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Syllabus

ENGINEERING MATHEMATICS

Linear Algebra: Matrix algebra, Systems of linear equations, Eigen values and eigenvectors.

Calculus: Functions of single variable, Limit, continuity and differentiability, Mean value theorems, Evaluation of definite and improper integrals, Partial derivatives, Total derivative, Maxima and minima, Gradient, Divergence and Curl, Vector identities, Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

Differential equations: First order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Cauchy's and Euler's equations, Initial and boundary value problems, Laplace transforms, Solutions of one dimensional heat and wave equations and Laplace equation.

Complex variables: Analytic functions, Cauchy's integral theorem, Taylor and Laurent series. Probability and Statistics: Definitions of probability and sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Poisson, Normal and Binomial distributions.

Numerical Methods: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpson's rule, single and multi-step methods for differential equations.

STRUCTURAL ENGINEERING

Mechanics: Bending moment and shear force in statically determinate beams. Simple stress and strain relationship. Stress and strain in two dimensions, principal stresses, stress transformation, Mohr's circle. Simple bending theory, flexural and shear stresses, unsymmetrical bending, shear centre. Thin walled pressure vessels, uniform torsion, buckling of column, combined and direct bending stresses.

Structural Analysis: Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures and analysis of statically indeterminate structures by force/ energy methods, analysis by displacement methods (slope deflection and moment distribution methods), influence lines for determinate and indeterminate structures. Basic concepts of matrix methods of structural analysis.

Concrete Structures: Concrete Technology- properties of concrete, basics of mix design. Concrete design- basic working stress and limit state design concepts, analysis of ultimate load capacity and design of members subjected to flexure, shear, compression and torsion by limit state methods. Basic elements of prestressed concrete, analysis of beam sections at transfer and service loads.

Subject wise Weightage for Scientist 'SC'

SL No.	Subject	Year of examination							
		2013	2014	2015	2015	2018	2019	2020	2024
1	Strength of Materials	36	21	12	21	18	24	27	2
2	Engineering Mechanics	15	3	18	12	24	9	6	-
3	Fluid Mechanics	36	24	21	27	18	21	12	4
4	Structural Analysis	12	3	18	-	-	-	6	1
5	Reinforced Cement Concrete	30	39	6	27	18	18	36	22
6	Surveying	12	12	18	18	24	27	18	8
7	Prestressed Concrete	3	6	3	-	-	-	-	-
8	Construction Management	-	-	3	6	-	3	6	1
9	Building Materials	15	12	12	15	12	18	3	1
10	Concrete Technology	6	15	12	15	12	12	21	-
11	Hydrology and Imigation	3	12	18	6	6	12	9	4
12	Environmental Engineering	6	12	12	15	15	15	12	7
13	Transportation Engineering	12	18	9	6	6	6	9	8
14	Soil Mechanics and Foundation Engineering	24	30	27	24	30	27	21	12
15	Steel Structures	-	3	12	12	9	12	24	1
16	Engineeing Mathematics	30	30	30	30	30	30	30	30
17	Ralway Engineering	-	-	3	6	3	6	-	-
18	Estimation	-	-	-	-	-	-	-	2
	Total	**240**	**240**	**240**	**240**	**240**	**240**	**240**	**240**

Previous Year Cut Off for Interview

Sl.No.	Year	Categary	Cut off
1	2013	General (UR)	155
2		OBC	145
3		SC	131
1	2014	General (UR)	161
2		OBC	121
3		SC	107
1	2015	General (UR)	173
2		OBC	157
3		SC	136
4		ST	123
5		PWD	103
1	2017	General (UR)	192
2		OBC	184
3		SC	172
4		ST	158
1	2018	General (UR)	194
2		OBC	182
3		SC	173
4		ST	152
1	2019	General (UR)	190
2		OBC	187
3		SC	170
4		ST	164
1	2020	General (UR)	197
2		OBC	185
3		EWS	188

1. A cohesive soil yields a maximum dry density of 18kN/m^3 during a standard proctor compaction test. If the specific gravity is 2.65, what would be its void ratio? (Adopt unit weight of water as 10kN/m^3)

(a) 0.5523 (b) 0.4722

(c) 0.7121 (d) 0.5835

2. A footing 2m x 1m exerts a uniform pressure of 150kN/m^2 on the soil. Assuming a load dispersion of 2 vertical to 1 horizontal, the average vertical stress in (kN/m^2) at 1.0m below the footing is

(a) 50 (b) 75

(c) 80 (d) 100

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

List - I	List - II
A. Axel Bendixen	1. The mathematical theory of elasticity
B. Hardy Cross	2. Theory of curved bars
C. Winkler	3. Slope-deflection method
D. St. Venant	4. Moment distribution

(a) A B C D
1 2 3 4

(b) A B C D
3 4 2 1

(c) A B C D
1 2 4 3

(d) A B C D
3 2 4 1

4. The standard size of brick is

(a) 20cm x 10cm x 10cm (b) 19cm x 9cm x 9cm

(c) 18cm x 9cm x 9cm (d) 18cm x 10cm x 10cm

5. The velocity of flow of water in a pipe of 150 mm dia is 0.3m/sec, a diaphragm with a central hole 80mm in diameter is placed in the pipe obstructing the flow. With coefficient of contraction C_c=0.60, the loss of head from Vena Contracta to a point downstream will be

(a) 0.1083m (b) 0.2250m

(c) 1.2054m (d) 0.8250m

6. If the depletion of oxygen is found to be 5 ppm after incubating a 2.5% solution of sewage sample for 5 days at 20^0 C, B.O.D of the sewage is

(a) 50 ppm (b) 100 ppm

(c) 150 ppm (d) 200 ppm

7. A trapezoidal section of an open channel has side slope 2H:1V. If bottom width is `b' and depth `d ', the relation between b & d for most economical trapezoidal section of the channel is:

(a) b = 0.472 d (b) b/d = 0.5

(c) $b^2 = 0.3\ d^2$ (d) $d = \sqrt{b}$

8. If the difference in elevation of an edge of the pavement 9m wide and its crown is 15 cm, the camber of the pavement is

(a) 1 in 60 (b) 1 in 45

(c) 1 in 30 (d) 1 in 15

9. The scour depth D of a river during flood, may be calculated from the Lacey's equation

(a) $D = 0.47 (Q/f)^{1/2}$ (b) $D = 0.47 (Q/f)$

(c) $D = 0.47 (Q/f)^{1/4}$ (d) $D = 0.47 (Q/f)^{1/3}$

10. The Glycerine is flowing at 25^0C in a pipe of diameter150 mm with a velocity of 3.6m/s. The flow is

(a) Laminar (b) Turbulent

(c) Critical (d) Rectilinear

11. A concrete column 200 x 200 mm^2 in cross bars of 1200 mm^2, total cross the column if permissible stress in concrete is 5 N/mm^2

(a) 264 kN (b) 274 kN

(c) 284 kN (d) 294 kN

12. For design of Flexure members, the strain in the reinforcing bars under tension at ultimate state as per IS 456

(a) $f_y/1.15E$ (b) $f_y /1.15 E_s +0.002$

(c) f_y/E_s (d) $f_y / E_s +0.002$

13. A soil has liquid limit of 35, plastic limit of 20 and moisture content 25%. What will be its liquidity index and plasticity index

(a) 0.67, 15 (b) 0.33, 15

(c) 0.67, 25 (d) 0.33, 20

14. If the moment of inertia of a section about its axis is sectional area is A, its radius of gyration

(a) r = I/A (b) $r = \sqrt{I/A}$

(c) $r = 3\sqrt{I/A}$ (d) $r = \sqrt{A/I}$

15. A uniform cantilever beam has a span of 2m and carries a point load of 6kN at free end. The magnitude of moment to be applied at free end for zero vertical deflection at that point is neglect self

(a) 5 kN.m (b) 10 kN.m

(c) 11 kN.m (d) 8 kN.m

16. A bar 40mm in diameter and subjected to a tensile force of 40,000 kgs. Undergoes elongation resulting in decrease in diameter considering the properties of the material as $E = 2x10^5$ and Poison's ratio μ as 0.3, the modulus of rigidity will be:

(a) 76923.07 N/mm^2 (b) $20x10^4$ kg/cm^2

(c) 56898.50 N/mm^2 (d) $3x10^5$ Kg/cm^2

17. If the volume of a liquid weighing 3000 kg is 4 cubic metres, 0.75 is its

(a)Specific weight (b)Specific mass

(c)Specific gravity (d)Specific volume

18. The height of water level in a tank above the centre of a circular hole 2.5 cm in diameter is 50m. The velocity of water flowing through the hole is (neglect friction between jet and wall)

(a) 20.53 m/sec (b) 25.85 m/sec

(c) 31.32 m/sec (d) 40.40 m/sec

19. A simply supported beam is considered as a deep beam if the ratio of effective span to overall depth is less than

(a) 1 (b) 2

(c) 3 (d) 4

20. In two dimensional stress system, the radius of the Mohr's circles represents

(a) Maximum normal stress (b) Minimum normal stress

(c) Minimum shear stress (d) Maximum shear stress

21. If 5x+3y+7z = 5, 3x+2by+2z = 9, 7x+2y+10z = 5, be a system of equations, then

(a) It has only trivial solution, x=0, y=0, z=0 (b) System is consistent and has infinite solution

(c) System is consistent and has unique solution (d) System is inconsistent

22. What is the angle between the tangents to the curve $x=t$, $y=t^2$, $z=t^3$ at $t= \pm 1$

(a) $\cos^{-1}(-3/7)$ (b) $\cos^{-1}(1/7)$

(c) $\cos^{-1}(3/7)$ (d) $\cos^{-1}(-1/7)$

23. What is the Laplace transform of $e^{-3t}(2\cos 5t - 3\sin 5t)$

(a) $2s + 9/ s^2 + 6s + 34$ (b) $3s - 9/ s^2 + 6s + 34$

(c) $2s - 9/ s^2 + 6s + 34$ (d) $S + 9/ s^2 + 6s + 34$

24. x is a uniformly distributed random variable that takes values between 0&1. The value of $E\{x^2\}$will be

(a) 0 (b) 1/8

(c) 1/4 (d) 1/2

25. The earth pressure of a soil at rest, is proportional to

(a) $\tan(45^0 - \phi)$ (b) $\tan(45^0 + \phi)$

(c) $(1 - \sin \phi)$ (d) $(1 + \sin \phi)$

26. The slope of the *e*-log *p* curve for a soil mass gives:

(a) Coefficient of permeability, *k* (b) Coefficient of consolidation C_v

(c) Compression index, C_c (d) Coefficient of volume compressibility, m_v

27. Stress produced in a bar by a suddenly applied load is the one produced by the same load when applied gradually. The value of `X' is

(a)Twice (b)Thrice

(c)Same as (d)Half of

ANSWER KEY - 2013

Q.No.	Answer	Q.No.	Answer	Q.No.	Answer	Q.No.	Answer
1	b	21	c	41	b	61	d
2	a	22	c	42	a	62	c
3	b	23	c	43	b	63	b
4	b	24	c	44	a	64	b
5	a	25	c	45	b	65	c
6	d	26	c	46	b	66	c
7	a	27	a	47	c	67	d
8	c	28	-	48	b	68	d
9	d	29	a	49	a	69	a
10	a	30	c	50	c	70	c
11	c	31	d	51	c	71	d
12	b	32	b	52	d	72	a
13	b	33	d	53	c	73	b
14	b	34	a	54	b	74	b
15	d	35	c	55	c	75	a
16	a	36	d	56	b	76	c
17	c	37	a	57	c	77	a
18	c	38	c	58	c	78	b
19	b	39	c	59	b	79	c
20	d	40	d	60	b	80	c

SOLUTIONS WITH EXPLANATION

1. Answer: **Option (b)**

$\gamma_d = (G \times \gamma_w) / (1 + e)$ — γ_d = Dry density

G = specific gravity — e = void ratio

$\gamma_d = (G \times \gamma_w) / (1 + e)$

$18 = (2.65 \times 10) / (1+e)$

$1+ e = 26.5/18$

$e = 1.472 – 1$

$e = 0.4722$

2. Answer: **Option (a)**

Given uniform pressure 150 kN/m^2 — Footing size = 2m x1m

Vertical load Q = 150 x 2 x 1 = 300 — Load dispersion = 2V: 1H

Dispersed area for 1m depth = 3m x 2m

The average vertical stresses = 300 / (3 x 2) = 50 kN/m^2

3. Answer: **Option (b)**

Axel Bendixen	Slope deflection method
Hardy Cross	Moment distribution method
Winkler bach theory	Theory of curved bars
Saint Venant	Mathematical theory of elasticity

4. Answer: **Option (b)**

Modular or Nominal Size of a brick: 20 x 10 x 10 cm

Standard Size of brick: 19 x 9 x 9 cm

5. Answer: **Option (a)**

Given pipe diameter D = 150 mm — Velocity of flow = 0.3 m/sec

Hole diameter d = 80mm — Coefficient of contraction C_c = 0.60

The loss of head from vena contracta is $H_L = [\frac{A}{aC_C} - 1]^2 [\frac{V^2}{2g}]$

$$H_L = [\frac{3.141 \ x \ 0.25 \ x \ 0.15 \ x \ 0.15}{0.60 \ x \ 3.141 \ x \ 0.25 \ x \ 0.08 \ x \ 0.08} - 1]^2 [\frac{0.3^2}{2 \ x \ 9.81}]$$

H_L = 0.1083m

6. Answer: **Option (d)**

Biochemical oxygen demand BOD = (Initial Dissolved oxygen – Final Dissolved oxygen) x Dilution Factor

Dilution Factor = Number of times sewage is diluted with distilled water.

For 2.5% solution Dilution Factor = 100/2.5 =40

Given depletion of oxygen after 5 days 5ppm i.e. Initial Dissolved oxygen – Final Dissolved oxygen = 5ppm

Hence, BOD = 40 x 5 = 200ppm.

7. Answer: **Option (a)**

Most economical or most efficient Section: When it pass a maximum discharge for given cross sectional area.

Most economical or most efficient Rectangular Section: occurs when wetted perimeter is minimum. Conditions are

$y = \frac{B}{2}$ and $R = \frac{y}{2}$

Most economical or most efficient Trapezoidal Section: occurs when wetted perimeter is minimum. Conditions are

$\frac{B+2zy}{2} = y\sqrt{1+z^2}$ and $R = \frac{y}{2}$ for design $\theta = 60°$ $Z = \frac{1}{\sqrt{3}}$ $A = \frac{y^2}{z}$

z = side slope. R = hydraulic radius

Most economical or most efficient Triangular Section: occurs when wetted perimeter is minimum. Conditions are

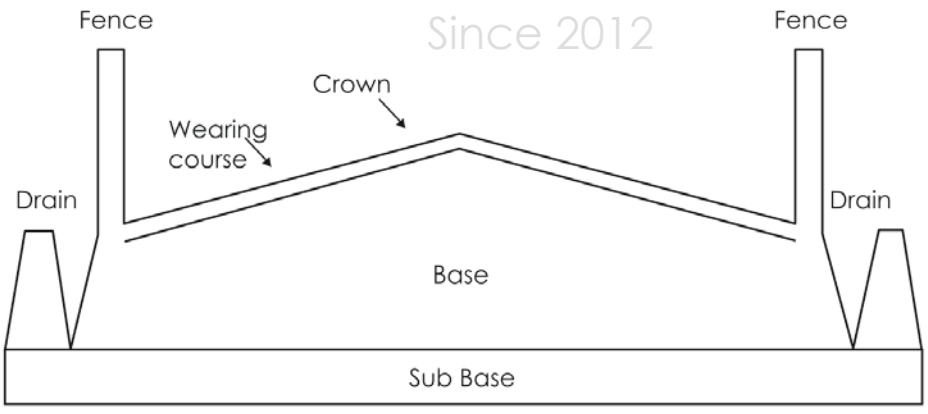
$\theta = 45°$ or $z = 1$ $R = \frac{y}{2\sqrt{2}}$

From the above for trapezoidal section $\frac{B+2zy}{2} = y\sqrt{1+z^2}$

z = 2, B=b and y= d substituting in above equations we get $\frac{b+4d}{2} = d\sqrt{1+4^2}$

From above we get b = 0.472 d

8. Answer: **Option (c)**



Camber of pavement = Crown / (width x 0.5) = 0.033

Camber of pavement = 1 in 30

SI.NO	Type of road service	Range of camber in areas of rainfall heavy	light
1	Cement concrete and high type bituminous surface	1 in 50 (2%)	1 in 60 (1.7%)
2	Thin bituminous surface	1 in 40 (2.5%)	1 in 50 (2.0%)
3	Wbm, gravel	1 in 33 (3%)	1 in 40 (2.5%)
4	Earth road	1 in 25 (4%)	1 in 33 (3%)

9. Answer: **Option (d)**

Lacey's regime equations:

- Silt factor f = $1.76\sqrt{d}$ where d mean size of particle in mm
- Velocity v = $(Qf^2/140)^{1/6}$
- Scour depth R = $1.35\ (q^2/f)^{1/3}$
- Longitudinal slope S = $f^{5/3}$ / $3340\ Q^{1/6}$
- Wetted perimeter P = $4.75\sqrt{Q}$
- Velocity v = $\sqrt{\left(\frac{2}{5}\right) f\ R}$
- Normal regime scour depth D = $0.473\ (Q/f)^{1/3}$

10. Answer: **Option (a)**

Given diameter of pipe = 150mm Velocity of flow = 3.6 m/s

Reynolds number: Ratio of inertial force to viscous force.

$$R_e = \frac{\rho v d}{\mu}$$

Laminar flow $R_e < 2000$ Transitional flow $2000 < R_e < 4000$

Turbulent flow $Re > 4000$ ρ of glycerine = 1258 kg/m³

μ of glycerine = 0.96N.s/m²

Substituting the values in equation we get $R_e = \frac{\rho v d}{\mu}$

$$R_e = \frac{1258 \text{ x } 3.6 \text{ x } 0.15}{0.96} = 708$$

Therefore the flow is laminar as R_e is less than 2000.

11. Answer: **Option (c)**

Safe load for column $P = \sigma_c A_c + \sigma_s A_{sc}$ Given $\sigma_c = 5MPa$, $E_s = 15\ E_c$ and $A_{sc} = 1200\ mm^2$

$\sigma_s = m \text{ x } \sigma_c$ Modular ratio $m = E_s / E_c = 15$

$\sigma_s = 15 \text{ x } 5 = 75$ MPa A_c = Gross area – area of steel

A_c = (200 x 200) – 1200 = 38800 mm^2 P = (5 x 38800) + (75 x 1200)

Safe load P = 284kN

12. Answer: **Option (b)**

In Limit State design, as per IS 456:2000 the maximum strain in the tension reinforcement in the section at failure shall not be less than $0.002+f_y/1.15E_s$.

13. Answer: **Option (b)**

Plasticity index: Liquid limit minus plastic limit = 35-20 = 15

Liquidity index: Ratio of water content minus plastic limit to plasticity index.

Liquidity index = (25-20) / 15 = 0.33

14. Answer: **Option (b)**

Radius of gyration is defined as square root of the ratio of Moment of Inertia (I) and Area of cross section (A).

$$r = \sqrt{\frac{I}{A}}$$

15. Answer: **Option (d)**

Deflection of a cantilever beam due to point load at free end is $\delta_1 = Wl^3/3EI$

Deflection of a cantilever beam due to moment at free end is $\delta_2 = Ml^2/2EI$

$\delta_1 = \delta_2$ $Wl^3/3EI = Ml^2/2EI$

$M = 2Wl / 3$ Given W = 6kN and l = 2m

Therefore M = 8kN-m

16. Answer: **Option (a)**

The relation between Young's Modulus (E), Poisson's ratio (μ) and Modulus of rigidity (G) is given by expression E = 2G (1+μ) From the above expression G = E / (2(1+μ))

Given E = 200 GPa and μ = 0.3 Hence G = 200/2.6 = 76.92 GPa

17. Answer: **Option (c)**

Mass Density or Specific mass (ρ): Mass per unit volume.

Absolute Quantity does not change with location.

As pressure increases mass density increases as large number of molecules are forced into a given volume.

Specific Weight (γ): Weight per unit volume and varies from place to place.

Relation: $\gamma = \rho g$

Specific Volume: Reciprocal of density.

Specific gravity: Ratio of specific weight or mass density of a fluid to the specific weight or mass density of a standard fluid. Specific Gravity must be measured and specified at a particular temperature.

Mass density of a fluid = 3000/4 = 750kg/ m^3

Specific Gravity = Mass density of a fluid / Mass density of water

Specific Gravity = 750 / 1000 =0.75

18. Answer: **Option (c)**

Given height of water above the centre of a circular hole of diameter 2.5cm is 50m

The maximum velocity at the outlet V = $\sqrt{2gh}$

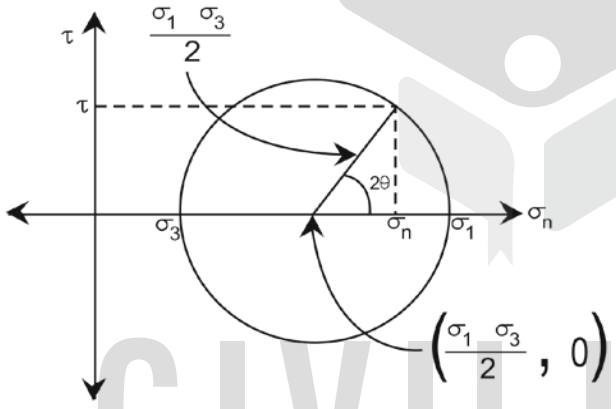
Therefore, V = $\sqrt{2\ x\ 9.81\ x\ 50}$ V = 31.32 m/s

19. Answer: **Option (b)**

Deep Beams: A beam said to be a deep beam when the ratio of effective span to overall depth, I/D is less than:

1. 2.0 for a simply supported beam and
2. 2.5 for a continuous beam.

20. Answer: **Option (d)**



Radius of a mohr's circle represents maximum shear stress.

21. Answer: **Option (c)**

For non-homogeneous system of linear equations the system AX = B has

1. A unique solution (consistent) if rank of A = rank of A/B = number of variables.
2. Infinitely many solutions (consistent) if rank of A = rank of A/B < number of variables.
3. No solution (inconsistent) if rank of A not equal to rank of A/B

Given question is a non-homogeneous system of linear equations, hence from above

Rank of A = $\begin{bmatrix} 5 & 3 & 7 \\ 3 & 2 & 2 \\ 7 & 2 & 10 \end{bmatrix}$

Rank of A/B (augmented matrix) = $\begin{bmatrix} 5 & 3 & 7 & 5 \\ 3 & 2 & 2 & 9 \\ 7 & 2 & 10 & 5 \end{bmatrix}$

After performing the row operations we can find the number of non-zero zeros are 3 in both the cases which is equal to number of unknowns.

Therefore, system is consistent and has unique solution.