Q. 1 – Q. 25carries one mark each.

Q.1 There is no value of x that can simultaneously satisfy both the given equations.Therefore, find the 'least squares error' solution to the two equations, i.e., find the value of x that minimizes the sum of squares of the errors in the two equations. _____

$$2x = 3$$
$$4x = 1$$

Q.2 What is the minimum number of multiplications involved in computing the matrix product PQR? Matrix$P$ has 4 rows and 2 columns, matrix Qhas 2 rows and 4 columns, and matrix$R$has 4 rows and 1 column. _____

Q.3 A 1-h rainfall of 10 cm magnitude at a station has a return period of 50 years. The probability that a 1-h rainfall of magnitude 10 cm or more will occur in each oftwo successive years is:

(A) 0.04 (B) 0.2 (C)0.02 (D) 0.0004

Q.4 Maximum possible value of Compacting Factor for fresh (green) concrete is:

(A) 0.5 (B) 1.0 (C) 1.5 (D) 2.0

Q.5 As per IS 800:2007, the cross-section in which the extreme fiber can reach the yield stress, but cannot develop the plastic moment of resistance due to failure by local buckling is classified as

(A) plastic section
(B) compact section
(C) semi-compact section
(D) slender section

Q.6 The creep strains are

(A) caused due to dead loads only
(B) caused due to live loads only
(C) caused due to cyclic loads only
(D) independent of loads

Q.7 As per IS 456:2000 for M20 grade concrete and plain barsin tension the design bond stress $\tau_{bd} = 1.2\ MPa$.Further, IS 456:2000 permits this design bond stress value to be increased by 60 % for HSD bars. The stress in theHSDreinforcing steel barsin tension,$\sigma_s = 360MPa$. Find the required development length,L_d, for HSD barsin terms of the bar diameter, ϕ. _____

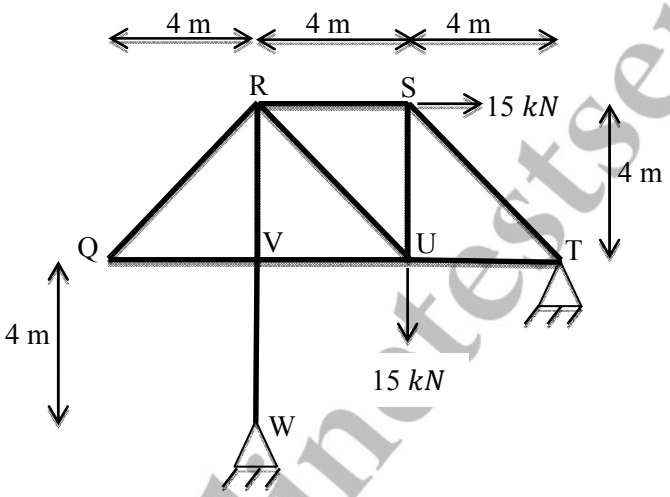
Q.8 The 'plane section remains plane' assumption in bending theory implies:

(A) strain profile is linear
(B) stress profile is linear
(C) both strain and stress profiles are linear
(D)shear deformations are neglected

Q.9 Two steel columns P (length L and yield strength$f_y = 250\,MPa$) and Q (length $2L$ and yield strength$f_y = 500\,MPa$) have the same cross-sections and end-conditions. The ratio of buckling load of column P to that of column Q is:

(A) 0.5 (B) 1.0 (C) 2.0 (D) 4.0

Q.10 The pin-jointed 2-D truss is loaded with a horizontal force of 15 kN at joint S and another 15 kN vertical force at joint U, as shown.Find the force in member RS (in kN) and report your answer taking tension as positive and compression as negative. _____



Q.11 A symmetric I-section (with width of each flange $= 50\,mm$, thickness of each flange $= 10\,mm$, depth of web = 100 mm, and thickness of web $= 10\,mm$) of steel is subjected to a shear force of 100 kN. Find the magnitude of the shear stress(in N/mm^2) in the web at its junction with the top flange. _____

Q.12 In its natural condition, a soil sample has a mass of 1.980 kg and a volume of0.001 m^3. After being completely dried in an oven, the mass of the sample is 1.800 kg.Specific gravity $G$is 2.7. Unit weight of water is 10 kN/m^3. The degree of saturation of the soil is:

(A) 0.65 (B) 0.70 (C) 0.54 (D) 0.61

Q.13 The ratio N_f/N_d is known as shape factor, where N_f is the number of flow lines and N_d is the number of equipotential drops. Flow net is always drawn with a constant b/a ratio, where b and a are distances between two consecutive flow lines and equipotential lines, respectively. Assuming that b/a ratio remains the same, the shape factor of aflow net will change if the

(A) upstream and downstream heads are interchanged
(B) soil in the flow space is changed
(C) dimensions of the flow space are changed
(D) head difference causing the flow is changed

Q.14 Following statementsare made on compacted soils, wherein DS stands forthe soils compacted on dry side of optimum moisture content and WS stands for thesoils compacted on wet side of optimum moisture content. Identify the *incorrect* statement.

(A) Soil structure is flocculated onDS and dispersed on WS.
(B) Construction pore water pressure is low on DS and high on WS.
(C)On drying, shrinkage is high on DS and low on WS.
(D)On access to water, swelling is high on DS and low on WS.

Q.15 Four columns of a building are to be located within a plot size of 10 m x 10 m. The expected load on each column is 4000 kN. Allowable bearing capacity of the soil deposit is 100 kN/m^2. The type of foundation best suited is

(A) isolated footing
(B) raft foundation
(C) pile foundation
(D)combined footing

Q.16 For subcritical flow in an open channel, the control section for gradually varied flow profiles is

(A) at the downstream end
(B) at the upstream end
(C) at both upstream and downstream ends
(D) at any intermediate section

Q.17 Group-I contains dimensionless parameters and Group- II contains the ratios.

Group-I	Group -II
P. Mach Number	1. Ratio of inertial force and gravitational force
Q. Reynolds Number	2. Ratio of fluid velocity and velocity of sound
R. Weber Number	3. Ratio of inertial force and viscous force
S. Froude Number	4. Ratio of inertial force and surface tension force

The correct match of dimensionless parameters in Group- I with ratios in Group-II is:

(A) P-3, Q-2, R-4, S-1
(B) P-3, Q-4, R-2, S-1
(C) P-2, Q-3, R-4, S-1
(D) P-1, Q-3, R-2, S-4

Q.18 For a two dimensional flow field, the stream function ψ is given as $\psi = \frac{3}{2}\left(y^2 - x^2\right)$. The magnitude of discharge occurring between the stream lines passing through points (0,3) and (3,4) is:

(A) 6 (B) 3 (C) 1.5 (D) 2

Q.19 An isohyet is a line joining points of

(A) equal temperature
(B) equal humidity
(C) equal rainfall depth
(D) equal evaporation

Q.20 Some of the water quality parameters are measured by titrating a water sample with a titrant. Group-I gives a list of parameters and Group-IIgives the list of titrants.

Group-I	Group-II
P.Alkalinity	1. N/35.5 $AgNO_3$
Q. Hardness	2. N/40 $Na_2S_2O_3$
R. Chloride	3. N/50 H_2SO_4
S. Dissolved oxygen	4. N/50 EDTA

The correct match of water quality parameters in Group-I with titrants in Group-II is:

(A) P-1, Q-2, R-3, S-4
(B)P-3, Q-4, R-1, S-2
(C)P-2, Q-1, R-4, S-3
(D) P-4, Q-3, R-2, S-1

Q.21 A water treatment plant is designed to treat 1 m^3/s of raw water. It has 14 sand filters. Surface area of each filter is 50 m^2. What is the loading rate (in $\frac{m^3}{day \cdot m^2}$) with two filters out of service for routine backwashing? _____

Q.22 Selectthe strength parameter of concrete usedindesign of plain jointed cement concrete pavements from the following choices:

(A) Tensile strength
(B) Compressive strength
(C) Flexural strength
(D) Shear strength

Q.23 It was observed that 150 vehicles crossed a particular location of a highway ina duration of 30 minutes. Assuming that vehicle arrival follows a negative exponential distribution, find out the number of time headways greater than 5 seconds in the above observation? _____

Q.24 For two major roads with divided carriageway crossing at right angle,a full clover leaf interchange with four indirect ramps is provided. Following statements are made on turning movements of vehiclesto all directions from both roads. Identify the *correct* statement:

(A) Merging from left is possible,butdiverging to left is notpossible.
(B) Both merging from left and diverging to left arepossible.
(C) Merging from left is not possible,butdiverging to left is possible.
(D) Neithermergingfrom left nordivergingto leftispossible.

Q.25 The latitude and departure of a line AB are +78 m and -45.1 m, respectively. The whole circle bearing of the line AB is:

(A) 30° (B) 150° (C) 210° (D) 330°

Q. 26 to Q. 55 carry two marks each.

Q.26 The state of 2D-stress at a point is given by the following matrix of stresses:

$$\begin{bmatrix}\sigma_{xx} & \sigma_{xy}\\ \sigma_{xy} & \sigma_{yy}\end{bmatrix} = \begin{bmatrix}100 & 30\\ 30 & 20\end{bmatrix} MPa$$

What is the magnitude of maximum shear stressin MPa?

(A) 50 (B) 75 (C) 100 (D) 110

Q.27 Find the magnitude of the error (correct to two decimal places) in the estimation of following integral using Simpson's $\frac{1}{3}$ Rule. Take the step length as 1. _____

$$\int_0^4 \left(x^4 + 10\right) dx$$

Q.28 The solution for $\int_0^{\pi/6} \cos^4 3\theta \sin^3 6\theta \, d\theta$ is:

(A) 0 (B) $\frac{1}{15}$ (C) 1 (D) $\frac{8}{3}$

Q.29 Find the value of λ such that the function $f(x)$ is a valid probability density function. _____

$$f(x) = \lambda(x-1)(2-x) \quad for\ 1 \le x \le 2$$
$$= 0 \quad otherwise$$

Q.30 Laplace equation for water flow in soils is given below.

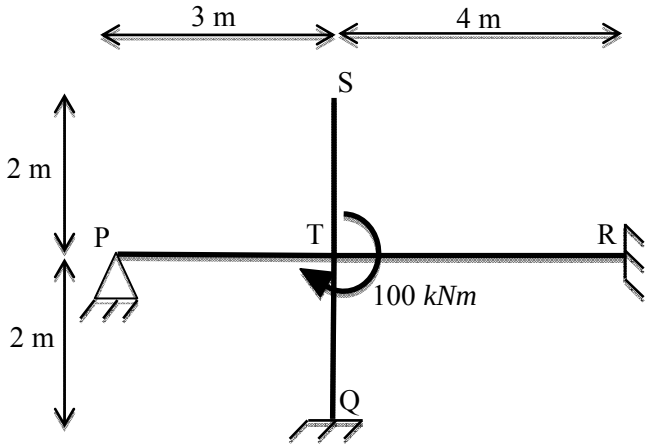
$$\frac{\partial^2 H}{\partial x^2} + \frac{\partial^2 H}{\partial y^2} + \frac{\partial^2 H}{\partial z^2} = 0$$

Head H does not vary in y and z directions.

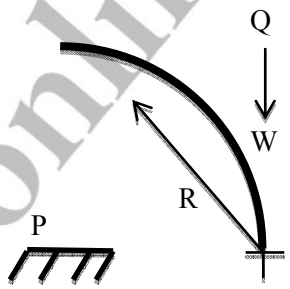
Boundary conditions are: at $x = 0$, $H = 5$;and $\frac{dH}{dx} = -1$.

What is the value of H at $x = 1.2$? _____

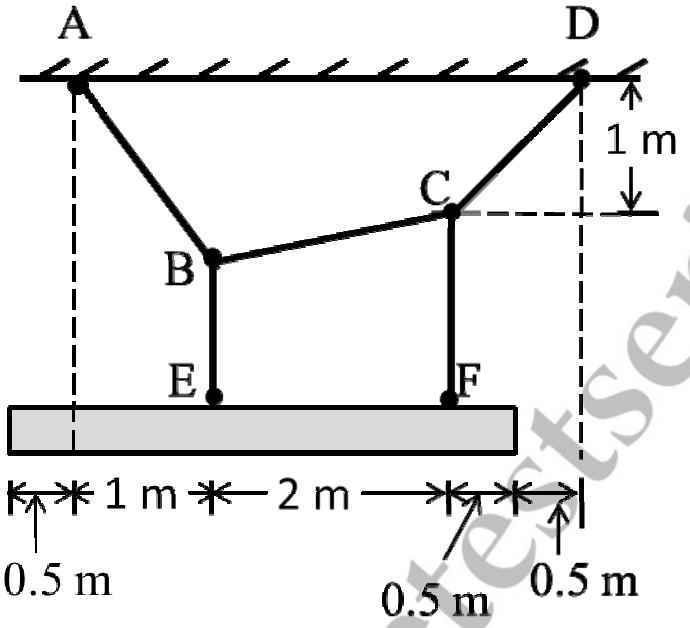
Q.31 All members in the rigid-jointed frame shown are prismatic and have the same flexural stiffnessEI. Find the magnitude of the bending moment at Q (in kNm) due to the given loading. _____



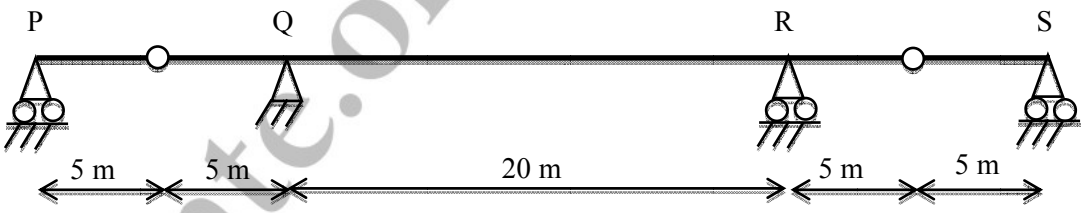
Q.32 A uniform beam $(EI = constant)PQ$ in the form of a quarter-circle of radius R is fixed at end P and free at the end Q, where a load W is applied as shown. The vertical downward displacement, δ_q, at the loaded point Q is given by: $\delta_q = \beta\left(\frac{WR^3}{EI}\right)$. Find the value of β(correct to 4-decimal places). _____



Q.33 A uniform beam weighing 1800 N is supported at E and F by cable ABCD. Determine the tension (in N) in segment AB of this cable (correct to 1-decimal place). Assume the cables ABCD, BE and CF to be weightless. _____



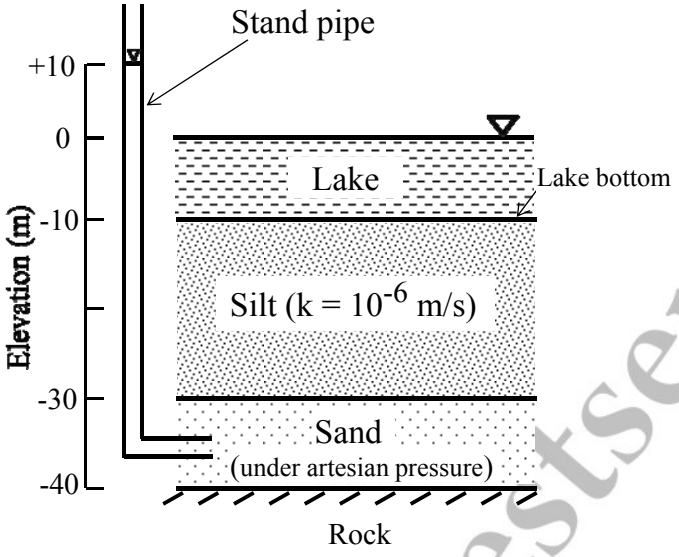
Q.34 Beam $PQRS$has internal hinges in spans PQ and RS as shown. The beammay be subjected to a moving distributed vertical load of maximum intensity 4 kN/m of any length anywhere on the beam. The maximum absolute value of the shear force (in kN) that can occur due to this loading just to the right of support Q shall be:



(A) 30 (B) 40 (C) 45 (D) 55

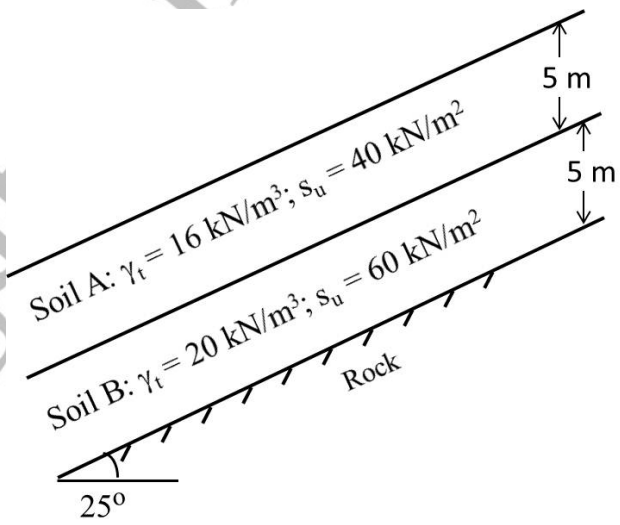
Q.35 A rectangular concrete beam 250 mm wide and 600 mm deep is pre-stressed by means of 16 high tensile wires, each of 7 mm diameter, located at200 mm from the bottom face of the beamat a given section. If the effective pre-stress in the wires is700 MPa, what is the maximum sagging bending moment (in kNm) (correct to 1-decimal place) due to live loadthat this sectionof the beam can withstand without causing tensile stress at the bottom face of the beam? Neglect the effect of dead load of beam. _____

Q.36 The soil profile below a lake with water level as elevation = 0 m and lake bottom at elevation = −10 m is shown in the figure, where k is the permeability coefficient. A piezometer (stand pipe) installed in the sand layer shows a reading of +10 m elevation. Assume that thepiezometric headis uniform in the sand layer. The quantity of water (in m^3/s) flowing into the lake from the sand layer through the silt layer per unit area of the lake bed is:



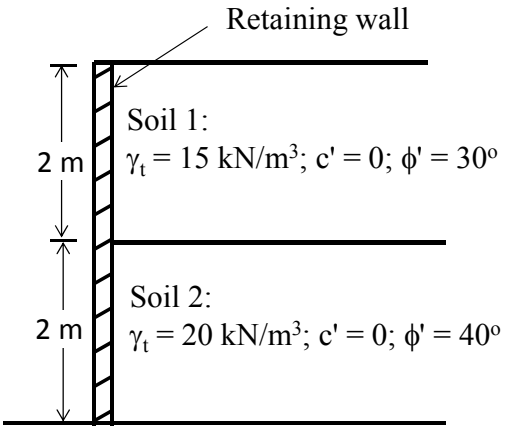
(A) 1.5×10^{-6}
(B) 2.0×10^{-6}
(C) 1.0×10^{-6}
(D) 0.5×10^{-6}

Q.37 The soil profile above the rock surface for a 25° infinite slope is shown in the figure, where s_u is the undrained shear strength and γ_t is total unit weight. The slip will occur at a depth of



(A) 8.83 m
(B) 9.79 m
(C) 7.83 m
(D) 6.53 m

Q.38 Two different soil types (Soil 1 and Soil 2) are used as backfill behind a retaining wall as shown in the figure, where γ_t is total unit weight, and c' and ϕ' are effective cohesion and effective angle of shearing resistance. The resultant active earth forceper unit length (in kN/m) acting on the wall is:



(A) 31.7 (B) 35.2 (C) 51.8 (D) 57.0

Q.39 A 2 km long pipe of 0.2 m diameter connects two reservoirs. The difference between water levels in the reservoirs is 8 m. The Darcy-Weisbachfriction factor of the pipe is 0.04. Accounting for frictional, entry and exit losses, the velocity in the pipe (in m/s) is:

(A) 0.63 (B)0.35 (C) 2.52 (D) 1.25

Q.40 The normal depth in a wide rectangular channel is increased by 10%. The percentage increase in the discharge in the channel is:

(A) 20.1 (B) 15.4 (C) 10.5 (D) 17.2

Q.41 The transplantation of rice requires 10 days and total depth of water required during transplantation is 48 cm. During transplantation, there is an effective rainfall (useful for irrigation) of 8 cm. The duty of irrigation water (in hectares/cumec) is:

(A) 612 (B) 216 (C)300 (D) 108

Q.42 A settling tank in a water treatment plant is designed for a surface overflow rate of30 $\frac{m^3}{day \cdot m^2}$. Assumespecific gravity of sedimentparticles = 2.65, density of water (ρ) = 1000 kg/m^3, dynamic viscosity of water (μ)=0.001 N.s/m^2,and *Stokes' law*isvalid.The approximate minimum size of particles that would be completely removed is:

(A) 0.01mm (B) 0.02 mm(C) 0.03 mm(D) 0.04 mm

Q.43 A student began experiment for determination of 5-day, 20°C BOD on Monday. Since the 5thday fell on Saturday, the final DO readings were taken on next Monday. On calculation, BOD (i.e. 7 day, 20°C) was found to be 150 mg/L. What would be the5-day, 20°C BOD (in mg/L)? Assume value of BOD rate constant (k) at standard temperature of 20°C as 0.23/day (base *e*). _____