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ESE - 2026

Preliminary Examination

QUESTIONS WITH DETAILED SOLUTIONS

CIVIL ENGINEERING

(SET-D)

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CIVIL ENGINEERING (SET - D)

SUBJECTWISE WEIGHTAGE

S.No.	Name of the Subject	Number of Questions
1	Strength of Materials	24
2	Structural Analysis	0
3	Construction Practice, Planning & Management	13
4	Reinforced Cement Concrete & PSC	13
5	Design of Steel Structures	12
6	Geotechnical Engineering	12
7	Fluid & Hydraulic Machines + OCF	13
8	Hydrology	8
9	Irrigation Engineering	4
10	Environmental Engineering	13
11	Transportation Engineering	14
12	Surveying	11
13	Building Materials	12
14	Geology	1
Total No. Of Questions		**150**

01. Which one of the following statements is **not** correct regarding soil sampling?

(a) In open drive sampler, the most widely used sample tube has an internal diameter of 100 mm and a length of 450 mm. The area ratio is approximately 30%.

(b) In thin-walled sampler, the internal diameter may range from 35 to 100 mm. The area ratio is approximately 100%.

(c) In split-barrel sampler, the internal and external diameters are 35 and 50 mm, respectively. The area ratio is approximately 100%.

(d) Continuous sampler is a highly specialized type of sampler which is capable of obtaining undisturbed samples up to 25 m in length. The sampler is used mainly in soft clays.

01. Ans: (b)

Sol: $D_i = 35$ mm

$D_o = 50$ mm

Area ratio, $A_r = \dfrac{D_o^2 - D_i^2}{D_i^2}$

$= \dfrac{50^2 - 35^2}{35^2} \times 100$

$= 104\% \simeq 100\%$

$\therefore$ For thin walled samples, $A_r \leq 10\%$

02. Which one of the following statements is **not** correct regarding Taylor's stability number?

(a) Taylor's stability number N is defined as $C_m/\gamma H$.

(b) The procedure is based on the Swedish method of slices.

(c) The results are embodied in Taylor's design charts which may be used for determining the factor of safety of a slope or for designing the height for a desired safety factor.

(d) It is an analytical approach.

02. Ans: (b)

Sol: Taylor's stability chart is based on friction circle method not on Swedish method of Slices.

03. A sample of sand, 5 cm in diameter and 15 cm long, was prepared at a porosity of 60% in a constant-head apparatus. The total head was kept constant at 30 cm and the amount of water collected in 5 seconds was 40 cm^3. The test temperature was 20°C. What is the seepage velocity?

(a) 0.21 cm/s (b) 0.98 cm/s

(c) 0.67 cm/s (d) 0.45 cm/s

03. Ans: (c)

Sol: **Given:**

$d = 5$ cm ; $L = 15$ cm

$n = 60\%$; $H = 30$ cm

$V_w = 40\ cm^3$; $t = 5$ sec

$\therefore V_s = \dfrac{V}{n}$; $V_s = \dfrac{Ki}{n}$

$\therefore V = \dfrac{Q}{A}$

$Q = \dfrac{V_w}{t} = \dfrac{40}{5} = 8\ cm^3/s$

$V = \dfrac{8}{\frac{\pi}{4} \times 5^2}$

$V_s = \dfrac{8}{\frac{\pi}{4} \times 5^2} \times \dfrac{1}{0.6}$

$V_s = 0.679$ cm/s

04. A soil layer is partially saturated due to capillary action and the degree of saturation is 50%. The height of point 'x' under consideration measured from groundwater table is 0.25 m. Assume unit weight of water is 10 kN/m^3. What is the approximate pore water pressure at point 'x' ?

(a) – 2.5 kN/m^2 (b) – 1.5 kN/m^2
(c) – 1.25 kN/m^2 (d) – 2.75 kN/m^2

04. Ans: (c)

Sol: **Given:**

$h_c = 0.25$ m

$S_r = 50\%$

Capillary pressure, $P_c = -\gamma_w h_c \times S_r$

$= -10 \times 0.25 \times 0.5$

$= -1.25$ kN/m^2

05. Which one of the following statements is **not** correct regarding clay minerals?

(a) The typical range of shrinkage limit of Kaolinite is 8.5 – 15.
(b) The typical range of shrinkage limit of Illite is 15 – 17.
(c) The typical range of liquid limit of Montmorillonite is 100 – 900.
(d) The typical range of plastic limit of Montmorillonite is 50 – 100

05. Ans: (a)

Sol: Typical Atterberg limit range of

Montmorillonite: $w_L = 100 – 900\%$
$w_p = 50 – 100\%$
$w_s = 8.5 – 15\%$

Kaolinite: $w_L = 30 – 110\%$
$w_p = 20 – 40\%$
$w_s = 25 – 29\%$

Illite: $w_L = 60 – 120\%$
$w_p = 35 – 60\%$
$w_s = 15 – 17\%$

06. A dam has been constructed across a river over a permeable stratum of soil of limited thickness. The head of water on the upstream side is 18 m and on the downstream side is 8 m. The flow net constructed across the dam gives N_f as 6 and N_d as 12. If the equivalent coefficient of permeability is 1.28×10^{-3} cm/s, what is the quantity of seepage per unit length of the section per cm length of dam?

(a) 0.64×10^{-3} cm^3/s (b) 0.64 cm^3/s
(c) 2.56×10^{-3} cm^3/s (d) 2.56 cm^3/s

06. Ans: (b)

Sol: $H = 18 – 8 = 10$ m

$N_f = 6$

$N_d = 12$

$K_e = 1.28 \times 10^{-3}$ cm/s

$Q = K_e H \frac{N_f}{N_d}$

$= 1.25 \times 10^{-3} \times 10 \times \frac{6}{12} \times 10^2$ cm^3/s/m

$= 6.4 \times 10^{-3} \times 10^2$

$= 0.64$ cm^3/s

07. An oedometer test has been performed on a clay sample of thickness 2 cm. 60% of consolidation has been observed after 15 minutes of loading under double drainage condition. What is the time taken to achieve same degree of consolidation for a 4 m clay layer on field under single drainage?

(a) 167 days (b) 16.7 days
(c) 1667 days (d) 1.6 years

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EXAM SYLLABUS:

ENGINEERING MATHEMATICS	20 Questions
NUMERICAL ABILITY	20 Questions
VERBAL ABILITY	10 Questions

- No. of Questions: 50
- Total Marks: 75
- Duration: 90 Minutes
- Mode: Online

07. Ans: (c)

Sol:

Test	Field
$H_1 = 2$ cm	$H_2 = 4$ m
$d_1 = \frac{2}{2} = 1$ cm	$d_2 = \frac{4}{1} = 4$ m (S.D)
$t_1 = 15$ min	$t_2 = ?$
$U_1 = 60\%$	$U_2 = 60\%$

$$\therefore t_2 = \frac{16 \times 10^4 \times 15}{60 \times 24} = 1667 \text{ days}$$

$$T_v = \frac{C_v.t}{d^2} \Rightarrow t \propto d^2$$

$$\frac{t_2}{t_1} = \left(\frac{d_2}{d_1}\right)^2$$

$$\frac{t_2}{15} = \left(\frac{4 \times 10^2}{1}\right) = 16 \times 10^4$$

08. Match the following lists:

List-I

P. Bacteria
Q. Virus
R. Protozoa
S. Helminths

List-II

1. Entamoeba histolytica
2. Ancylostoma duodenale
3. Hepatovirus A
4. Salmonella typhosa

Select the correct answer using the code given below:

	P	Q	R	S
(a)	4	3	2	1
(b)	4	3	1	2
(c)	2	3	1	4
(d)	1	3	2	4

08. Ans: (b)

Sol: P. Bacteria – 4. Salmonella typhosa Salmonella typhosa (also known as Salmonella typhi) is the bacterium responsible for causing typhoid fever.

Q. Virus – 3. Hepatovirus A Hepatovirus A is the viral agent that causes Hepatitis A, typically transmitted through the fecal-oral route.

R. Protozoa – 1. Entamoeba histolytica This is an anaerobic parasitic amoeba that causes amoebiasis (amoebic dysentery) in humans.

S. Helminths – 2. Ancylostoma duodenale Helminths are parasitic worms. Ancylostoma duodenale is a species of hookworm that lives in the small intestine of hosts such as humans.

09. What is the BOD_5 of a water sample for the given data?

Temperature of sample = 16°C; Initial dissolved oxygen at corresponding temperature is 10 mg/L; Dilution is 1:30, with seeded dilution water; Final dissolved oxygen of seeded dilution water is 8 mg/L; Final dissolved oxygen bottle with sample and seeded dilution water is 2 mg/L; Volume of BOD bottle is 300 mL.

(a) 183 mg/L (b) 153 mg/L
(c) 220 mg/L (d) 250 mg/L

09. Ans: (a)

Sol: $BOD_5 = D.F\left[(D.O_1) - (D.O_5)\right] - (dO_i - dO_5) \times \frac{\text{Seed vol}}{\text{total vol}}$

Dilution factor = 30 [i.e., 1 part sample 29 part seed vol]

Assuming dO_i (intital D.O in seed) = 10 mg/L)

$$\Rightarrow BOD_5 = 30\left[(10-2) - (10-8) \times \frac{29}{30}\right]$$

= 182 mg/L

10. As per the Manual on Water Supply and Treatment, Ministry of Urban Development, GOI, the fire demand for 1 lakh population is:
(a) 41,760 L/min (b) 35,050 L/min
(c) 31,625 L/min (d) 21,960 L/min

10. Ans: (*)

Sol: Volume = $100\sqrt{P}$ m^3/d
(where P is population in 1000's)
$= 100 \times \sqrt{100} = 1000\ m^3/d = 10^6\ \ell/d$
$= 10^6\ \ell/(24 \times 60\ min) = 695\ l/min$
use kuichling;
$V = 3182\sqrt{100} = 31820\ l/min$
(closest 'c' 31625 *l*/min)
As per manual no direct formulae or value assigned. Without mentioning of exact formulae to be used in question, it can't be determined.

11. As per IS 10500:2012, the value of Nitrate in drinking water should be in the range of:
(a) up to 45 mg/L (b) up to 60 mg/L
(c) up to 30 mg/L (d) up to 15 mg/L

11. Ans: (a)

Sol: As per IS 10500 : 2012 (Drinking Water Specification), the permissible limit of nitrate (as NO_3^-) in drinking water is: 45 mg/L (with no relaxation)

12. A confined aquifer is 6 m deep and the coefficient of permeability in the soil is 2 m^3/day-m^2. The wells are 100 m apart, and the difference in the water elevation in the wells is 3.0 m. The superficial velocity through the aquifer is:
(a) 0.09 m/day (b) 0.12 m/day
(c) 0.03 m/day (d) 0.06 m/day

12. Ans: (d)

Sol: $K = 2\ m^3/day\text{-}M^2$

$$i = \frac{\Delta h}{\ell} = \frac{3\ m}{100\ m} = 0.03$$

$V = Ki = 2\ M^3/day\text{-}M^2 \times 0.03 = 0.06$ m/day

13. A wastewater is expected to have BOD_3^{27} of about 300 mg/L. The initial DO of dilution water is 8.5 mg/L. The minimum DO that should remain is 1.5 mg/L. The dilution requirement for BOD determination is :
(a) 100 times dilution of the sample
(b) 50 times dilution of the sample
(c) 200 times dilution of the sample
(d) 150 times dilution of the sample

13. Ans: (b)

Sol: $BOD_3^{27} = (D.O_i - D.O_3) \times D.f$

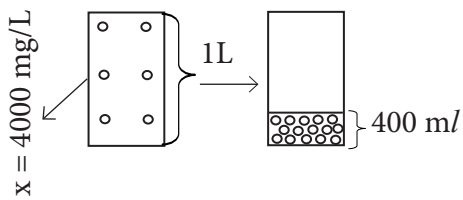
$$\Rightarrow D.f = \frac{300}{8.5 - 1.5} = \frac{300}{7} \approx 42$$

$\therefore$ D. F > 42

14. A sample of sludge has an SS concentration of 4000 mg/L. After settling for 30 minutes in a 1 L cylinder, the sludge occupies 400 mL. The Sludge Volume Index is:
(a) 100 (b) 50 (c) 200 (d) 150

14. Ans: (a)

Sol:



$$SVI = \frac{Volume_{settled}\ mol/L}{X\ g/L} = \frac{400\ ml/L}{4\ g/L} = 100\ ml/g$$

15. Raw primary and waste activated sludge containing 4% solids is to be anaerobically digested at a loading of 3 kg/(m³.day). The total sludge produced in the plant is 1500 kg of dry solids per day. Assume 1 L of sludge weighs about 1 kg. The approximate hydraulic retention time required is:
(a) 13.5 days (b) 15.5 days
(c) 10.5 days (d) 12.5 days

15. Ans: (a)

Sol: Solid % - 4%

Loading rate of sludge → 3 kg/m³/d

Total solids per day → 1500 kg/d

ρ_{sludge} = 1 kg/L

∴ Sludge volume per day = ?

4% → 1500 kg/d

$100\% \rightarrow \frac{1500 \times 100}{4} = 37500$ kg/d

= 37500 *l*/d = 37.5 m³/d

(∵ρ = 1 kg/L)

∴ Sludge tank (or) Digester volume = 1500 kg/d/ 3 kg/m³/d

∴ Hydraulic time = $\frac{500}{37.5}$ = 13.5 days

16. Which one of the following is **not** correct regarding measurement of horizontal distances?
(a) Absolute correction of chain or tape = True length - Nominal length.
(b) Steel Tape will give better result than invar tape.
(c) Tape or chain supported at the two ends will always sag.
(d) The correction due to 'chain or tape not horizontal' is always subtractive.

16. Ans: (b)

Sol: **Option (a):** Absolute correction = True length - Nominal length

This definition is correct. The absolute length correction accounts for the difference between a tape's actual(true) length and its marked nominal length, calculated as $C_a = \frac{L.c}{l}$

Where c is the difference per tape length.

Option (b): Steel tape will give better result than invar tape

This is incorrect. Invar tapes, made from a nickel-steel alloy, provide superior accuracy due to their extremely low thermal expansion coefficient, making them ideal for high-precision surveying like baseline measurements, outperforming standard steel tapes which are more affected by temperature.

Option (c): Tape or chain supported at the two ends will always sag

This is correct. When a tape or chain is supported only at its ends, its weight causes it to sag into a catenary curve, always requiring a subtractive sag correction $C_s = -\frac{w^2L^3}{24P^2}$

Option (d): The correction due to 'chain or tape not horizontal' is always subtractive

This is correct. For slope or alignment (not horizontal), the measured sloped length exceeds the true horizontal distance, so the correction is always subtractive.

17. In levelling, what is the combined collection (curvature and refraction) at a distance of 1 km?
(a) 6.7×10^{-6} m (b) 0.067 m
(c) 1675 m (d) 670 m

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17. Ans: (b)

Sol: Combined correction,

$C_{com} = -0.06735d^2m$

$d \rightarrow km$

$d = 1\ km$

$\Rightarrow C_{com} = -0.06735\ (1\ km)^2$

$= -0.06735\ m$

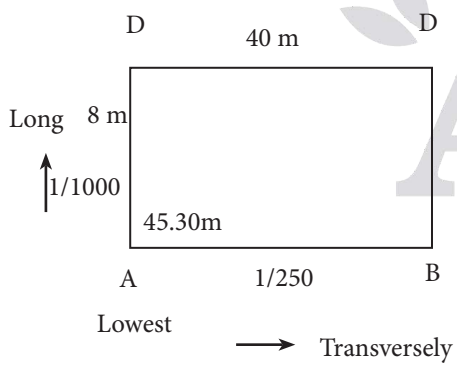
18. For setting out a rectangular platform ABCD, a rotating construction laser was used. It gave a reading of 0.878 m on a temporary B.M., having a level 45.110 m. The lowest corner A has a level 45.30 m. The platform has a cross fall of 1 in 1000 longitudinally and 1 in 250 transversely. If the platform is 8 m longitudinally, i.e., along AD or BD, and 40 m transversely, i.e., along AB or DC, what is the offset from the laser beam to the corner C of the platform?

(a) 0.688 m (b) 0.528 m

(c) 0.520 m (d) 0.680 m

18. Ans: (c)

Sol:



TBM = 45.110 m

BS = 0.878 m

$RL_C = 45.30 + \frac{8}{1000} + \frac{40}{250}$

$= 45.30 + \frac{8}{1000} + \frac{160}{1000}$

$= 45.30 + \frac{168}{1000}$

$RL_C = 45.30 + 0.168$

$= 45.468\ m$

Also, $RL_C = HI - FS_C$

$HI = RL_{TBM} + BS$

$= 45.110 + 0.878$

$= 45.988\ m$

$RL_C = 45.988 - FS_C$

$45.468 = 45.988 - FS_C$

$FS_C = 45.988 - 45.468$

$= 0.520\ m$

19. Sight rails are used for setting out :

(a) large buildings

(b) bridges

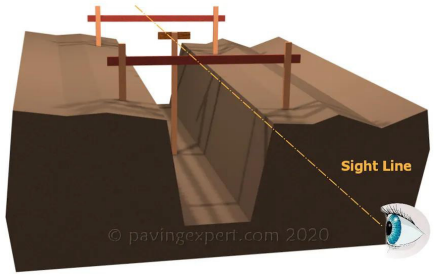
(c) the gradient of canal beds

(d) the gradient of trench of bottom or pipe inverts

19. Ans: (d)

Sol: Sight rails are primarily used to set and control the precise gradient and invert levels (bottom inside level) of trenches for sewers, drains, or pipes during excavation and laying.

Horizontal boards (sight rails) are fixed on upright posts driven into the ground, positioned above the trench line at intervals, with nails marking the exact offset above the required invert level.



20. Location of points by resection requires pointings made on at least :
(a) one known station
(b) two known stations
(c) three known stations
(d) four known stations

20. Ans: (b)

Sol: Resection.

It can be done by

1. Resection after orientation by Trough compass.
2. Resection after orientation by back sighting.
3. Resection after orientation by two–point problem.
4. Resection after orientation by three-point problem.

Therefore, the minimum number of references required are 2. (Two point problem)

Note: Three point problem is more accurate

21. Consider the length of the curve as L and radius of the curve as R. For a transition curve, the shift S of a circular curve is:
(a) $R^2 / 12 L$ (b) $L^2 / 24 R$
(c) $L^3 / 24 R^2$ (d) $L^2 / 12 R$

21. Ans: (b)

Sol: Shift is the amount by which the circular curve is moved inwards.

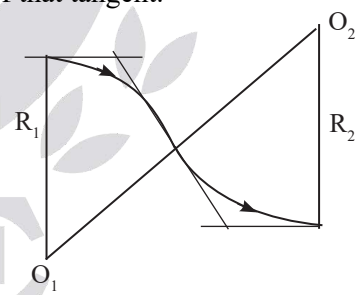
Shift in a transition curve is,

$$S = \frac{\ell^2}{24R}$$

22. A reverse curve consists of:
(a) two circular arcs of different radii with their centres of curvature on the same side of the different tangents only.
(b) two circular arcs of same radius with their centres of curvature on the same side of the common tangent only.
(c) two circular arcs of different radii with their centres of curvature on the opposite side of the different tangents only.
(d) two circular arcs of same or different radii with their centres of curvature on the opposite side of the common tangent.

22. Ans: (d)

Sol: A reverse curve is made up of two circular arcs bending in opposite directions, joined by a common tangent, with their centres of curvature on opposite sides of that tangent.



23. A parabola is preferred for vertical curves because:
(a) The slope is constant throughout.
(b) The rate of change of grade is constant throughout.
(c) The rate of change of radial acceleration is constant throughout.
(d) The rate of change of radial acceleration is zero.

23. Ans: (b)

Sol: Parabola has constant rate of change of gradient, which is equal to $\frac{G_1 - G_2}{L}$

$G_1 - G_2$ = Deflection angle

L = Length of curve

24. Maximum ordinate on a Mass Haul Diagram occurs:

(a) at the end of a cut

(b) at the end of an embankment

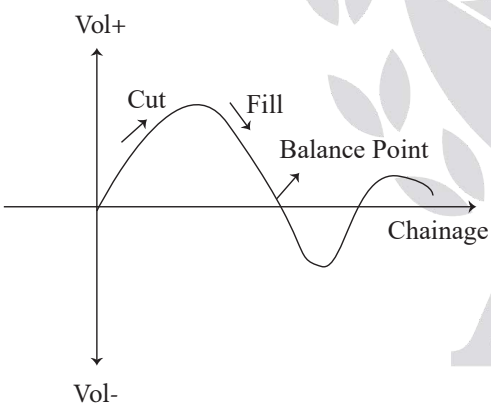
(c) when cut and fill are balanced

(d) at the midpoint of the cut

24. Ans: (a)

Sol:

Mass - haul diagram



The correct answer is (a) at the end of a cut.

In a Mass Haul Diagram, the ordinate represents the cumulative algebraic sum of earthwork volumes (positive for cut/excavation, negative for fill/embankment).

The curve rises during cut sections and falls during fill. The maximum ordinate occurs at the transition point where excavation (cut) ends and embankment (fill) begins — i.e., at the end of a cut. The minimum ordinate occurs at the end of a fill/embankment.

Note: Option (c) refers to a balance point where cumulative volume returns to zero, not the maximum height.)

25. Consider the following statements regarding anticline and syncline:

1. The presence of a syncline creates problem of seepage in a dam foundation.
2. There will be more bending of the anticlines in the upper strata and more joints due to tension stresses compared to lower strata.
3. A tunnel passing through a syncline will experience more lateral pressure in the middle part away from the portals.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

25. Ans: (d)

Sol: Synclines cause seepage problems in dam foundations due to inward-dipping strata that facilitate groundwater movement.

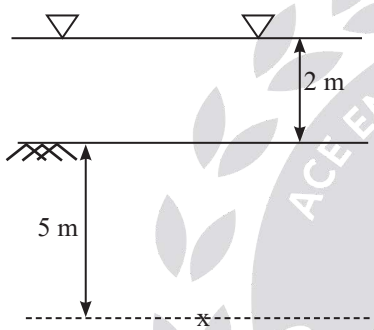
Anticlines show greater bending and jointing in upper strata because of tensile stresses during folding.

Tunnels through synclines experience higher lateral pressure at the central portion due to maximum overburden.

26. A river is 2 m deep. The river bed consists of a depth of sand of saturated unit weight 20 kN/m³. What is the effective vertical stress 5 m below the top of the sand?
(a) 68.6 kN/m² (b) 119.6 kN/m²
(c) 51 kN/m² (d) 10.2 kN/m²

26. Ans: (c)

Sol:



At depth of 5 m below top of sand

$\therefore \sigma' = \gamma' \times 5$

$= (20 - 10) \times 5 = 50 \text{ kPa} \simeq 51 \text{ kPa}$

27. In an in-situ vane test on a saturated clay, a torque of 35 Nm is required to shear the soil. The vane is 50 mm wide by 100 mm long. What is the undrained strength of the clay?
(a) 56 kN/m² (b) 76 kN/m²
(c) 150 kN/m² (d) 50 kN/m²

27. Ans: (b)

Sol: T = 35 N-m

d = 50 mm

H = 100 mm

C_u = ?

$$T = \pi d^2 C_u \left[\frac{H}{2} + \frac{d}{6}\right]$$

$$C_u = \frac{T}{\pi d^2 \left[\frac{H}{2} + \frac{d}{6}\right]} \frac{N - m}{mm^3}$$

$$C_u = \frac{35 \times 10^3}{\pi \times 50^2 \left[\frac{100}{2} + \frac{50}{6}\right]} = 0.0764 = N/mm^2$$

$$= 76.4 \text{ kN/m}^2$$

28. A footing 2.5 m × 2.5 m carries a pressure of 400 kN/m² at a depth of 1 m in sand. The saturated unit weight of the sand is 20 kN/m³ and the unit weight above the water table is 17 kN/m³ The design shear strength parameters are c′ = 0 and ϕ = 40° (N_q = 64 ; N_γ = 95). What is the factor of safety with respect to shear failure, if the water table is 5 m below ground level?
(a) 1.5 (b) 6 (c) 7 (d) 3

28. Ans: (c)

Sol: B = 2.5 m ; q = 400 kPa

D = 1 m ; C′ = 0

ϕ = 40°

F = ?

γ = 17

$q \le q_s$

$q = q_s$

$$q = \frac{q_u - \gamma D}{F} + \gamma D$$

$$q_u = \underbrace{1.3CN_c}_{0} + \gamma D N_q + 0.4\gamma B N_\gamma$$

$$q = \frac{\gamma D (N_q - 1) + 0.4\gamma B N_\gamma}{F} + \gamma D$$

$$400 = \frac{17 \times 1 \times [64 - 1] + 0.4 \times 17 \times 2.5 \times 95}{F} + 17 \times 1$$

$\therefore F = 7.013 \simeq 7$

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29. A long braced excavation in soft clay is 4 m wide and 8 m deep. The saturated unit weight of the clay is 20 kN/m^3 and the undrained shear strength adjacent to the bottom of the excavation is given by $c_u = 40$ kN/m^2 ($\phi_u = 0$). What is the factor of safety against base failure of the excavation?
(Take $N_c = 7.1$)
(a) 1.5 (b) 3.25 (c) 1.25 (d) 1.8

29. Ans: (d)

Sol: $F = \frac{C_u N_c}{\gamma H} = \frac{40 \times 7.1}{20 \times 8}$

$= 1.775 \simeq 1.8$

30. Which one of the following is not correct regarding the typical values of the coefficient of earth pressure at rest?
(a) For dense sand: 0.35
(b) For loose sand: 0.6
(c) Normally consolidated clay: 0.55
(d) Over-consolidated clay: 0.25

30. Ans: (d)

Sol: **Typical values of K_o:**
Dense sand $\Rightarrow K_o = 0.4 - 0.5$
Loose sand $\Rightarrow K_o = 0.5 - 0.6$
N.C.C $\Rightarrow K_o = 0.5 - 0.65$
O.C.C $\Rightarrow K_o = 0.7 - 1.0$

31. Identify the correct sequence of treatment flow scheme for groundwater with low mineral content but presence of objectionable gases:
(a) Raw Water - Aeration - Disinfectant - Disinfection Tank - Supply
(b) Raw Water- Disinfection Tank- Disinfectant - Aeration - Supply
(c) Raw Water- Disinfectant - Disinfection Tank -Sedimentation Tank - Aeration - Supply
(d) Raw Water- Disinfection Tank- Aeration - Sedimentation Tank - Supply

31. Ans: (a)

Sol: Sedimentation is not required as water has low mineral content.
Aeration to be done before disinfection as efficiency of disinfection will decrease if there are impurities in water.

32. In solid waste management, compaction ratio is defined as:
(a) The ratio of the as-compacted density to the as-discarded density.
(b) The ratio of the as-discarded density to the as-compacted density.
(c) The ratio of the as-deposited density to the as-compacted density.
(d) The ratio of the as-compacted density to the as-deposited density.

32. Ans: (d)

Sol: Compaction ratio = $\frac{\rho_{\text{compacted}}}{\rho_{\text{as deposited}}}$

Density of discarded means the density of solid waste discarded at home, but up to time solid waste reaches landfill, it will be compacted a bit.
$\therefore$ Density before compaction to be considered (i.e. $\rho_{\text{as deposited}}$)

33. Which of the following statements are correct regarding sound in environmental engineering?
1. Sound Intensity can be defined as the time-weighted average sound power per unit area normal to the direction of propagation of the sound wave.
2. Sound Intensity can be defined as the time-weighted average sound power per unit area parallel to the direction of propagation of the sound wave.
3. Sound Pressure can be defined as the force on a unit surface area perpendicular to the direction of the sound.
4. Sound Pressure can be defined as the force on a unit surface area parallel to the direction of the sound.

Select the correct answer using the code given below:

(a) 1 and 4 (b) 1 and 3
(c) 2 and 4 (d) 2 and 3

33. Ans: (b)

Sol: **Statement 1 (Correct):** Sound Intensity (I) is a vector quantity representing the flow of energy. It is defined as the sound power passing through a unit area normal (perpendicular) to the direction of propagation.

Mathematically: $I = \frac{P}{A}$ (where A is the area perpendicular to the flow).

Statement 2 (Incorrect): Intensity is never measured parallel to the direction of propagation, as the energy "flows" through the area, not along it.

Statement 3 (Correct): Sound Pressure (p) is the local pressure deviation from the ambient atmospheric pressure caused by a sound wave.

Since pressure is defined as force per unit area, in acoustics, we measure this force on a surface perpendicular to the direction of the sound wave.

Statement 4 (Incorrect): Similar to Statement 2, measuring force parallel to the direction of a longitudinal wave (like sound) would not capture the pressure exerted against a surface.

34. Match the following lists:

List-I

P. IS 4954:1968
Q. IS 3028:1998
R. IS 4758:1968
S. IS 3483:1965

List-II

1. Measurement of noise emitted by moving vehicles
2. Code of practice for noise reduction in industrial buildings
3. Recommendations for noise abatement in town planning
4. Methods of measurement for noise emitted by machines

Select the correct answer using the code given below:

	P	Q	R	S
(a)	4	3	2	1
(b)	4	3	1	2
(c)	3	1	4	2
(d)	1	3	2	4

34. Ans: (c)

Sol: **P – 3:** IS 4954:1968 provides recommendations for noise abatement in town planning.

Q – 1: IS 3028:1998 outlines the measurement of noise emitted by moving vehicles.

R – 4: IS 4758:1968 details methods for measuring noise emitted by machines.

S – 2: IS 3483:1965 is the code of practice for noise reduction in industrial buildings.

35. Which of the following statements are correct regarding landfills?

1. The landfill must be proximate to wastewater treatment facilities.
2. Landfills are not compatible with airport siting.
3. The bottom of the landfill must be below the highest expected groundwater elevation.

Select the correct answer using the code given below:

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

35. Ans: (a)

Sol: **Statement 1 is Correct:** Proximity to wastewater facilities is preferred because leachate (polluted runoff) is often transported there for treatment.

Statement 2 is Correct: Landfills attract birds, creating a significant bird strike hazard for aircraft. Regulations typically mandate a buffer zone of several kilometers from runways.

Statement 3 is Incorrect: To prevent catastrophic groundwater contamination, the landfill base must be at least 1.5 to 3 meters above the highest expected groundwater table, never below it.

36. A 20 cm storm occurred for 6 hrs in a catchment having a CN of 50. What is the net rainfall using SCS method?

(a) 11.57 cm (b) 15-70 cm
(c) 151.70 mm (d) 17.51 cm

36. Ans: (*)

Sol: $P = 20\text{ cm} = 200\text{ mm} = 7.87\text{ inches}$

$S = \frac{1000}{CN} - 10$; Here S in inches

$= \frac{1000}{50} - 10$

$S = 10\text{ inches}$

$I_a = 0.2S = 0.2 \times 10 = 2\text{ inches}$

$Q = \frac{[P - I_a]^2}{P - I_a + S} = \frac{[7.87 - 2]^2}{7.87 - 2 + 10} = 2.17\text{ inches}$

$= 5.51\text{ cm}$

Correct answer = 5.51 cm

Probably $S = \frac{1000}{CN} - 10$; though S inches but examiner might have considered it in cm

$S = \frac{1000}{50} - 10 = 10\text{ cm}$

$I_a = 0.2 \times S = 2\text{ cm}$

$Q = \frac{(P - I_a)^2}{P - I_a + S} = \frac{(20 - 2)^2}{20 - 2 + 10} = \frac{18^2}{28} = 11.57\text{ cm}$

37. The sliding factor of a gravity dam is defined as:

(a) $\frac{\text{The stabilizing moment}}{\text{The overturning moment}}$

(b) $\frac{\text{The sum of the vertical forces}}{\text{The sum of the horizotnal forces}}$

(c) $\frac{\text{The overturning moment}}{\text{The stabilizing moment}}$

(d) $\frac{\text{The sum of the horizontal forces}}{\text{The sum of the vertical forces}}$

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37. Ans: (d)

Sol: Sliding factor $\frac{\Sigma H}{\Sigma V}$

$$FSS = \frac{\mu}{SF} = \frac{\mu \Sigma V}{\Sigma H}$$

38. The depths of penetrations along the length of a border strip at points 30 m apart were probed. The observed values are 2.0 m, 1.9 m, 1.8 m, 1.6 m and 1.5 m. The water distribution efficiency is:

(a) 0.905 (b) 0.805 (c) 0.725 (d) 0.685

38. Ans: (a)

Sol: $\eta_d \Rightarrow$

$$y_m = \frac{2 + 1.9 + 1.8 + 1.6 + 1.5}{5}$$

$$= \frac{8.8}{5} = 1.73 \text{ m}$$

$$\bar{y}_d = \frac{0.27 + 0.17 + 0.07 + 0.13 + 0.23}{5} = \frac{0.87}{5}$$

$$= 0.174 \text{ m}$$

$$\eta_d = \left(1 - \frac{\bar{y}_d}{y_m}\right)100 = \left(1 - \frac{0.174}{1.73}\right) \times 100$$

$$= \frac{1.73 - 0.174}{1.73} \times 100 = 0.899 = 0.905$$

39. Which one of the following statements is correct regarding aqueducts?

1. The choice of a particular type of aqueduct does not depend upon its length.
2. The selection of a type of aqueduct lies on the considerations of economy.
3. On a very wide drainage, Type III aqueduct is most economical.
4. In Type III aqueduct, the width of the aqueduct is minimum but the cost of bank connections is maximum.

Select the correct answer using the code given below:

(a) 2 and 4 (b) 1 and 3
(c) 1 and 2 (d) 3 and 4

39. Ans: (a)

Sol: **Statement 2 is Correct:** The selection depends entirely on economy. Engineers must balance the cost of the main structure (the trough) against the cost of transition works (the wings).

Statement 4 is Correct: In Type III, the canal is flumed (narrowed) to its minimum width to save on expensive masonry/concrete costs over the drainage. However, this requires the most expensive and complex bank connections and transitions to return the canal to its normal section. Conversely, Statement 1 is incorrect as length determines the dominant cost, and Statement 3 is incorrect because Type I is usually cheaper for very wide drainages.

40. A storm with 12.0 cm precipitation produced a direct runoff of 6.8 cm. The time distribution of the storm is given in the following Table.

What is the ϕ -index?

(Take duration of excess rainfall as 8 hrs)

Time from start (hr)	Incremental rainfall in each hour (cm)
1	0.56
2	0.95
3	1.90
4	2.80
5	2.00
6	1.80
7	1.20
8	0.61

(a) 0.55 cm/hr (b) 0.31 cm/hr
(c) 0.46 cm/hr (d) 0.65 cm/hr

40. Ans: (d)

Sol: Duration of rainfall (t) = 8 hrs

Duration of excess rainfall (t_e) = 8 hrs

$$\phi - \text{Index} = \frac{P_e - R}{t_e}$$

Since duration of rainfall (t)

= duration of excess rainfall (t_e)

$$\Rightarrow P = P_e$$

$$\phi\text{-Index} = \frac{P - R}{t} = \frac{12\text{ cm} - 6.8\text{ cm}}{8\text{ hrs}}$$

$$= 0.65\text{ cm/hr}$$

41. Consider the following statements regarding polluted water resources:

1. If the polluted water is discharged directly to the recipient (such as lakes and rivers) without treatment, it usually leads to serious deterioration of the ecological life in the water body.
2. The polluted water is usually treated in a sewage treatment plant before it is led to the recipient.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

41. Ans: (c)

Sol: Statement 1 is correct because untreated wastewater contains high organic loads that deplete dissolved oxygen (High BOD), leading to eutrophication and the death of aquatic life.

Statement 2 is correct because Sewage Treatment Plants (STPs) are the standard infrastructure used to remove toxins and pathogens. This ensures that the effluent meets environmental safety standards before being discharged into rivers or lakes, thereby protecting the downstream ecosystem.

42. In the context of clouds and raindrop formation, which one of the following give the minimum precipitation and are found at great heights (up to 12 kms) from the Earth's surface?

(a) Cirrus (b) Nimbostratus

(c) Cumulus (d) Cumulonimbus

42. Ans: (a)

Sol: Cirrus clouds are high-altitude formations found at great heights of up to 12 km and are composed primarily of ice crystals, which results in them providing minimum or no precipitation

43. The annual evaporation from a lake with surface area of 1500 hectare is 240 cm. What is daily average evaporation rate in hectare-metre per day during the year?

(a) 9.863 Ha.m (b) 3600 Ha.m

(c) 360 Ha.m (d) 986.3 Ha.m

43. Ans: (a)

Sol: Annual Evaporation volume = Area × depth

= 1500 ha × 2.4 m

= 3600 ha-m

$$\text{Daily evaporation rate} = \frac{3600\text{ ha} - \text{m}}{365\text{ days}}$$

$$= 9.863\text{ ha-m/day}$$

44. In the process of drainage of water through soil during rainfall, the excess water present is called

(a) Gravitational water

(b) Hygroscopic water

(c) Capillary water

(d) Saturation water

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44. Ans: (a)

Sol: The excess water that drains through the soil during rainfall is known as Gravitational water. This water occupies the larger soil pores and moves downward under the influence of gravity. Capillary water and hydroscopic water are retained in the soil pores.

45. A cyclone formed outside the tropical zone near the boundary between warm and cold air is called:
(a) Extratropical Cyclone (b) Tropical Cyclone
(c) Anticyclone (d) Typhoon

45. Ans: (a)

Sol: A cyclone formed outside the tropical zone at the boundary between warm and cold air masses is called an Extratropical Cyclone. These are also known as wave cyclones or frontal cyclones and typically occur in the mid-latitudes.

46. While taking the stopping sight distance into consideration, when L > SSD then the general equation for length L of the parabolic curve is:

(a) $L = \frac{NS^2}{\sqrt{2H} + \sqrt{2h}^2}$ (b) $L = \frac{2NS^2}{\sqrt{2H} + \sqrt{2h}}$

(c) $L = \frac{NS^2}{\sqrt{H} + \sqrt{h}^2}$ (d) $L = \frac{NS^2}{2\sqrt{H} + \sqrt{h}^2}$

46. Ans: (a) or (d)

Sol: The general equation for the length L of a parabolic summit curve when L > SSD (Stopping Sight Distance) is:

$$L = \frac{NS^2}{(\sqrt{2H} + \sqrt{2h})^2} = \frac{NS^2}{2(\sqrt{H} + \sqrt{h})^2}$$

In the question, brackets are not clearly shown in the options.

47. For a street having 15 m width, what is the spacing between lighting units to produce average lux of 6.0? (Take lamp size as 6000 lumen, coefficient of utilization as 0.5, and maintenance factor as 0.9)
(a) 30 m (b) 15 m (c) 45 m (d) 60 m

47. Ans: (a)

Sol: $S = \frac{\phi \times CU \times MF}{W \times E_{avg}}$

$$S = \frac{6000 \times 0.5 \times 0.9}{6 \times 15} = 30 \text{ m c/c}$$

48. Match the following lists:

List-I

P. Cut and Cover
Q. Shield Driven
R. Sequential Excavation

List-II

1. Circular Tunnel
2. Horseshoe Tunnel
3. Rectangular Tunnel

Select the correct answer using the code given below:

	P	Q	R
(a)	1	2	3
(b)	3	1	2
(c)	1	3	2
(d)	3	2	1

48. Ans: (b)

Sol: **Cut and Cover (P-3):** This method involves excavating a trench from the surface, building the structure, and backfilling. It typically results in a rectangular box-frame shape, ideal for shallow metro stations.

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Shield Driven (Q-1): Utilizing a Tunnel Boring Machine (TBM) with a rotating cutter head, this method inherently produces a circular profile, providing excellent structural resistance against uniform earth pressure.

Sequential Excavation (R-2): Also known as NATM, this allows for varied profiles by excavating in stages. The horseshoe shape is the standard choice for mining and mountain tunnels to provide a flat base for transport.

49. Select the correct order of steps in travel demand modelling :
    (a) Trip Generation - Mode Choice - Trip Distribution - Traffic Assignment
    (b) Trip Generation - Trip Distribution - Mode Choice - Traffic Assignment
    (c) Traffic Assignment - Trip Generation Trip Distribution - Mode Choice
    (d) Mode Choice - Trip Generation - Trip Distribution - Traffic Assignment

49. Ans: (b)

Sol: The correct order is (b) Trip Generation — Trip Distribution — Mode Choice — Traffic Assignment. This sequence represents the classic Four-Step Model used in transportation planning:

Trip Generation: Determines the total number of trips originating from or destined for a specific zone.

Trip Distribution: Links origins to destinations, answering "where" the trips are going.

Mode Choice: Analyzes the split between different transport methods (e.g., car, bus, or rail).

Traffic Assignment: Predicts the specific routes travelers will take on the network. Trip generation, Trip distribution, Mode choice, Traffic assignment.

50. Match the following lists with corresponding acceptability limits of physical properties of aggregates for Bituminous Macadam construction, that is recommended by the Ministry of Road Transport and Highways specifications for Road and Bridge works:

List-I

P. Los Angeles abrasion value
Q. Aggregate impact value
R. Soundness loss with sodium sulphate test
S. Aggregate stripping

List-II

1. 12% maximum
2. 25% maximum
3. 30% maximum
4. 40% maximum

Select the correct answer using the code given below:

	P	Q	R	S
(a)	1	2	3	4
(b)	4	3	1	2
(c)	3	1	2	4
(d)	2	1	3	4

50. Ans: (b)

Sol: P. Los Angeles abrasion value → Measures hardness and resistance to wear.
Maximum 40% → 3

Q. Aggregate impact value → Measures resistance to sudden shock.
Maximum 30% → 2

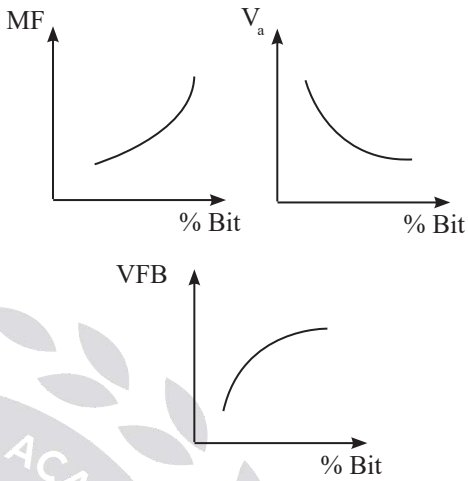
R. Soundness loss with sodium sulphate test → Measures durability against weathering.
Maximum 12% → 1

S. Aggregate stripping → Measures loss of binder adhesion.
Maximum 25% → 4

51. Which one of the following statements is correct regarding Marshall test?
(a) With increase in bitumen content, flow value increases, air voids decrease and voids filled with bitumen increase.
(b) With increase in bitumen content, flow value increases, air voids decrease and voids filled with bitumen decrease.
(c) With increase in bitumen content, flow value decreases, air voids increase and voids filled with bitumen decrease.
(d) With increase in bitumen content, flow value decreases, air voids decrease and voids filled with bitumen decrease.

51. Ans: (a)

Sol: Flow value → Measures deformation under load.
Increases with bitumen content because the mix becomes softer.
Air voids → The voids in the compacted mix.
Decrease with increase in bitumen content because more bitumen fills the voids.
Voids filled with bitumen (VFB) → Proportion of voids in the mix that are filled with bitumen.
Increase with bitumen content because more binder occupies the voids.



52. In Indian Railways, the field survey normally covers a width of :
(a) 100 m on either side of the track.
(b) 200 m on either side of the track.
(c) 300 m on either side of the track.
(d) 500 m on either side of the track.

52. Ans: (b)

53. In Indian Railways, the widening of the gauge (extra width) on curves is :

(a) $W = \frac{13(B+L)}{R^2}$ (b) $W = \frac{26(B+L)^2}{R}$

(c) $W = \frac{13(B+L)^2}{R}$ (d) $W = \frac{13(B+L)^2}{2R}$

53. Ans: (c)

Sol: **Extra Widening (EW)**

$$E_W = \frac{13(B+L)^2}{R} \text{ cm}$$

B - Wheel base (m)
L - Lap between flange and pail
R - Radius of curve (m)

54. What is the approximate psychological widening required for a pavement of 7 m on a horizontal curve of radius 225 m, if the longest wheel base of vehicle expected on the road is 7.0 m?
(Take the design speed as 70 km/h)
(a) 0.40 m (b) 0.50 m
(c) 0.60 m (d) 0.70 m

54. Ans: (b)

Sol: [n = 2 for 7 m wide road]

$$W_{ps} = \frac{n}{2} \times \left(\frac{V}{9.5\sqrt{R}}\right) = \frac{2}{2}\left[\frac{70}{9.5\sqrt{225}}\right] = 0.49 \text{ m}$$

$$\approx 0.50 \text{ m}$$

55. As per IRC guidelines, match the following lists:

List-I

P. Initial walking time for pedestrian
Q. Green time required for first vehicle to cross the STOP bar
R. Reaction time - Overtaking sight distance
S. Reaction time - Stopping sight distance

List-II

1. 2.0 seconds
2. 2.5 seconds
3. 6.0 seconds
4. 7.0 seconds

Select the correct answer using the code given below:

	P	Q	R	S
(a)	4	3	1	2
(b)	3	4	1	2
(c)	3	4	2	1
(d)	4	3	2	1

55. Ans: (a)

Sol: Initial walking time = 7 sec
SSD reaction time = 2.5 sec
OSD reaction time = 2 sec

56. What is the capacity of the road section, if speed (V) - density (K) study has resulted in a linear relationship V = 60 – 0.5K?
(a) 1800 (b) 7200 (c) 900 (d) 3600

56. Ans: (a)

Sol: $V = 60 - 0.5K$

$$V_m = 60 \; ; \; K_m = \frac{60}{0.5}$$

$$q_m = \left(\frac{60}{2}\right)\left[\frac{60}{\left(\frac{5}{10}\right)2}\right]$$

$$= (30)\frac{60 \times 10}{5 \times 2} = 30 \times 60 = 1800 \text{ veh/hr}$$

57. For the spot speed study distribution, x: N [55, 49], what is the speed of the next vehicle with a probability of 97.5%?
(Take equivalent static on the standard normal distribution (z) = 1.96)
(a) 64 km/h (b) 68 km/h
(c) 72 km/h (d) 76 km/h

57. Ans: (b)

Sol: $V = V_{mean} + (K)\,(SD)$

$V = 55 + (1.96)\,(7) = 68.72 \text{ kmph} \simeq 68 \text{ kmph}$

58. A line AB between the stations A and B was measured as 348 m using a 20 m tape, too short by 0.05 m. What is the correct length of AB?
(a) 347.41 m (b) 349.15 m
(c) 347.13 m (d) 348.87 m

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58. Ans: (c)

Sol: $L = 20$ m $\quad l' = 348$ m

$L' = 20 - 0.05$ $\quad l' = l'\left(\frac{L'}{L}\right)$

$= 19.95$ m $\quad = 348 \times \frac{19.95}{20}$

$= 347.13$ m

59. A tape of standard length 20 m at 85°F was used to measure a base line. The measured distance, was 882.50 m. What is the true length of the line, if the mean temperature during measurement was 63°F and the coefficient of thermal expansion of the tape material is 6.5×10^{-6} per °F?

(a) 872.982 m (c) 882.374 m

(b) 879.282 m (d) 882.626 m

59. Ans: (c)

Sol: $l = 882.50$ m

$T_0 = 85°F$

$T_m = 63°F$

$\alpha = 6.5 \times 10^{-6}/°F$

$C_{temp} = \alpha (T_m - T_o) L$

$= 6.5 \times 10^{-6} (63–85)882.50$ m

$= – 0.1261$ m

$CL = ML + C_{temp}$

$= 882.50 – 0.1261$

$= 882.3738$

$= 882.374$ m

60. With what accuracy must a difference in elevation between two ends of a 30 m tape be known if the difference in the elevation is 3 m and the accuracy ratio is to be at least 1 in 600000?

(a) 0.0005 m (c) 0.0003 m

(b) 0.0157 m (d) 0.0006 m

60. Ans: (a)

Sol: $DA = \frac{1}{600000}$

- For 30 m, error allowed $= \frac{30}{600,000} = 0.00005$ m
- Corr. for slope, $C = \frac{h^2}{2L}(-ve)$

This correction depends on how accurately 'h' is measured

$\therefore \delta C = \frac{2h.\delta h}{2L}$

$\Rightarrow \delta C = \frac{h}{L}\delta h$ $\quad \therefore \delta C = \frac{3}{30}\delta h$

$h = 3$ m $\quad \delta C = 0.1\ \delta h$

$L = 30$ m

We need, $\delta C \le 0.00005$

$\Rightarrow 0.1\ \delta h \le 0.00005$

$\Rightarrow \delta h \le \frac{0.00005}{0.1}$

$\Rightarrow \delta h \le 0.0005$ m

61. Soil materials which have the property to store water due to good number of pores in them, but passage of water through them is not possible, are called :

(a) Aquifuge (b) Aquiclude

(c) Aquitard (d) Aquifer

61. Ans: (b)

Sol: In hydrogeology, geological formations are classified based on their ability to store and transmit water. An Aquiclude is a material like clay that possesses high porosity and can store significant amounts of water, but its permeability is so low that it effectively prevents the passage or flow of water through it.

62. Which one of the following is not a type of groyne?
(a) Repelling groyne (b) Attracting groyne
(c) Perpendicular groyne (d) Straight groyne

62. Ans: (d)

Sol: **Repelling Groynes (a):** Point upstream, forcing the current away from the bank to encourage sedimentation.

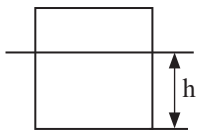
Attracting Groynes (b): Point downstream, drawing the river flow toward the bank.

Perpendicular Groynes (c): Also called deflecting groynes, these are built at 90° to the bank to deflect the current locally."Straight" is a descriptive shape, not a functional type.

63. A wooden block of rectangular section 1.25 m wide, 2 m deep, 4 m long floats horizontally in sea water. The specific gravity of wood is 0.64 and water weighs 1000 kg(f)/m³. Under this situation, the position of centre of buoyancy of wood is at:
(a) 1.28 m above the base
(b) 0.64 m above the base
(c) 0.32 m above the base
(d) 0.96 m above the base

63. Ans: (b)

Sol:



$h = H\left\{\frac{S_b}{S_f}\right\} = 2(0.64) = 1.28$ m

"B" must be $\frac{h}{2}$ above base

$\Rightarrow$0.64 m above base

64. A rectangular pontoon is 5 m long, 3 m wide and 1.20 m high. The depth of immersion of the pontoon is 1.0 m in sea water. If the centre of gravity is 0.6 m above the bottom of the pontoon, what is the metacentric height of the same? (Take the density of sea water as 1000 kg/m³)
(a) 0.65 m (b) 0.75 m
(b) 0.85 m (d) 0.50 m

64. Ans: (a)

Sol: $GM = \frac{I}{\nabla} - BG$

$I = \frac{5 \times 3^3}{12} = \frac{45}{4}$ m^4

$V = 5 \times 3 \times 1 = 15$ m^3

$BG = 0.6 - 0.5 = 0.1$ m

$\Rightarrow GM = \frac{45}{4 \times 15} - 0.1$

$\Rightarrow GM = 0.65$ m

65. What are the vorticity components at a point (1, 1, 1) for the following flow field?
$u = 2x^2 + 3y$, $v = -2xy + 3y^2 + 3zy$,
$w = -1.5z^2 + 2xz - 9y^2z$
(a) $\Omega_x = -21$units $\Omega_y = -2$ units, $\Omega_z = -5$ units
(b) $\Omega_x = -2$ units $\Omega_y = -12$ units, $\Omega_z = -5$ units
(c) $\Omega_x = -2$ units $\Omega_y = -21$ units, $\Omega_z = -5$ units
(d) $\Omega_x = -5$ units $\Omega_y = -2$ units, $\Omega_z = -21$ units

65. Ans: (a)

Sol: $\vec{\Omega} = \begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ u & v & w \end{vmatrix}$

$\Rightarrow \vec{\Omega} = \left\{\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right\}\hat{i} + \left\{\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right\}\hat{j} + \left\{\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right\}\hat{k}$

$\Rightarrow \vec{\Omega} = \{-18yz - 3y\}\hat{i} + \{0 - 2z\}\hat{j} + \{-2y - 3\}\hat{k}$

$x = y = z = 1 \Rightarrow \vec{\Omega} = -21\hat{i} - 2\hat{j} - 5\hat{k}$

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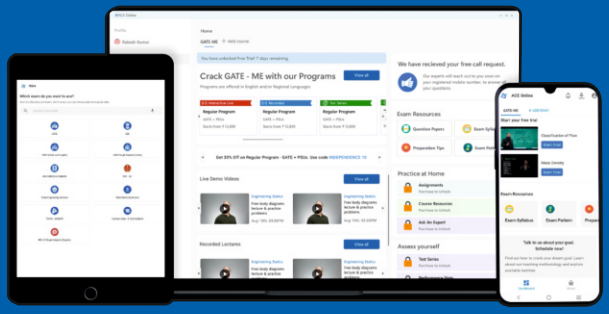

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66. Which of the following correctly depicts the continuity equation in its integral form?

(a) $\frac{\partial \rho}{\partial x} + \nabla.(\rho \vec{V}) = 0$ (b) $\frac{\partial V}{\partial t} - \nabla.(\rho \vec{V}) = 0$

(c) $\frac{\partial \rho}{\partial t} + \nabla.(\rho \vec{V}) = 0$ (d) $\frac{\partial \rho}{\partial t} - \nabla.(\rho \vec{V}) = 0$

66. Ans: (c)

Sol: $\frac{\partial \rho}{\partial f} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$

$\frac{\partial \rho}{\partial t} + \vec{\nabla}\{\rho \vec{V}\} = 0$

67. Which of the following sets of equations represent(s) possible two-dimensional incompressible flows?

1. $u = x + y$; $v = x - y$
2. $u = x + 2y$; $v = x^2 - y^2$
3. $u = 4x + y$; $v = x - y^2$
4. $u = xt + 2y$; $v = x^2 - yt^2$
5. $u = xt^2$; $v = xyt - y^2$

Select the correct answer using the code given below:

(a) 1 only (c) 1, 2 and 3 only

(b) 1 and 2 only (d) 2, 3, 4 and 5

67. Ans: (a)

Sol: For incompressible flow : $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$

1. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$
2. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 1 - 2y \neq 0$
3. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 4 - 2y \neq 0$
4. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = t - t^2 \neq 0$
5. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = t^2 + xt - 2y \neq 0$

68. A venturimeter having area of $700\ cm^2 \times 150\ cm^2$ is inserted in a vertical pipe carrying water, flowing in the upward direction. A differential manometer connected to the inlet and throat gives a reading of 20 cm. What is the approximate discharge by assuming $C_d = 1.0$ and $g = 1000\ cm/s^2$?

(a) 110 L/s (b) 100 L/s

(c) 125 L/s (d) 95 L/s

68. Ans: (a)

Sol: $Q = \frac{Cd.A_1A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2gh}$

$= \frac{1 \times (0.07 \times 0.015)}{\sqrt{0.07^2 - 0.015^2}}\sqrt{2 \times 10 \times 0.2}$

$\Rightarrow Q = 0.030\ m^3/s$

$= 30\ lt/s$

$\because$ The above answer is not present in options and mercury is mostly used as Manometric fluid.

$\therefore\ Q = \frac{A_1A_2}{\sqrt{A_1^2 - A_2^2}}\sqrt{2gh\left\{\frac{S_M}{S_W} - 1\right\}}$

$= \frac{(0.07 \times 0.015)}{\sqrt{0.07^2 - 0.015^2}}\sqrt{2 \times 10 \times 0.2\left\{\frac{13.6}{1} - 1\right\}}$

$Q \simeq 0.11\ m^3/s = 110\ lt/s$

69. The flow of incompressible fluid is defined by u= 2, v = 8x. What is the stream function?

(where C = constant)

(a) $\varphi = -2x^2 + y + C$

(b) $\varphi = -4x^2 + 2y + C$

(c) $\varphi = -4x + 2y^2 + C$

(d) $\varphi = -4x - 2y^2 + C$

69. Ans: (b)

Sol: $u = 2,\ v = 8x$

$$u = \frac{\partial \psi}{\partial x} \Rightarrow \psi = 2y + f(x)$$

$$-\frac{\partial \psi}{\partial x} = v$$

$$-f'(x) = 8x$$

$$f(x) = -4x^2$$

$$\Rightarrow \psi = 4x^2 + 2y + C \text{ (or) } 4x^2 - 2y + C$$

70. Water at 60° C flows between two large flat plates. The lower plate moves to the left at a speed of 0.3 m/s. The plate spacing is 3 mm and the flow is laminar. The pressure gradient required to produce zero net flow at a cross-section is :
(Take $\mu = 5 \times 10^{-4}$ Ns/m² at 60° C)

(a) – 100 N/m².m (b) – 10 N/m² .m
(c) – 1000 N/m².m (d) – 50 N/m² .m

70. Ans: (a)

Sol: $Q = V = 0$

$$\Rightarrow \frac{U}{2} + \frac{1}{12\mu}\left\{-\frac{dp}{dx}\right\}B^2 = 0$$

$$\Rightarrow \frac{dp}{dx} = \frac{6\mu U}{B^2} = \frac{6 \times 5 \times 10^{-4} \times 0.3}{9 \times 10^{-6}} = 100 \text{ Pa/m}$$

71. Without velocity of approach, the discharge through a Cipolletti weir is :

(a) $Q = \frac{2}{3} C_d L \sqrt{2g}\, H^{3/2}$

(b) $Q = \frac{1}{2} C_d L \sqrt{5g}\, H^{2/3}$

(c) $Q = \frac{2}{3} C_d L \sqrt{g}\, H^{2/3}$

(d) $Q = \frac{1}{2} C_d L \sqrt{5g}\, H^{3/2}$

71. Ans: (a)

Sol: $Q_{CW} = Q_{\text{suppressed Rectangle}}$

$$= \frac{2}{3} C_d \sqrt{2g}.L.H^{3/2}$$

72. The rate of flow of water through a horizontal pipe is 0-25 m³/s. The diameter of the pipe which is 200 mm is suddenly enlarged to 400 mm. The pressure intensity in the smaller pipe is 11.772 N/cm². The approximate power lost due to enlargement is:
(Take g = 10 m/s²)

(a) 4.50 kW (b) 9.00 kW
(c) 2.25 kW (d) 1.80 kW

72. Ans: (a)

Sol: $V_1 = \frac{4Q}{\pi d_1^2} = \frac{4 \times 0.25}{\pi \times 0.2^2} = \frac{25}{\pi}$

$$V_2 = \frac{4Q}{\pi d_2^2} = \frac{4 \times 0.25}{\pi \times 0.4^2} = \frac{25}{4\pi}$$

$$h = \frac{(V_1 - V_2)^2}{2g} = \frac{1}{2g}\left\{\frac{75}{4\pi}\right\}^2$$

$$\Rightarrow h = 1.815 \text{ m}$$

$$P_{\perp} = \gamma Q h$$

$$= 9.81 \times 0.25 \times 1.815$$

$$P_{\perp} = 4.45 \text{ kW}$$

73. Water is flowing with a velocity of 1.5 m/s in a pipe of length 2500 m and of diameter 500 mm. At the end of the pipe, a valve is provided. What is the rise in pressure, if the valve is closed in 25 seconds?
(Take the value of C as 1460 m/s)

(a) 15 N/cm² (b) 150 N/cm²
(c) 7.5 N/cm² (d) 75 N/cm²

73. Ans: (a)

Sol: $T_C = \frac{2L}{C} = \frac{2500 \times 2}{1460} < T_a$

$\therefore$ Gradual closure

$\therefore P = \frac{\rho VL}{T_a} = \frac{1000 \times 1.5 \times 2500}{25}$

$\Rightarrow P = 1.5 \times 10^5$ Pa $= 15$ N/cm^2

74. A Pelton wheel is having a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 700 litre/s under a head of 31.25 m. The buckets deflect the jet through an angle of 150°. Assuming co-efficient of velocity as unity, g as 10 m/s^2, and the density of water as 1000 kg/m^3, the approximate power given by water to the runner of the turbine is:

(a) 196 kW (b) 98 kW
(c) 49 kW (d) 294 kW

74. Ans: (a)

Sol: u = 10 m/s, Q = 0.7 m^3/s, H = 31.25 m

$\theta = 30^o$

$V = \sqrt{2gH} = \sqrt{2 \times 10 \times 31.25} = 25$ m/s

R.P = $\rho Q (v - u)(1 + K\cos\theta).u$

$= 1000 \times 0.7 (25 - 10)(1 + 1 \times \cos 30) \times 10$

$= 196$ kW

75. Consider the following statements regarding the operating characteristic curves of centrifugal pumps:

1. The input power curve will pass through the origin.
2. The head curve will have maximum value of head when the discharge is maximum.
3. The output power curve will start from origin.
4. The efficiency curve will start from origin.

Which of the above statements are correct?

(a) 1 and 2 (b) 3 and 4
(c) 2 and 4 (d) 1 and 3

75. Ans: (b)

Sol: In pump characteristic curves, discharge is taken on x axis

at starting point,

1. discharge = 0
2. output power = $\rho g Q H_m = 0$
3. Input power = output power + losses

$= \rho g Q H_m$ + losses $\neq 0$

At starting point mechanical losses are non zero because pump is still running

$\therefore \eta = \frac{\text{Output power}}{\text{Input power}} = 0$

76. Water absorption for burnt clay heavy duty bricks should not be more than :

(a) 10 percent (b) 20 percent
(c) 5 percent (d) 15 percent

76. Ans: (a)

Sol: As per Clause 6.2 of IS 2180: 1988, the code which deals with heavy duty burnt clay bricks, the water absorption should not be more than 10%.

77. The decomposition of felspar is represented as $K_2Al_2O_3.6H_2O + CO_2 + nH_2O =$

(a) $K_2CO_3 + Al_2O_3.2SiO_2.2H_2O + 4SiO_2.nH_2O$
(b) $K_2CO_3 + Al_2O_3.SiO_2.2H_2O + 4SiO_2.nH_2O$
(c) $K_2CO_3 + Al_2O_3.2SiO_2.H_2O + 4SiO_2.nH_2O$
(d) $K_2CO_3 + Al_2O_3.SiO_2.H_2O + 4SiO_2.nH_2O$

77. Ans: (a)

Sol: Feldspar is the name given to a group of minerals which have both silica and alumina in their chemistry.

The subject question deals with Orthoclase Feldspar which has the chemical formula:

$K_2O.Al_2O_3.6SiO_2$

This mineral decomposes as follows in the presence of CO_2 and H_2O.

$K_2O.Al_2O_3.6SiO_2 + CO_2 + nH_2O$
$= K_2CO_3 + Al_2O_3.2SiO_2.2H_2O + 4SiO_2.nH_2O.$

78. The metal oxide used to make emerald green glass is :

(a) MnO_2 (b) Cr_2O_7
(c) Cobalt oxide (d) Iron oxide

78. Ans: (b)

Sol: Emerald green color in glass is produced by using Potassium dichromate $K_2Cr_2O_7$ during the manufacture of the glass.

79. Match the following lists:

List-I

P. Cupping
Q. Bowing
R. Checks
S. Knots

List-II

1. Caused by wood limbs encased by wood of the free trunk
2. Caused by grain irregularities in the board
3. Small cracks appearing at the ends of boards due to rapid drying
4. Unequal shrinking in the radial and tangential direction

Select the correct answer using the code given below:

	P	Q	R	S
(a)	2	4	1	3
(b)	4	2	3	1
(c)	1	2	4	3
(d)	3	1	2	4

79. Ans: (b)

Sol: Cupping of timber boards occurs due to unequal shrinkage in radial and tangential directions.

Bowing of timber boards occurs due to grain irregularities.

Checks in timber are the small cracks appearing at the ends of boards due to rapid drying.

Knots are caused by encasement of broken wood limbs by the wood of the free trunk.

80. Which one of the following statements is not correct regarding the fineness of cement?

(a) Fine cement is more liable to suffer from shrinkage cracking than a coarse cement.
(b) Fine cement shows faster rate of heat evolution and total quantity of heat evolved is much larger than coarse cement.
(c) Fine cement will show faster rate of hardening than coarse cement.
(d) Fine cement shows the same setting time as coarse cement

80. Ans: (d)

Sol: As the fineness of cement increases its specific surface area also increases due to which there is higher rate of hydration leading to faster initial and final setting times.

81. Match the following lists:

List-I (Types of cement)

P. Rapid hardening
Q. Quick-setting
R. High alumina
S. Low-heat

List-II (Uses)

1. Repair of bridges
2. Dams
3. Concrete under water
4. Refractory concrete in industries

Select the correct answer using the code given below:

	P	Q	R	S
(a)	2	4	1	3
(b)	4	2	3	1
(c)	3	1	2	4
(d)	1	3	4	2

81. Ans: (d)

Sol: Rapid hardening cement, due to its high initial strength, is preferred for repair works.

Quick setting cement is used for underwater concereting.

High Alumina cement can resist high temperatures and hence it is used in the construction of refractories.

Low heat cement is preferred in mass concrete works as higher heat of hydration leads of shrinkage cracks in concrete.

82. The approximate composition of CaO in Portland cement is in the range of:

(a) 60% - 65%
(b) 50% - 55%
(c) 65% - 70%
(d) 55% - 60%

82. Ans: (a)

Sol: For the manufacture of OPC, the raw materials should contain around 60 to 67% lime.

83. The percentage of MgO in cement is calculated using:

(a) Weight of residue × 32.4
(b) Weight of residue × 27.4
(c) Weight of residue × 42.7
(d) Weight of residue × 72.4

83. Ans: (d)

Sol: Percentage of Magnesia (MgO)

= Weight of residue × 72.4

Here the reside refers to Magnesium Pyrophosphate which is collected after the chemical analysis of cement as per IS 4032 : 1985.

84. The minimum value of Modulus of Rupture for Class A lime should be :

(a) 1.15 N/mm^2
(b) 1.05 N/mm^2
(c) 1.5 N/mm^2
(d) 1.25 N/mm^2

84. Ans: (b)

Sol: As per IS 712: 1984, for Class A lime in 1:3 lime & sand mixture, modulus of rupture should not be more than 1.05 N/mm^2.

85. Match the following lists:

List-I (Cement mortar for different works)

P. Normal brickwork

Q. Plastering work

R. Grouting cavernous rocks

S. Guniting

List-II (Proportion of cement: Sand in mortar)

1. 1:4
2. 1:3
3. 1:6
4. 1:1.5

Select the correct answer using the code given below:

	P	Q	R	S
(a)	2	4	1	3
(b)	3	1	4	2
(c)	1	2	4	3
(d)	3	2	1	4

85. Ans: (b)

Sol: For Brick Masonry, 1:6 Cement Mortar is used.
For Plastering works, 1:4 Cement Mortar is used.
For Grouting works, 1:1.5 Cement Mortar is used.
For Guniting works, 1:3 Cement Mortar is used.

86. Which one of the following statements is correct regarding the factors influencing strength of concrete?

(a) If the size of cube is decreased, the compressive strength tends to increase and modulus of elasticity decreases.

(b) If the size of cube is decreased, the compressive strength tends to decrease and modulus of elasticity increases.

(c) If the size of cube is decreased, the compressive strength tends to increase and modulus of elasticity also increases.

(d) If the size of cube is decreased, the compressive strength tends to decrease and modulus of elasticity also decreases.

86. Ans: (c)

Sol: As the size of concrete specimen decreases, the strength measured comes out to be higher. Since strength and modulus of elasticity are directly proportional to each other, modulus of elasticity also increases with decrease in size of the concrete specimen.

87. The cement content in a mix design is 378 kg/m^3, water content 170 kg, sand is 30% of total aggregate, entrapped air is 1%, specific gravity of cement, coarse aggregate and fine aggregate are, respectively 3.15, 2.70 and 2.60. The fine aggregate is approximately :

(a) 510 kg (b) 600 kg
(c) 550 kg (d) 450 kg

87. Ans: (c)

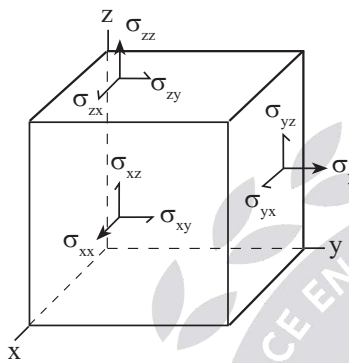
Sol: Assume X as the weight of total aggregates.

Volume of concrete = Volume of individual ingredients of concrete

$$1-\frac{1}{100}=\frac{378}{3150}+\frac{0.3X}{2600}+\frac{0.7X}{2700}+\frac{170}{1000}$$

Solving the above equation will give X = 1868 Kgs and weight of fine aggregate = 0.3X = 560 Kgs.

88. The component of stress acting on infinitesimal element is shown in the figure. Which one of the following statements is not correct?



(a) The normal stress components are sigma σ_{xx}, σ_{yy} and σ_{zz}. The shear stress components are σ_{yz}, σ_{zx}, σ_{xy}, σ_{zy}, σ_{xz}, and σ_{yx}.

(b) On a free surface, the two shear stress components in the surface vanish, that is, if z is the normal to a free surface, $\sigma_{yz} = \sigma_{zx} = 0$.

(c) If the surfaces are assumed to have friction, then the shear stresses acting on the surface vanish, that is, $\sigma_{yz} = \sigma_{zx} = 0$.

(d) Unless there is a pressure acting on a free surface, the stress normal to it also vanishes, that is, $\sigma_{zz} = 0$

88. Ans: (c)

Sol: **(a) Correct:** In a 3D stress state, σ_{xx}, σ_{yy}, σ_{zz} represent normal stresses (perpendicular to the faces), while the remaining components with mixed subscripts represent shear stresses.

(b) Correct: A "free surface" cannot support shear stress because there is no external material to apply a tangential force. If z is the normal to that surface, any shear components containing z(σ_{yz}, σ_{zx}) must be zero.

(c) Incorrect: This statement is logically backwards. If a surface has friction, it can support shear stresses. Shear stresses vanish on a surface specifically when it is a "frictionless" surface or a "free surface," not when friction is assumed.

(d) Correct: On a free surface (an external boundary with no load), there is no resistance to motion in the normal direction. Therefore, unless an external pressure is applied, the normal stress (σ_{zz}) must be zero.

89. An element 2 cm long is extended to twice of its initial length and then compressed to its initial length. The engineering strains for the extension and compression are, respectively:
(a) 1 and – 0.5
(b) 2 and – 1
(c) 0.5 and –1
(d) 0.693 and – 0.693

89. Ans: (a)

Sol: $L_o = 2$ m;
$L_f = 2 \times 2 = 4$ cm

$$\varepsilon_{ext} = \frac{L_f - L_o}{L_o} = \frac{4-2}{2} = 1$$

$$\varepsilon_{comp} = \frac{2-4}{4} = \frac{-1}{2}$$

90. A rectangular block is subjected to two perpendicular stresses of 10 MPa tension and 10 MPa compression. What are the stresses on planes inclined at 45° with the horizontal plane?

(a) Normal Stress = 10 Mpa and Shear stress = 20 Mpa

(b) Normal Stress = 0 Mpa and Shear stress = –10 Mpa (counter clockwise direction)

(c) Normal Stress = 5 Mpa and Shear Stress = –20 Mpa (counter clockwise direction)

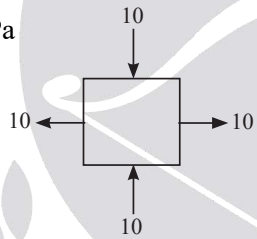
(d) Normal Stress = 10 Mpa and Shear stress = 5 Mpa

90. Ans: (b)

Sol: **Given Data**

σ_x (Tension): +10 MPa

σ_y (Compression): –10 MPa



τ_{xy} (Shear stress on initial planes): 0 MPa

θ (Inclination): 45°

The formula for normal stress on an inclined plane is:

$$\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos(2\theta) + \tau_{xy}\sin(2\theta)$$

$$\sigma_n = \frac{10 + (-10)}{2} + \frac{10 - (-10)}{2}\cos(90^\circ) + 0$$

$= 0$MPa

The formula for shear stress on an inclined plane is:

$$\tau_n = -\frac{\sigma_x - \sigma_y}{2}\sin(2\theta) + \tau_{xy}\cos(2\theta)$$

$$\tau_n = -\frac{10 - (-10)}{2}\sin(90^\circ) + 0 = -10 \text{ MPa}$$

91. The angle made by the resultant stress with the normal of the oblique plane is known as obliquity (ϕ) and is expressed as:

(a) $\tan\phi = \dfrac{\text{Shear Stress}}{\text{Normal Stress}}$

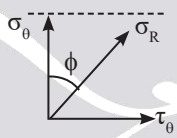
(b) $\cos\phi = \dfrac{\text{Shear Stress}}{\text{Normal Stress}}$

(c) $\tan\phi = \dfrac{\text{Normal Stress}}{\text{Tangential Stress}}$

(d) $\cos\phi = \dfrac{\text{Normal Stress}}{\text{Tangential Stress}}$

91. Ans: (a)

Sol: Obliquity, $\tan\phi = \left[\dfrac{\tau_\theta}{\sigma_\theta}\right]$



$$\phi = \tan^{-1}\left[\frac{\tau_\theta}{\sigma_\theta}\right]$$

92. A central load of 2500 N is acting on a leaf spring. The leaf spring is to be made of 12 steel plates of 6 cm width and 5 mm thickness. If the bending stress is limited to 200 N/mm², then the length and deflection at the centre of the spring are, respectively:

(Assume Modulus of elasticity as 2×10^5 N/mm²)

(a) 660 mm; 16.08 mm

(b) 760 mm; 26.08 mm

(c) 860 mm; 36.08 mm

(d) 960 mm; 46.08 mm

92. Ans: (d)

Sol: W = 2500 N, n = 12, b = 6 cm = 60 mm

t = 5 mm, σ = 200 MPa, E = 2×10^5 MPa

$$\sigma = \frac{3WL}{2nbt^2} \rightarrow L = 960 \text{ mm}$$

$$\text{Deflection, } \sigma = \frac{3WL^3}{8Enbt^3} = 46 \text{ mm}$$

93. A 150 N load is acting on a close coiled helical spring. The mean coil diameter has to be 12 times that of the wire diameter. If the maximum shear stress is not to exceed 150 N/mm², what is the diameter of the coil?

(a) 57.64 mm (b) 67.64 mm

(c) 77.64 mm (d) 87.64 mm

93. Ans: (b)

Sol: To solve this, use the maximum shear stress formula for a helical spring: $\tau = k\frac{8WD}{\pi d^3}$.

Given the spring index C = D/d = 12,

we first calculate the Wahl Correction Factor,

$$\frac{4C-1}{4C-4} + \frac{0.615}{C} \approx 1.12$$

Substituting the values (W = 150 N, τ = 150 N/mm²) into the rearranged formula $d^2 = \frac{8WCK}{\pi\tau}$, we find the wire diameter d ≈ 5.64 mm.

Finally, calculating the mean coil diameter D = C × d results in approximately 67.64 mm.

94. A circular rod of 20 mm diameter and 400 mm length is subjected to a tensile force of 50 kN. What is the volumetric strain, if Poisson's ratio = 0.25 and Young's modulus E = 2×10^5 N/mm² ?

(a) 79.57×10^{-5} (b) 39.75×10^{-5}

(c) 79.57×10^{-3} (d) 39.75×10^{-3}

94. Ans: (b)

Sol: $\varepsilon_V = \frac{(\sigma_x + \sigma_y + \sigma_z)}{E}(1-2\mu)$ $\quad \sigma_x = \frac{50 \times 10^3}{\frac{\pi}{4}(20^2)}$

$\sigma_x = 159.15$ MPa

$$= \frac{(159.15)(1-2\times0.25)}{2\times10^5} = 0.00039 \text{ mm}^3$$

$$= 39.75 \times 10^{-5} \text{ mm}^3$$

95. A rod which tapers uniformly from 30 mm diameter to 15 mm diameter in a length of 300 mm is subjected to an axial load of 6 kN. If Young's modulus is 2×10^5 N/mm², what is the elongation of the rod?

(a) $\frac{0.06}{\pi}$ mm (b) $\frac{0.08}{\pi}$ mm

(c) $\frac{0.6}{\pi}$ mm (d) $\frac{0.8}{\pi}$ mm

95. Ans: (b)

Sol: $\delta\ell = \frac{4(6\times10^3)(300)}{\pi(2\times10^5)(30\times15)} = \frac{0.08}{\pi}$ mm

96. Which one of the following is a measure of the ability of a material to absorb energy before fracture?

(a) Resilience

(b) Strain Energy Density

(c) Resilience Modulus

(d) Modulus of Toughness

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96. Ans: (d)

Sol: **Modulus of Toughness:** This represents the total area under the entire stress-strain curve from the origin to the point of fracture. It measures the ability of a material to absorb energy throughout both its elastic and plastic deformations.
Resilience / Modulus of Resilience: This is the area under the stress-strain curve only up to the elastic limit (yield point). It measures the energy a material can absorb and then release upon unloading without permanent deformation.
Strain Energy Density: This is the energy stored in a material per unit volume at any given state of strain.
Resilience Modulus: Often used in pavement engineering, this specifically refers to the elastic modulus of a material under repeated (cyclic) loading.

97. A 10 coils 120 mm mean diameter closely coiled helical spring is made up of a 12 mm steel wire. If the spring is carrying an axial load of 150 N, what is the maximum shear stress?
(Take modulus of rigidity $C = 8.16 \times 10^4$ N/mm^2)

(a) 16.52 N/mm^2 (b) 20.52 N/mm^2
(c) 26.52 N/mm^2 (d) 32.52 N/mm^2

97. Ans: (c)

Sol: $$\tau_{max} = \frac{16WR}{\pi d^3} = \frac{16(150)(60)}{\pi(12^3)}$$
$$= 2652 \text{ MPa}$$
$$= 26.52 \text{ N/mm}^2$$

98. The optimistic time estimate is defined as:
(a) The best guess of the minimum time that would be required to complete the activity.
(b) The best guess of the maximum time that would be required to complete the activity.
(c) The shortest possible time in which an activity can be completed, under ideal conditions.
(d) The longest possible time in which an activity can be completed, under any conditions.

98. Ans: (c)

Sol: **Optimistic time:** Shortest possible time under ideal conditions and it is also known as "Lower bound"
Pessimistic time: Highest duration under very bad/ worst conditions and this time is also known as "Upper bound"
Most likely time: This duration lies between optimistic and pessimistic times. The most likely time is possible under normal conditions.

99. What is the expected time of completion of an activity, if the optimistic time (t_o) is 4 days, most likely time (t_L) is 6 days and pessimistic time (t_p) is 11 days?
(a) 6.5 days (b) 9.5 days
(c) 3.25 days (d) 4.25 days

99. Ans: (a)

Sol: Expected time $(t_E) = \frac{t_0 + 4t_L + t_P}{6}$
$$= \frac{4 + 4(6) + 11}{6} = 6.5$$

100. Independent float is defined as:

(a) Maximum amount of time by which an activity can be delayed from early start without delaying the project.

(b) Maximum amount of time by which an activity can be delayed without delaying the early start of any following activity.

(c) Maximum amount of time by which an activity can be delayed without delaying the project but will cause delay to the early start of some following activity.

(d) Maximum amount of time by which an activity can be delayed without delaying the project; even if all predecessors are at late start and all successors at early start.

100. Ans: (d)

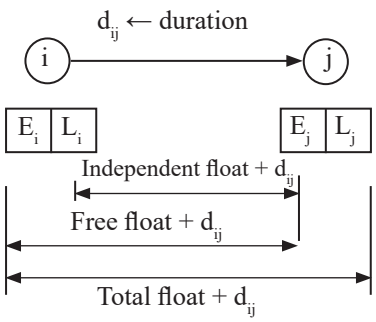
Sol: Independent float = $(E_j - L_i) - d_{ij}$

E_j = Earliest start time of succeeding activity

L_i = Latest start time of activity under consideration

Successor can start early $\Rightarrow E_j$

Predecessor can start early $\Rightarrow L_i$



101. The details of marks of the technical and the financial bids of four bidders, who bid for a project having an estimated cost of ₹ 1,00,000 are given as follows:

Contractor	Score of Technical Bid	Financial Bid (INR)
A	80	1,35,000
B	75	1,25,000
C	45	1,01,000
D	60	1,15,000

To whom can the contract be awarded with the following conditions:

1. Technical score must be more than 50.
2. Job is awarded to the bidder with highest composite score evaluated considering equal weightage for financial and technical bid.
3. The call may be cancelled if the award price deviates more than 20% of the estimated cost.

Choose the correct answer from the options given below:

(a) Cancel the call, though contractor B is technically qualified but quoted more than 20% of the estimated cost.

(b) Cancel the call, though contractor A is technically qualified but quoted more than 20% of the estimated cost.

(c) Cancel the call, though contractor D is technically qualified but quoted more than 20% of the estimated cost.

(d) Contractor C

101. Ans: (a)

Sol: Contractor 'c' is eliminated since his technical bid score is less than 50.

Contractor	Technical bid score	Financial bid score $= \frac{\text{Lowest bid}}{\text{Bid price}} \times 100$	Composite score = 0.5 × Technical bid score + 0.5 × Financial bid score
A	80	$\frac{115000}{135000} \times 100 = 85.18$	82.59
B	75	$\frac{115000}{125000} \times 100 = 92$	**83.5**
D	60	$\frac{115000}{115000} \times 100 = 100$	80

'B' has highest composite score, hence he is technical qualified, however the call may be canceled since the bid price is above 20% of the estimated project cost.

102. A construction firm is considering to execute a structural modification project in a running manufacturing mill. Due to technical reasons, the work is to be executed slowly and carefully. It is expected that only 20 tons of fabrication is possible in each month. The firm has an estimated fixed cost (equipment, supervision, overhead deployment) of ₹1,50,000 per month, variable cost (labour and material) of ₹ 30,000 per month and ₹ 35,000 for normal cost of fabrication. What is the rate that should be quoted by the firm to achieve at least 10% profit?

(a) ₹ 35,000 (b) ₹ 41,000
(c) ₹ 45,000 (d) ₹ 49,000

102. Ans: (d)

Sol: Fabrication possibility = 20 tons/month

Fixed cost = Rs. 150000 / month

Variable cost = Rs. 30000 / month

Normal cost of Fabrication = Rs. 35000

Total cost per month = 150000 +30000+35000 × 20

= 1,80,000 + 7,00,000

= 8,80,000

Total cost per ton $= \frac{8,80,000}{20} = 44000$

10% profit

Quoted price for getting 10% profit = 1.1× 44000

≈ 49000

103. A preliminary survey indicates that 20% of the time of a gang of workers is spent idly. What is the total number of observations required to determine the proportion of idle time within +/-5% with 95% confidence limit?

(Take Z values as 2.0)

(a) 256 (b) 128 (c) 512 (d) 1024

103. Ans: (a)

Sol: Idle time percentage = 20%

$\Rightarrow P = 0.2$

Confidence level = 95%

z = 2.0 (given)

error (e) = ± 5% (or) 0.05

Number of observations $(n) = \frac{z^2 P(1-P)}{e^2}$

$= \frac{(2)^2 \times 0.2 \times 0.8}{(0.05)^2}$

= 256

104. Construction of a military helipad at an altitude of 2400 m involves 88000 m^3 (loose) of excavation area in soft soil. This task needs to be completed in 200 working hours. The company entrusted two dozers, each with an output of 220 m^3/h under job conditions for task execution. It also holds wheel loaders and 22 m^3 dump trucks. One loader can load in trucks, about 120 m^3 of excavated soil per hour. The dump truck cycle time for disposal of excavated materials is 40 minutes. This includes 8 minutes of loading time by a loader team that consists of 2 loaders. In this case, the total number of dumpers required to complete the task on time is:
(a) 6 (b) 12 (c) 18 (d) 24

104. Ans: (c)

Sol: Required Production Rate = 88000 / 200 m3/hr
= 440 m^3/hr

Dumper Truck Production per Truck
Trips per hour = 60 / 40
= 1.5 trips/hr
Production per Truck = 1.5 × 22 = 33 m^3/hr
Number of Trucks needed = 440 / 33
= 13.33 (say 14)

18 No of trucks is the nearest option which can handle the production.

105. What is the amount of water required per hour for compacting loose soil being spread by a shovel and dozer at the rate of 230 m^3/h for a soil having density of 1.5 gm/m^3 and 8% moisture content needing 12% optimum moisture content for compaction?
(a) 6900 litres/hour (b) 13800 litres/hour
(c) 20700 litres/hour (d) 27600 litres/hour

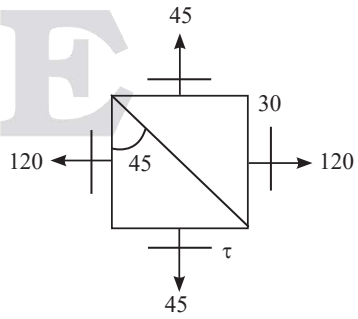
105. Ans: (b)

Sol: % of moisture to be added = 12% - 8%
= 4%
Soil compacted per hour = 230 × 1500
= 345000 kg/m^3
(Considering density of soil = 1500 kg/m^3)
Water required = 0.04 × 345000 kg/hr.
= 13800 kg/hr.
= 13800 Ltr/hr
(Since density of water is 1kg / Ltr)

106. An element in plane stress is subjected to normal stresses p_1 = 120 N/mm^2 and p_2 = 45 N/mm^2 (both are tensile stresses) and shearing stress of 30 N/mm^2 (simple shear). What is the normal stress (p_n) acting as an element rotated through an angle 45°
(a) $P_n = -37.5\ N/mm^2$
(b) $P_n = 52.5\ N/mm^2$
(c) $P_n = -73.5\ N/mm^2$
(d) $P_n = 112.5\ N/mm^2$

106. Ans: (d)

Sol:



$$\sigma_\theta = \frac{120+45}{2} + \frac{120-45}{2}\cos(2\times 45) + 30\sin(2\times 45)$$
$$= \frac{165}{2} + 30(1) = 112.5\ MPa$$

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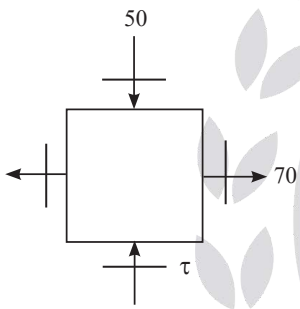
107. At a point in an elastic material, a direct tensile stress of 70 N/mm^2 and a direct compressive stress of 50N/mm^2 are applied on planes at right angles to each other. If the maximum principal stress in the material is limited to 75 N/mm^2 what is the shear stress?

(a) 65 N/mm^2 (b) 55 N/mm^2
(c) 75 N/mm^2 (d) 25 N/mm^2

107. Ans: (a)

Sol:



$\sigma_1 = 75$ MPa

$\tau_{max} = ?$

$\sigma_x + \sigma_y = \sigma_1 + \sigma_2$

$70 + (-50) = 75 + \sigma_2$

$20 = 75 + \sigma_2$

$20 - 75 = \sigma_2$

$[\sigma_2 = -55]$

$$\tau_{max} = \frac{75-(-55)}{2} = \frac{30}{2} = 65\text{MPa}$$

108. A material has strength in tension, compression and shear as 30 N/mm^2, 90 N/mm^2 and 25 N/mm^2 respectively. If a specimen of diameter 25 mm is tested in compression, then identify the failure load and failure plane.

(a) Failure load is 14726 N and failure plane is 30° to the plane of axial compression
(b) Failure load is 24543 N and failure plane is 45° to the plane axial compression
(c) Failure load is 36574 N and failure plane is 60° to the plane of axial compression
(d) Failure load is 18745 N and failure plane is 90° to the plane of axial compression

108. Ans: (b)

Sol: $\sigma_{ten} = 30$

$\sigma_{comp} = 90$ MPa ; $\sigma_{shear} = 25$

$P_C = (\sigma_C)(A) = 90\ (490.9) = 44.18$ kN ..... (i)

$\tau_{max} = \frac{\sigma}{2} \rightarrow \frac{\sigma}{2} = 25 \rightarrow \sigma = 50$ MPa

$P_C = \sigma \cdot A = 50\ (490.8) = 24545$ N

Shear failure occurs first @ 24.54 kN
(least of (1) & (2)

The material fails at the lower of the two loads. Therefore, it fails in shear at 24,545 N. In axial loading, the maximum shear stress always occurs on a plane inclined at 45° to the direction of the load.

109. A simply supported beam of span 3.0 m has a cross-section matrix 120mm × 180mm . If the permissible stress in the material of the beam is 10 N/mm^2, what is the maximum uniformly distributed load (UDL) that it can carry, (Ignore the moment due to self-weight)

(a) 9.72kN /m (b) 4.52 kN/m
(c) 5.76kN / m (d) 8.80kN / m

109. Ans: (c)

Sol: $f = M/Z$

but $M = \frac{wl^2}{8}$

$Z = \frac{bd^2}{6}$

$f = 10 = \frac{\left(\frac{wl^2}{8}\right)}{Z}$

$10 = \left[\frac{(w)(3000^2)}{8}\right] \Big/ \left[\frac{120 \times 180^2}{6}\right]$

$w = 5.76$ N/mm or 5.76 kN/m

110. A surveyor's steel tape 30 m long has a cross-section of 15mm×0.75 mm. With this, line AB is measured as 150 m. If the force applied during measurement is 120 N more than the force applied at the time of calibration, what is the actual length of the line? (Take the modulus of elasticity for steel as 200 kN/mm²)

(a) 149.992 m (b) 150.008 m

(c) 151.016 m (d) 148.008 m

110. Ans: (b)

Sol: $A = 15 \times 0.75$ mm²

M.L = 150 m

$\Delta P = 120$ N

$E = 200$ kN/mm²

$CL = ML + C_{Pull}$

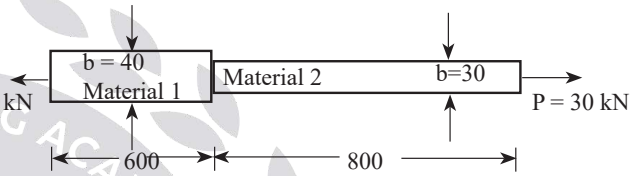
$= 150 + \frac{\Delta PL}{AE}$

$= 150 + \frac{120 \times 150}{15 \times 7.5 \times 200 \times 10^3}$

$= 150.008$ m

111. The stepped bar shown in the figure is made up of two different materials. Material 1 has Young's modulus = 2×10^5N /mm², while that of Material 2 is 1×10^5 N /mm² . What is the extension of the bar under a pull of 30 kN if both the portions are 20 mm in thickness?

(The dimensions shown below are in mm)



(a) 0.5125 mm (b) 0.4000 mm

(c) 0.1125 mm (d) 0.2875 mm

111 Ans: (a)

Sol: $\delta l = \frac{30 \times 10^3}{10^5}\left[\frac{600}{40 \times 20 \times 2} + \frac{800}{30 \times 20 \times 1}\right]$

$= 0.5125$ mm

112. Two parallel walls, 8 m apart, are stayed together by a steel rod of 20 mm diameter passing through metal plates and nuts at each end. The nuts are screwed up to the plates while the bar is at a temperature of 400 K. What is the pull exerted by the bar after it has cooled to 300 K, if the total yielding at the two ends is 5 mm?

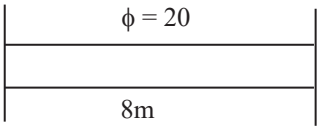
(Take coefficient of thermal expansion for steel as 12×10^{-6} per K and Young's modulus of steel as 2×10^5 N/mm²)

(a) 75.398 kN (b) 240 kN

(c) 115 kN (d) 36.128 kN

112. Ans: (d)

Sol:



Free expansion

$\delta l = l\alpha\,\Delta T$

$= 8000\,(1.2 \times 10^{-6})\,(100)$

$= 9.6$ mm

$\Delta t = 100^{o}$ k

Yield = 5 mm

Expansion prevented = 9.6 – 5 = 4.6 mm

$$4.6 = \frac{Pl}{AE}$$

$$P = \frac{4.6\left(\frac{\pi}{4}\right)(20^2)\,(2 \times 10^5)}{8000} = 36128 \text{ N}$$

$= 36.128$ kN

113. Which one of the following statements is ***not*** correct regarding principal stresses and planes?

(a) The planes on which shearing stresses are zero are called principal planes and the stresses normal to principal planes are known as principal stresses.

(b) The principal planes are the planes of maximum or minimum normal stresses.

(c) The planes of extreme shearing stresses are at 90° to the principal planes.

(d) The sum of normal stresses in any two mutually perpendicular directions is constant in case of a general two-dimensional stress.

113. Ans: (c)

Sol: **(a) Correct:** By definition, principal planes are those specific orientations where the shear stress (τ) is zero. The normal stresses acting on these planes are the principal stresses.

(b) Correct: Principal stresses represent the mathematical extrema (maximum and minimum) of normal stresses at a given point.

(c) Incorrect: The planes of maximum/extreme shearing stress are actually at 45° to the principal planes, not 90°. In a Mohr's Circle, these planes are 90° apart, but in the physical element (real space), the angle is halved.

(d) Correct: This is known as the First Invariant of Stress. For any two mutually perpendicular planes (e.g., x and y), the sum $\sigma_x + \sigma_y$ remains constant, regardless of the angle of inclination.

114. What is the maximum torque T_E that can be applied to a solid steel cylindrical shaft 8 cm in diameter, if the shaft is to remain elastic? (Take the elastic limit in shear and the shear modulus as $\tau_0 = 145$ MPa and G = 76 GPa, respectively)

(a) 14,580 N-m (b) 7,290 N-m

(c) 3,645 N-m (d) 29,160 N-m

114. Ans: (a)

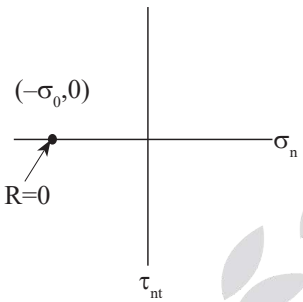
Sol: $\tau_{max} = \frac{16T}{\pi d^3}$

$$145 = \frac{16(T)}{\pi\,(80^3)}$$

$T = 14.58$ kN-m

≈ 14580 N-m

115. Given the state of stress $\sigma_x = \sigma_y = -\sigma_0$ (where $\sigma_0 > 0$) and $\tau_{xy} = 0$ as figure, which one of the following statements is ***not*** correct?



(a) The radius of the Mohr circle R = 0
(b) No shear stress exists on any plane passing through this point.
(c) The state of stress shown here is called a state of 'Pure Shear'.
(d) The normal stress is same for all planes passing through this point.

115. Ans: (c)

Sol: (c) Incorrect: This state is not "Pure Shear." A state of Pure Shear occurs when $\sigma_x = -\sigma_y$ (equal tension and compression), which results in a Mohr circle centered at the origin with a non-zero radius. This state is actually Hydrostatic Stress.

116. A fixed-fixed beam 'AB' of length 3 m is subjected to a point load of 45 kN at a distance 2 m from left support 'A'. What are the vertical reaction forces at both the supports 'A' and B'?
(a) R_A = 15kN and R_B = 30kN
(b) R_A = 15kN and R_B = 11.67kN
(c) R_A = 33.33kN and R_B = 30kN
(d) R_A = 11.67kN and R_B = 33.33kN

116. Ans: (d)

Sol: Given Values
Load (W): 45 kN
Distance from A (a): 2 m
Distance from B (b) : 3 – 2 = 1 m
Total Length (L): 3 m

$$R_A = \frac{Wb^2(3a+b)}{L^3}$$

$$= \frac{45 \times 1^2 \times (3(2)+1)}{3^3} = 11.67 \text{ kN}$$

$$R_B = \frac{Wa^2(3b+a)}{L^3}$$

$$= \frac{45 \times 2^2 \times (3(1)+2)}{3^3} = 33.33 \text{ kN}$$

117. A cantilever wooden beam is 3 m long and carries a UDL of 4 kN/m. The cross-section of the beam is 100 mm width and 200 mm depth. What is the maximum bending stress for this section?
(a) 2.7 MPa (b) 27 MPa
(c) 270 MPa (d) 0.27 MPa

117. Ans: (b)

Sol: $f_{max} = \frac{M}{Z}$

$$\left[Z = \frac{100 \times 200^2}{6}\right]; \left[M = \frac{wl^2}{2} = \frac{(4)(3)^2}{2}\right]$$

M = 18 kN-m
f_{max} = 27 MPa

118. In the context of measures of surfaces, which one of the following is not correct?
(a) 1Sq. mile = 2.590.Sq. kilometres
(b) 1Sq. mile = 259 Hectares
(c) 1Sq. mile = 640 Acres
(d) 1Sq. mile = 10^9 Sq. centimetres

118. Ans: (d)

Sol: Standard Relations

1 sq mile $= 2.59\ km^2$

$= 259\ Ha$

$= 640\ Ha$

$= 2.59 \times 10^{10}\ cm^2$

119. A hollow steel column carrying an axial load of 2.1 MN has an ultimate stress of $510 N/mm^2$. The internal diameter of the column is 150 mm. Consider the factor of safety as 4. What is the external diameter of the column?

(a) 201.49 mm (b) 208. 49 mm

(c) 214.49 mm (d) 218.49 mm

119. Ans: (b)

Sol: $P = 2.1 \times 10^6\ N$; $FS = 4$

$\sigma = 510\ MPa$; $d_i = 150$; $d_o = ?$

$$\therefore \frac{\sigma}{FS} = \frac{P}{A}$$

$$\frac{510}{4} = \frac{2.1 \times 10^6}{\frac{\pi}{4}(d_o^2 - 150^2)}$$

$$d_o^2 = 43471$$

$$d_o = 208.49\ mm$$

120. The tensile stresses at a point across two mutually perpendicular planes are 150N / mm^2 and 80N/ mm^2.What are the tangential and normal stresses, respectively, on a plane inclined at 30° to the axis of the minor stress?

(a) 112.5 N/mm^2 ; 10.31 N/mm^2

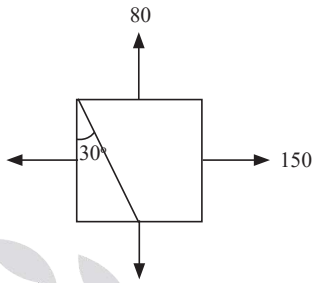
(b) 122.5 N/mm^2; 20.31 N/mm^2

(c) 132.5N / mm^2; 30.31 N / mm^2

(d) 142.5N / mm^2 ; 40.31 N / mm^2

120. Ans: (c)

Sol:



Shear stress on $\theta = 30^o$ plane

$$\tau_\theta = \frac{150 - 80}{2} \sin(2 \times 30)$$

$$= 35\left(\frac{\sqrt{3}}{2}\right) = 30.31\ MPa$$

121. As per IS 1893 : 2016, what is the percentage of imposed load to be considered in the calculation of seismic weight, if the imposed uniformly distributed floor load is 4 kN/m^2?

(a) 25 (b) 50 (c) 40 (d) 75

121. Ans: (d)

Sol: Under IS 1893 (Part 1) : 2016, specifically in Table 10, the code specifies the percentage of imposed (live) load to be considered for calculating the seismic weight of a building. The percentage depends on the intensity of the uniformly distributed load (UDL).

Imposed Uniformly Distributed Floor Load (kN/m^2)	Percentage of Imposed Load
Up to and including 3.0	25 %
Above 3.0	50%

122. Which one of the following statements is **not** correct regarding the response reduction factor?
(a) It accounts for inherent system ductility.
(b) It accounts for redundancy.
(c) It influences the non-linear behaviour of a building during strong earthquake shaking.
(d) It accounts for the importance of the building

122. Ans: (d)

Sol: The response reduction factor is a numerical value used in seismic codes (IS 1893)
Importance of building is typically accounted for by a separate parameter known as importance factor (I) but not reduction factor (R)

123. Which one of the following statements in **not** correct regarding the working stress method?
(a) Stress-strain relation is considered linear till yield stress.
(b) To take care of uncertainties in the design, permissible stress is kept as a fraction of yield stress
(c) Increase of permissible stresses by 25% is permitted when dead load, live load and wind load are considered.
(d) Working stress method gives the uneconomical sections.

123. Ans: (c)

Sol: As per IS 456 code the permissible stresses in concrete and steel shall be increased by 33.33% when the structure is subjected to wind load (or) earthquake load in addition to dead load and live load.

124. As per IS 800:2007, the maximum effective slenderness ratio for 'members always in tension (other than pre-tensioned members)' is:
(a) 180 (b) 250 (c) 350 (d) 400

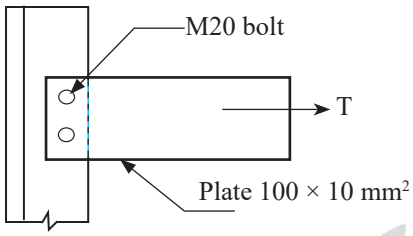
124. Ans: (d)

Sol: IS 800-2007; Table '3' the code specifies limits for the maximum effective slenderness ratio (KL/r) to prevent excessive sagging or vibration in structural members.

Table - 3 Maximum Values of effective slenderness ratio

Member	Maximum effective slenderness ratio (KL/r)
A member carrying compressive loads resulting from dead loads and imposed loads	180
A tension member in which a reversal of direct stress occurs due to loads other than wind or seismic forces.	180
A member subjected to compression forces resulting only from combination with wind/earthquake actions, provided the deformation of such member does not adversely affect the stress in any part of the structures.	250
Compression flange of a beam against lateral torsional buckling	300
A member normally acting as a tie in a roof truss or a bracing system not considered effective when subject to possible reversal of stress into compression resulting from the action of wind or earthquake forces.	350
Members always under tension (other than pre-tensioned members)	400

125. What is the net area for the tension member shown in the figure, in case of punched holes?



(a) 560 mm²
(b) 1000 mm²
(c) 520 mm²
(d) 440 mm²

125. Ans: (c)

Sol: $A_n = (B - n'd_o)\, t$

→ For punched holes

d_o = d + clearance + 2 mm

= 20 + 2 + 2 = 24 mm

$A_n = (100 - 2 \times 24)\, 10 = 520 \text{ mm}^2$

126. What is the design tensile strength of the plate 130mm × 12mm with holes for 16 mm diameter bolts by considering yielding of gross section?
(Take $f_y = 250\text{N/mm}^2$ and $\gamma_{m0}=1.1$)

(a) 332.986 kN
(b) 340.570 kN
(c) 354.545 kN
(d) 380.765 kN

126. Ans: (c)

Sol: Based on gross section yielding

$$T_{dg} = \frac{A_g f_y}{\gamma_{mo}} = \frac{(130 \times 12)250}{1.1}$$

$= 354.545 \times 10^3$ N $= 354.545$ kN

127. Consider the following statements:
The design strength of a tension member is the lowest of:
1. Design strength due to yielding of gross-section.
2. Rupture strength of critical section.
3. The block shear strength.

Which of the above statements are correct?

(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

127. Ans: (d)

Sol: Design tensile strength of member (T_d)

T_d is smaller of → T_{dg}, → T_{dn}, → T_{db}

where,

T_{dg} is based on gross section yielding

T_{dn} is based on net section rupture

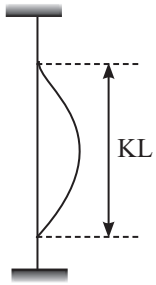
T_{db} is based on block shear failure

128. As per IS 800:2007, what is the effective length of prismatic compression member for the restrained (both in translation and rotation) boundary conditions at both the ends?
(Take L as actual length of the member)

(a) 2 L
(b) 0.65 L
(c) 0.8 L
(d) 1.2 L

128. Ans: (b)

Sol:



Effective length (KL) = 0.65L

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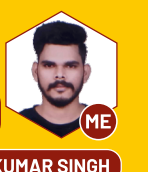
AIR 10 —  ME — AMIT KUMAR SINGH

Total 36 Ranks in Top-10 (E&T:10 | EE: 09 | CE:07 | ME: 10)

129. What is the working load of a compression member with effective sectional area as 7500 mm^2 and design compressive stress of 300 N/mm^2?
(Take factor of safety (FOS) = 1.5)
(a) 2250 kN (b) 1500 kN
(c) 750 kN (d) 562.5 kN

129. Ans: (b)

Sol: Working load $= \frac{\text{Design load}}{\text{FOS}} = \frac{\text{Stress} \times \text{Area}}{\text{FOS}}$

$= \frac{300 \times 7500}{1.5}$

$= 1500 \times 10^3$ N

$= 1500$ kN

130. Which one of the following statements related to a design of laced columns as per IS 800:2007 is not correct?
(a) The slenderness ratio for lacing bars should not exceed 145.
(b) In bolted/riveted construction, the minimum width of lacing bars shall be four times the nominal diameter of the bolt/rivet.
(c) Lacing bars should be inclined at 40° to 70° to the axis of built up member.
(d) The effective slenderness ratio of laced columns shall be taken as 1.05 times the actual maximum slenderness ratio, in order to account for shear deformation effects.

130. Ans: (b)

Sol: **(a) Correct:** The slenderness ratio (kl/r) for lacing bars is strictly limited to 145 to prevent the individual lacing components from buckling.

(b) Incorrect: In bolted or riveted construction, the minimum width of lacing bars should be three times the nominal diameter of the bolt/rivet, not four times.

(c) Correct: To ensure efficient truss action, lacing bars must be inclined at an angle between 40° and 70° relative to the axis of the built-up member.

(d) Correct: Because laced columns are less stiff than solid columns due to shear deformation, the code requires increasing the actual maximum slenderness ratio by 5% (a factor of 1.05) for design purposes.

131. A roof of a hall measuring 8 m × 12 m consists of 100 mm thick reinforced concrete slab supported on I-beams spaced 3 m apart. The steel beam is designed considering finishing load of 1.5 kN/m^2 and live load of 1.5 kN/m^2. What is the permissible deflection for this beam as per IS 800:2007, by considering effective length of beam as 9 m?
(a) 27.67 mm (b) 14.5 mm
(c) 30 mm (d) 35 mm

131. Ans: (c)

Sol: As per IS800-2007, Permissible deflection $= \frac{\text{Span}}{300}$

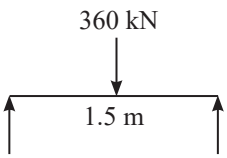
$= \frac{9000}{300}$

$= 30$ mm

132. A simply supported beam of effective span 1.5 m is carrying a factored concentrated load of 360 kN at mid span. What is the section modulus of the beam?
(Take $f_y = 250$N / mm^2 and $\gamma_{m0} = 1.1$)
(a) 594 $\times 10^3$ mm^3 (b) 651$\times 10^3$mm^3
(c) 768$\times 10^3$ mm^3 (d) 256$\times 10^3$mm^3

132. Ans: (a)

Sol:



$f_y = 250\ N/mm^2$

$\gamma_{mo} = 1.1$

$$BM(M) = \frac{WL}{4} = \frac{360 \times 1.5}{4} = 135\ kN\text{-}m$$
$$= 135 \times 10^6\ N\text{-}mm$$

Design moment = Design stress × Sectional modulus

$$135 \times 10^6 = \frac{f_y}{1.1} \times \text{sectional modulus}$$

Sectional Modulus = $594 \times 10^3\ mm^3$

133. What is the effective length of a simply supported beam of span length 7 m for the following restraint conditions at the support under normal loading conditions?

Torsional restraint: Fully restrained;

Warping restraint: Both the flanges fully restrained

(a) 5.25 m (b) 5.95 m

(c) 4.90 m (d) 6.30 m

133. Ans: (c)

Sol: From Table 15 [As per IS800-2007]

Table 15 Effective Length for Simply Supported Beams, L_{LT}

(*Clause* 8.3.1)

Sl No.	Conditions of Restraint at Supports		Loading Condition	
	Torsional Restraint	Warping Restraint	Normal	Destabilizing
(1)	(2)	(3)	(4)	(5)
i)	Fully restrained	Both flanges fully restrained	0.70 *L*	0.85 *L*
ii)	Fully restrained	Compression flange fully restrained	0.75 *L*	0.90 *L*
iii)	Fully restrained	Both flanges fully restrained	0.80 *L*	0.95 *L*
iv)	Fully restrained	Compression flange partially restrained	0.85 *L*	1.00 *L*
v)	Fully restrained	Warping not restrained in both flanges	1.00 *L*	1.20 *L*
vi)	Partially restrained by bottom flange support connection	Warping not restrained in both flanges	1.0 *L* + 2 *D*	1.2 *L* + 2 *D*
vii)	Partially restrained by bottom flange bearing support	Warping not restrained in both flanges	1.2 *L* + 2 *D*	1.4 *L* + 2 *D*

NOTES
1 Torsional restraint prevents rotation about the longitudinal axis.
2 Warping restraint prevents rotation of the flange in its plane.
3 *D* is the overall depth of the beam.

Effective length = 0.70 L = 0.70 × 7 = 4.9 m

134. What is the bending moment in case of continuous purlins?
(Take the effective length of the purlin as L and load intensity as w)
(a) $wL^2 / 8$ (b) $wL^2 / 10$
(c) $wL^2 / 32$ (d) $wL^2 / 24$

134. Ans: (b)

Sol: IS:800 recommends the purlins to be designed as continuous beams
Design BM is $\frac{wL^2}{10}$

135. In the case of stiffened seated connection, to avoid local buckling, typically the ratio of outstanding leg length to its thickness should be:
(a) greater than 8 (b) less than 8
(c) less than 16 (d) greater than 16

135. Ans: (c)

Sol: The stiffening leg should have sufficient bearing area. Its thickness may be kept not less than the web thickness of the supported beam. To avoid local buckling, the ratio of outstanding leg length to its thickness should be less than 16.

136. What is the time required to grade and finish 30 km of road formation with width equal to thrice the width of the motor grader, using six passes of the motor grader with speed for each of the successive two passes as 6 km/h, 8 km/h and 10 km/h, respectively?
(Take machine efficiency based on operator's skill, machine characteristics and working conditions as 75%)
(a) 45 hours (b) 15 hours
(c) 90 hours (d) 60 hours

136. Ans: (c)

Sol: Given, Road width = 3 × blade width.
Each strip of grader width needs 6 passes.
Thus, each full road width needs 18 passes lengthwise.
Two passes at 6 km/hr needs = 30×2/6 Hrs =10 Hrs.
Two passes at 8 km/hr needs = 30×2/8 Hrs=7.5 Hrs.
Two passes at 10 km/hr needs = 30× 2/10 Hrs
= 6 Hrs.
Total Time for One Blade Width = 10 + 7.5 + 6
= 23.5 Hrs.
Total Time for Full Road Width = 3 × 23.5 Hrs
= 70.5 Hrs
Given efficiency = 75%
Total Time for Full Road Width = 70.5 / 0.75 Hrs
= 94 Hrs
Among the given options 90 hrs is the nearest option.

137. Match the following lists:

List-I

P. ISO 9001:2015
Q. ISO 9004:2018
R. ISO 10005:2018
S. ISO 10006:2017

List-II

1. Guidelines for Quality Plans
2. Requirements for Quality Management Systems
3. Guidelines for Quality Management in Projects
4. Guidelines to achieve Sustained Success

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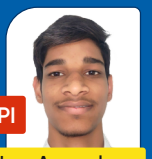

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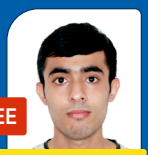

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AIR 10 CE Adnan Quasain

& many more...

Total 41 Ranks in Top-10

(ME: 10 | EC: 04 | EE: 05 | CE: 04 | CS: 02 | IN: 05 | DA: 01 | PI: 07 | XE: 02 | ES: 01)

Select the correct answer using the code given below:

	P	Q	R	S
(a)	2	4	1	3
(b)	4	2	1	3
(c)	1	2	4	3
(d)	3	1	2	4

137. Ans: (a)

Sol: **ISO 9001:2015 (2):** The core standard specifying the Requirements for a Quality Management System (QMS).

ISO 9004:2018 (4): Provides guidelines for moving beyond basic requirements to achieve Sustained Success and performance improvement.

ISO 10005:2018 (1): Offers specific guidelines for developing and using Quality Plans.

ISO 10006:2017 (3): Focuses on quality management principles within Projects.

138. For the following data, what is the rate of crashing?

Crash cost = INR 10,000

Normal cost = INR 5,000

Normal time = 10 days

Crash time = 5 days

(a) INR 1000/day (b) INR 5000/day

(c) INR 10000/day (d) INR 500/day

138. Ans: (a)

Sol: Crash cost slope

$$= \frac{\Delta C}{\Delta T} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$$

$$= \frac{10000 - 5000}{10 - 5} = 1000/\text{day}$$

139. Under time-related financial incentive schemes, the employee is paid :

(a) according to the overtime worked in proportion to the basic hourly wages and regulatory measures

(b) according to the measurable completed job

(c) for completing the fixed quantity of a specified job

(d) as bonus after a pre-determined time

139. Ans: (d)

Sol: Time related financial incentive scheme is specified, hence option (a) (or) option (d) will be the answer. Predetermined time is the standard time for a particular job. If an employee could complete the job less than the standard time then the incentive scheme is applied and bonus is paid.

140. Considering A and B as two activities of a project, what are the standard deviation of Activity A and B?

Activity A	**Activity B**
Optimistic time	Optimistic time
$(t_o) = 4$ days	$(t_o) = 4$ days
Most likely time	Most likely time
$(t_L) = 7$ days	$(t_L) = 6$ days
Pessimistic time	Pessimistic time
$(t_p) = 16$ days	$(t_p) = 22$ days

(a) Standard deviation of Activity A = 2 and B = 3

(b) Standard deviation of Activity A = 6 and B = 9

(c) Standard deviation of Activity A = 4 and B = 6

(d) Standard deviation of Activity A = 4.5 and B = 3

140. Ans: (a)

Sol:

Activity	Standard deviation $(\sigma) = \frac{t_p - t_0}{6}$
A	$\frac{16-4}{6} = 2$
B	$\frac{22-4}{6} = 3$

141. If the standard deviation is 4 N/mm² and the desired characteristic strength is 20 N/mm² what is the mean strength of concrete?
(a) 26.4N / mm² (b) 14.6N/mm²
(c) 28 N /mm² (d) 16N / mm²

141. Ans: (a)

Sol: Mean strength of concrete
$f_m = f_{ck} + 1.65\sigma$
$= 20 + 1.65 \times 4 = 26.6$ N/mm²

142. As per IS 456:2000, what is the creep coefficient of concrete at the age of 28 days of loading?
(a) 2.2 (b) 1.1 (c) 1.6 (d) 2.8

142. Ans: (c)

Sol:

Age	Creep Co-efficient
7 days	2.2
28 days	1.6
1 year	1.1

143. As per IS 875 (Part 2) 1987, what is the minimum imposed load that needs to be considered for living rooms?
(a) udl = 3 kN/m²; concentrated load = 4.5 kN
(b) udl = 4 kN/m²; concentrated load = 2.7 kN
(c) udl = 2.5 kN/m²; concentrated load = 2.7 kN
(d) udl = 2 kN/m²; concentrated load = 1.8 kN

143. Ans: (d)

Sol: As per IS 875 (Part 2) – 1987, the minimum imposed load for living rooms (residential buildings) is:
Uniformly Distributed Load (UDL) = 2 kN/m²
Concentrated Load = 1.8 kN

144. What is the typical unit weight of brick masonry used by designers?
(a) 24 kN /m³ (b) 20 kN/m³
(c) 0.13kN/m³ (d) 25kN/m³

144. Ans: (b)

Sol: Unit weight of brick masonry is 20 kN/m³ for structural design.

145. Which one of the following statements related to IS 875 (Part 3) - 1987 is **not** correct?
(a) The design wind velocity depends on terrain, height and structure size.
(b) The design wind depends on topography.
(c) The design wind pressure is 0.6 × (design wind velocity)²
(d) Up to a height of 50 m, the wind pressure is considered to act uniformly.

145. Ans: (d)

Sol: **(d) Incorrect:** Wind pressure does not act uniformly up to 50 m. Under IS 875, wind velocity (and thus pressure) increases with height due to the reduction in ground friction. While older or simpler codes might have used simplified pressure blocks, the 1987 code requires calculating pressure at various height intervals to account for this gradient.

146. As per IS 875 (Part 2) - 1987, what is the reduction in total distributed imposed load (in percent) for design of supporting structural elements in a structure with 10 floors?
(a) 10% (b) 20% (c) 30% (d) 40%

146. Ans: (d)

Sol: As per is 875 (part 2) - 1987 the redistribution in total distribution imposed load

For one floor = 0%

For two floors = 10%

For five floors = 30%

For five to ten floors = 40%

147. A one-way slab has effective span of 3.6 m and is 150 m thick. The live load expected on it is 3kN/m². What is the load for checking serviceability?

(a) 14.4 kN (b) 6.75 kN

(c) 0.75 kN (d) 16.40 kN

147. Ans: (b)

Sol: Dead load = $\gamma D = 2.5 \times 0.15 = 3.75$ kN/m²

Live load = 3 kN/m²

Total load for checking serviceability per m²

$= 3.75 + 3 = 6.75$ kN

148. As per IS 456:2000, the strength of concrete achieved in structure is taken as:

(a) $(2/3)^{rd}$ times the strength of the cube cast at laboratories.

(b) $(1/3)^{rd}$ times the strength of the cube cast at laboratories.

(c) $(1/6)^{th}$ times the strength of the cube cast at laboratories.

(d) $(1/4)^{th}$ times the strength of the cube cast at laboratories.

148. Ans: (a)

Sol: As per IS456-2000, the strength of concrete achieved in structures is taken as 0.67 times cube strength of concrete.

149. As per IS 456:2000, which one of the following statements is ***not*** correct?

(a) The strain diagram across the depth of the cross-section is linear.

(b) The tensile strength of concrete is ignored.

(c) The stress in steel shall correspond to strain in steel.

(d) If a partial safety factor of 1.15 is used for design purpose, then the maximum stress in steel is limited to $0.45f_y$. (Where f_y = characteristic strength of steel)

149. Ans: (d)

Sol: As per IS 456-2000, the design strength of steel is $0.87f_y$

i.e., $f_d = \frac{0.67f_y}{\gamma_s} = \frac{0.67f_y}{1.15} = 0.87f_y$

150. As per IS 1893:2016, what is the value of constant 'A' in the equation mentioned below for determining cyclic stress ratio (CSR)?

$$CSR = A\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{v0}}{\sigma'_{v0}}\right)r_d$$

Where, a_{max} = Peak ground acceleration (PGA) preferably in terms of g,

g = acceleration due to gravity,

r_d = stress reduction factor.

(a) 0.5 (b) 0.15 (c) 0.36 (d) 0.65

150. Ans: (d)

Sol: As per IS 1893 (Part 1): 2016, the cyclic stress ratio (CSR) is given by:

$$CSR = 0.65\left(\frac{a_{max}}{g}\right)\left(\frac{\sigma_{v0}}{\sigma'_{v0}}\right)r_d$$

Hence, the value of constant A = 0.65

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