There is a horizontal curve of radius 200 m in a certain locality. What should be the superelevation required to maintain this design speed ? If the maximum superelevation of 0·07 is not to be exceeded, what should be the maximum allowable speed on this curve ? Also determine the extra widening required and length of transition curve using the following data : 20

Length of wheel base of the largest vehicle = 6·1 m

Pavement width = 7·2 m

Number of lanes = 2

Rate of introduction of superelevation = 1 in 200

Type of terrain = Plain

Safe limit of coefficient of friction = 0·15