# MADE EASY

# ESE 2023
# Preliminary Examination

## Detailed Solutions

## CIVIL ENGINEERING

Set **A**

Exam held on 19-02-2023

## Civil Engineering Paper Analysis of ESE 2023 Preliminary Examination

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## UPSC ESE Prelims 2023 Civil Engineering analysis
### by MADE EASY faculties
https://www.youtube.com/watch?v=bMxUUrmh9AQ

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**1.** According to Terzaghi, a foundation is shallow if its
  (a) depth is equal to or less than its width
  (b) depth is twice the width
  (c) width is thrice the depth
  (d) width is one fourth of depth

**Ans.** **(a)**
  According to Terzaghi,

  For shallow foundation, $\dfrac{D_f}{B} \leq 1$

  For deep foundation, $\dfrac{D_f}{B} > 1$

<div align="right">**End of Solution**</div>

**2.** The ultimate bearing capacity is
  (a) the minimum net pressure intensity causing shear failure of soil
  (b) the minimum gross pressure at the lose of the foundation at which the soils fails in shear.
  (c) the difference in intensities of the gross pressure after the construction of the structure.
  (d) the total pressure at the base of the footing due to the weight of the superstructure.

**Ans.** **(b)**
  • Ultimate bearing capacity is the minimum gross pressure intensity at the base of foundation at which the soil fails in shear.
                             OR
  • Ultimate bearing capacity is the maximum gross pressure the soil can support without shear failure.

<div align="right">**End of Solution**</div>

**3.** Which one of the following is NOT the common nomenclature of geosynthetics?
  (a) Geotextiles              (b) Geogrids
  (c) Geogrouts               (d) Geonets

**Ans.** **(c)**
  Geosynthetics are the synthetic fabrics used in various geotechnical applications such as road and railway embankments, earth dikes and coastal protection structures designed to perform one or more basic functions such as filtration, drainage, separation of soil layers, reinforcement or stablizations. Various Geosynthetic are Geotextiles, Geogrids, Geonets, Geosynthetic clay linear, Geomembrane, Geocomposity, Geofoams.

<div align="right">**End of Solution**</div>

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**4.** Which one of the following is an advantage when geotextiles is used in road works?
(a) Prior stripping of the natural soil
(b) Economy of aggregate
(c) Increase of different settings
(d) Slower consolidation of fills

**Ans. (b)**
The most frequent role of geotextiles is road construction is as a separator between the subgrade and subbase. This prevents the subgrade material from intruding into sub-base due to repeated traffic loading. The savings in sub-base materials, which would otherwise be lost due to mixing with the subgrade.

*End of Solution*

**5.** Consider the following statements related to ultimate bearing capacity of footing based on the SPT and CPT values:
1. The empirical correlations established in the USA between $N$ and soil properties indicate the value of $N$ conforms to certain standard energy ratios.
2. The value of $N$ to be used for getting $\phi$ is the corrected values for standard energy.
3. The angle $\phi$ obtained by this method can't be used for obtaining the bearing capacity factors.

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

**Ans. (a)**
The angle $\phi$ obtained by using $N$ values can be used to find out the values of bearing capacity factor.

*End of Solution*

**6.** The unified classification system is based on the recognition of the type and predominance of the constituents considering
(a) grain length
(b) gradation
(c) elasticity
(d) non-compressibility

**Ans. (b)**
Unified classification system is based on recognition of the type and predominance of the constituents considering grain size, gradation, plasticity and compressibility.

*End of Solution*

**7.** Which one of the following coffer dams is suitable for small heights?
(a) Cantilever sheet pile coffer dam
(b) Braced coffer dam
(c) Embankment protected coffer dam
(d) Double wall coffer dam

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**Ans.** **(a)**

A coffer dam may be made of earth materials, timber or steel sheet piling. Cantilever sheet pile coffer dams are suitable for small heights, since these are susceptible to large leakage and flood damage.

*End of Solution*

**8.** A footing 3 m × 1.5 m in plan transmits a pressure of 160 kN/m$^2$ on a cohesive soil having E = 8 × 10$^4$ kN/m$^2$ and μ = 0.48. What is the immediate settlement at the centre, assuming the footing to be flexible? (Take $I_w$ = 1.52)
(a) 2.11 mm                                      (b) 3.21 mm
(c) 3.51 mm                                      (d) 4.62 mm

**Ans.** **(c)**

Immediate settlement or elastic settement is given as,

$$S = \frac{qB(1-\mu^2)I_w}{E}$$

$$= \frac{160 \times 1.5(1-0.48^2) \times 1.52}{8 \times 10^4} = 3.51 \times 10^{-3} \text{ m} = 3.51 \text{ mm}$$

*End of Solution*

**9.** By means of Boussinesq's stress distribution theory, which one of the following pressure distribution diagrams can be prepared?
(a) Strain isobar
(b) Vertical pressure distribution on a horizontal plane
(c) Vertical pressure distribution on an inclined plane
(d) Pressure distribution diagram on an oblique plane

**Ans.** **(b)**

Boussinesq's stress distribution theory is used for vertical pressure distribution on horizontal plane, vertical pressure distribution on vertical plane and stress isobar.

*End of Solution*

**10.** Which one of the following is an assumption made by Coulomb in the development of his earth pressure theory for sand and for active state?
(a) The rupture surface is non-uniform surface
(b) There is a wall friction on the pressure surface
(c) Failure is three dimensional
(d) The soil is cohesive

**Ans.** **(b)**

**Assumptions of Coulomb's theory:**
1. Soil is homogeneous, isotropic, semi infinite, dry and cohesionless.
2. Face of wall in contact with backfill is vertical or inclined and is rough.
3. The failure wedge acts as a rigid body and stresses over it are uniform distributed.

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4. The failure is essentially 2D and rupture surface is planer which passes from heel of the wall.
5. The location and direction of resultant thrust is known which passes from lower third point of the wall by assuming triangular distribution of earth pressure.
6. Wedge failure is considered which is under equilibrium.

*End of Solution*

**11.** Which one of the following is a correct general consideration for a mechanically stabilized earth wall failure?
(a) Compression in reinforcement
(b) Bearing capacity failure
(c) Shearing in the wall
(d) Partly sliding of wall soil

**Ans.** **(b)**
Mechanically stabilized earth wall failure.

*End of Solution*

**12.** Which one of the following is the part of assumptions made by Terzaghi while developing the mathematical statement of the consolidation process?
(a) The soil is non-homogeneous
(b) The soil particles and water are incompressible
(c) The partial deformation of soil is due to partial change in volume
(d) Coefficient of permeability is variable during consolidation

**Ans.** **(b)**
**Assumptions of Terzaghi's theory for 1-D consolidation**:
- Soil is homogeneous.
- Soil is fully saturated.
- Solid particles are incompressible.
- Compression and flow are one dimensional.
- Strains in the soil are relatively small.
- Darcy's law is valid.
- Coefficient of permeability and coefficient of volume compressibility remains constant.

*End of Solution*

**13.** Which one of the following statements is NOT correct?
(a) The porosity of rock depends upon size and shape of the rock grains
(b) Specific gravity is useful for calculating the rock over burden stress
(c) The porosity does not depend on rock mechanical processes
(d) The porosity of spherical rock grains is high in case of cubic packing

**Ans.** **(c)**
Porosity of a rock depends upon grain size distribution, shape, the presence of cement between the grains developed to different degrees.
The porosity of spherical rock grain is high is case of cubic packing.

*End of Solution*

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**14.** Consider the following objectives related to the sub-surface investigation:
1. To establish the geological profile.
2. To establish Hydrogeological conditions.
3. To monitor future changes in ground conditions through instrumentation.

Which of the above objectives are correct?
(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

**Ans.** **(d)**

Objectives of sub-surface investigation:
1. To establish the geological profile.
2. To determine engineering properties for the various unit within the eventual ground model.
3. To establish hydrogeological conditions.
4. To monitor future changes in ground condition through instrumentation.

*End of Solution*

**15.** Dip fault is a fault plane
(a) parallel to the dip of beds
(b) parallel to the strike of a bedding plane
(c) diagonal to the dip of a bedding plane
(d) with no relationship to the bedding plane

**Ans.** **(a)**

Dip fault runs parallel to the dip of the bed, cut across the strike of the bed. It is a fault that runs perpendicular to the strike of the affected rocks. (i.e. parallel to the plane of the angle of dip of the rocks).

*End of Solution*

**16.** Which one of the following consists of horizontal and vertical location of certain points by linear and angular measurements and is made to determine the natural features of a country?
(a) Cadastral survey
(b) Topographical survey
(c) Astronomical survey
(d) Military survey

**Ans.** **(b)**

Topographical survey consists of horizontal and vertical location of certain points by linear and angular measurement and is made to determine the natural features of a country such as rivers, streams, lakes hills etc. and artificial features as roads, railways, canals, towns and villages.

*End of Solution*

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**17.** Which one of the following statements is NOT correct?
(a) Trigonometric levelling has never been used in geodetic surveys
(b) The differences in elevation are determined indirectly by trigonometric levelling
(c) The electronic distance measurement devices can be used for measuring the vertical distances
(d) The combined effects of curvature and refraction produce vertical readings that are slightly too short

**Ans.** **(a)**
Trigonometric leveling is used in geodetic surveying, particularly in areas where traditional leveling methods are not feasible or practical, such as in mountainous regions or areas with dense vegetation.

*End of Solution*

**18.** A line AB between the stations A and B was measured as 348.28 m using a 20 m tape, too short by 0.05 m. What is the correct length of line AB?
(a) 349.15 m                    (b) 348.41 m
(c) 347.41 m                    (d) 346.15 m

**Ans.** **(c)**
Given,
Designated length of tape, $L$ = 20 m
Incorrect length of tape, $L'$ = 20 – 0.05 = 19.95 m
Measured length of line $AB$, $l'$ = 348.28 m
Let,    True length of $AB = l$
As we know,    $L \times l = L' \times l'$
$\Rightarrow$    $20 \times l = 19.95 \times 348.28$
$\Rightarrow$    $l = 347.41$ m

*End of Solution*

**19.** The levelling is carried out between two stations P and Q separated by 1000 m. The Back Sight (BS) reading is noted as 0.70 m on station P, whose BM is 240.00 m. Next, the Fore Sight (FS) reading is taken on an intermediate point and the value is 1.25 m. Then the instrument is shifted to a new location and BS is taken on intermediate point as 0.85 m. Finally, the FS reading is taken on station Q as 1.10 m. What is the Reduced Level of Q?
(a) 239.20 m                    (b) 240.80 m
(c) 241.25 m                    (d) 241.80 m

**Ans.** **(a)**

| Point | B.S | F.S. | H.I. | R.L. |
|-------|-----|------|------|------|
| P | 0.7 | | 240.7 | 240.0 |
| Intermediate | 0.85 | 1.25 | 240.3 | 239.45 |
| Q | | 1.1 | | 239.2 |

So,    R.L. of $Q$ = 239.2 m

*End of Solution*

**20.** The length of a line originally 100 mm long on a map plotted to a scale of 1/1000, was found to be 96 mm due to shrinkage of the map. The map prepared using a tape of length 20 m was later found to be actually 20.03 m. If a certain area on the map, measured using a planimeter, is 282 mm$^2$, what is the correct area on the ground?

(a) 237 m$^2$

(b) 307 m$^2$

(c) 347 m$^2$

(d) 397 m$^2$

**Ans.** **(b)**

$$\text{Shrunk scale} = \text{Shrinkage factor} \times \text{Original scale}$$

$$= \left(\frac{96}{100}\right) \times \frac{1}{1000}$$

$$= \frac{96}{100} \times \frac{1\,mm}{1\,m} = \frac{1\,mm}{\left(\frac{1}{0.96}\right)m}$$

$$1\,mm = \left(\frac{1}{0.96}\right)m$$

$$\therefore \qquad \text{Scale for area} = 1\,mm^2 = \left[\frac{1}{0.96}\right]^2 m^2$$

So, measured area of the ground,

$$\Rightarrow \qquad A' = 282 \times \left(\frac{1}{0.96}\right)^2 = 305.98958\ m^2$$

Designated length of tape,

$$L = 20\ m$$

Incorrect length of tape, $L' = 20.03$ m

So,

$$\text{true area} = \left[\frac{L'}{L}\right]^2 \times \text{measured area}$$

$$= \left[\frac{20.03}{20}\right]^2 \times 305.98958$$

$$= 306.91\ m^2 \simeq 307\ m^2$$

*End of Solution*

**21.** In Map versus Aerial photograph, due to symbolic representation the clarity of details is

(a) less on map than on a photo

(b) more on map than on a photo

(c) less on a photo than on map

(d) more on a photo than on map

**Ans.** **(b)**

**Differences between Map and Aerial Photograph,**

1. The map is an orthographic projection, whereas an aerial photograph is a central projection, i.e. perspective projection.

2. The map has a single constant scale, whereas it varies from point to point depending upon their elevations in an aerial photograph. In the case of the photograph, the terrain area which has higher elevation is closer to the camera and therefore appears

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larger than the terrains area laying at a lower elevation.
3. The number of details on a map are selective whereas in a aerial photograph there is a large number of details.
4. Due to the symbolic representation, the clarity of details is more on the maps than on photo.

*End of Solution*

**22.** In multilevel classification system, Level IV classification is suitable for
(a) Landsat MSS images
(b) High-altitude aerial photographs
(c) Low-altitude aerial photographs
(d) Medium-altitude aerial photographs

**Ans.** **(c)**

| Level | System | Image scale |
|-------|--------|-------------|
| I | Landsat TM and MSS images; AVHRR images | Smaller than 1:250,000 |
| II | High-altitude aerial photographs; TM and SPOT images AVHRR images (with ancilliary data) | 1:80,000 to 1:250, 000 |
| III | Medium-altitude aerial photographs | 1:20,000 to 1:80, 000 |
| IV | Low-altitude aerial photographs | Larger than 1:20,000 |

*End of Solution*

**Directions for the following TWO (02) items:**
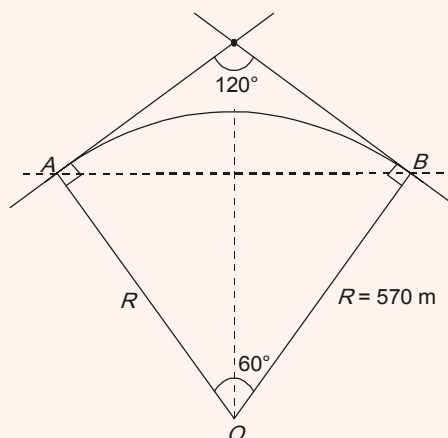
Read the following information and answer the two items that follow:

The chainage of the intersection point of two straights is 1060 m, and the angle of intersection is 120°. If radius of a circular curve to be set out is 570 m, and peg interval is 30 m.

**23.** What is the length of the curve?
(a) $190\pi$ m
(b) $185\pi$ m
(c) $180\pi$ m
(d) $170\pi$ m

**Ans.** **(a)**

Length of curve = Angle subtended at O × Radius

$$= \frac{\pi}{3} \times 570 = 190\pi \text{ m}$$

*End of Solution*

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**24.** What is the length of the long chord?
(a) 370 m                     (b) 470 m
(c) 670 m                     (d) 570 m

**Ans.** **(d)**

Length of long chord = $AB = 2R\sin\left(\frac{\Delta}{2}\right)$

$$= 2R\sin\left(\frac{60°}{2}\right)$$

$$= 2R\sin30°$$

$$= 2 \times R \times \frac{1}{2} = 2 \times 570 \times \frac{1}{2} = 570 \text{ m} \qquad [\because R = 570 \text{ m}]$$

*End of Solution*

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**25.** The design speed for a two-way traffic on a two way lane road is 50 kmph. What is the value of safe stopping sight distance, if co-efficient of friction is 0.37 and reaction time of driver as 2.5 sec?
(a) 34.8 sec                   (b) 61.4 sec
(c) 122.8 sec                  (d) 193.5 sec

**Ans.** **(b)**

$$\text{SSD} = 0.278Vt_R + \frac{V^2}{254f}$$

$$= 0.278 \times 50 \times 2.5 + \frac{50^2}{254 \times 0.37} = 61.4 \text{ m}$$

**Note**: Stopping sight distance unit should be in meter, not in seconds as given in options.

*End of Solution*

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**26.** Consider the following statements related to economic design of modern track:
1. Axle loading, possible weight reduction of the rolling stock and increase in number of axles should be rationalized.
2. Rail to sleeper fastenings for different type of sleepers at high speeds should have definite standards.
3. The weight of the sleeper and the rail may not be related to each other.
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

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**Ans.** **(a)**

A modern track has to be rationalized in view of the following to achieve over-all economy on Indian Railways.

i.  Rail requirements, like quality of steel, design of rail-section and manufacturing process, should be rationalized so that the rail section can sustain the expected stresses due to rolling loads.

ii.  Wheel diameter in relation to qualities of rail steel and steel of the wheel tyre should also be rationalized so as to keep Hertzian stresses within the endurance limits of the steel.

iii.  Axle loading, possible weight reduction of the rolling stock and increase in number of axles should be rationalized.

iv.  Rail-to-sleeper fastenings i.e., elastic fastenings for different types of sleepers at high speeds should have definite standards.

v.  The weight of the sleeper and the rail should be correctly related to each other.

*End of Solution*

**27.** The longitudinal joints in cement concrete pavements are constructed with suitable

(a)  tie bars
(b)  torsion rods
(c)  small spacing
(d)  shear rods

**Ans.** **(a)**

*End of Solution*

**28.** In which one of the following systems the optimum road length is calculated for an area based on the concept of obtaining maximum utility per unit length of road?

(a)  Saturation system
(b)  Unsaturated system
(c)  Minimum utility system
(d)  Average utility system

**Ans.** **(a)**

*End of Solution*

**29.** Which one of the following alignments is obtained by development accompanied by tunneling?

(a)  Valley alignment
(b)  Cross country alignment
(c)  Mountain alignment
(d)  Zig-zag alignment

**Ans.** **(c)**

The alignment of a tunnel constructed as part of a development project would depend on various factors, such as the topography of the area, the geological conditions, and the tunnel's purpose. A zig-zag alignment would not typically be used in tunnel construction, as it would increase construction costs and complexity without providing significant benefits. A "Mountain Alignment" typically refers to a tunnel alignment that follows the contour of a mountain or hill. This type of alignment is often used when a tunnel is needed to bypass a mountainous area or provide access to resources within a mountain. However, it is important to note that the alignment chosen for a tunneling project would depend on a wide range of factors, such as the area's geology, the presence of other infrastructure, and the project's specific needs.

*End of Solution*

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**30.** Which one of the following tests is carried out using a relatively large diameter plate to evaluate the load supporting capacity of pavement layers?

(a) California bearing ratio test

(b) California resistance value test

(c) Triaxial compression test

(d) Plate bearing test

**Ans. (d)**

*End of Solution*

**31.** Consider the following aspects of human vision which are important for a traffic engineer:

1. Field of vision
2. Visual acuity
3. Colour perception

Which of the above aspects are correct?

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

**Ans. (d)**

*End of Solution*

**32.** The survey of the highway construction work for preparation of longitudinal and cross sections, computations of earth work quantities; and other construction material and checking details of geometric design elements is carried out in

(a) Reconnaissance survey

(b) Preliminary survey

(c) Location of final alignment

(d) Detailed survey

**Ans. (b)**

*End of Solution*

**33.** The raising of outer rail over inner rail is called

(a) Cant deficiency

(b) Cant

(c) Capacity of the track

(d) Centre bound sleepers

**Ans. (b)**

Super elevation or cant –

Outer rail raised with respect to inner rail in order to generate centripetal force against centrifugal force which occurs outward in horizontal plane from CG of vehicle.

*End of Solution*

**34.** The distance between successive vehicles moving in the same line measured from head at any instance is

(a) the space headway

(b) the time headway

(c) the one-way stream

(d) the head-way stream

**Ans. (a)**

*End of Solution*

**35.** The roads which are provided with a hard pavement course having at least a water bound macadam (WBM) layer are classified as
(a) Paved roads
(b) Unpaved roads
(c) Surface roads
(d) Unsurfaced roads

**Ans.** **(a)**

*End of Solution*

**36.** The planning surveys about engineering studies consists of
(a) Income per capita
(b) Living standard
(c) Traffic volume
(d) Road location and alignment studies

**Ans.** **(d)**

*End of Solution*

**37.** A cipolletti weir has length of 2.0 m and head over the weir is 1 m. What is the discharge over the weir? (Take $c_d$ = 0.62)
(a) 10.35 m$^3$/s
(b) 3.66 m$^3$/s
(c) 45.21 m$^3$/s
(d) 75.68 m$^3$/s

**Ans.** **(b)**

The discharge over a cipolletti weir is calculated by using the suppressed weir formula.

$$Q_1 = \frac{2}{3}C_d\sqrt{2g}\,LH^{3/2}$$

$$Q = \frac{2}{3}\times 0.62 \times \sqrt{2\times 9.81}\times 2 \times (1)^{3/2}$$

$$Q = 3.66 \text{ m}^3/\text{s}$$

*End of Solution*

**38.** Which one of the following is an advantage using a triangular notch over a rectangular notch?
(a) Ventilation of a triangular notch is necessary
(b) The same triangular notch cannot measure a wide range of flows accurately
(c) For heavy discharges, a triangular notch gives more accurate results than a rectangular notch.
(d) In a given triangular notch, only one reading is required to be taken for the measurement of discharge

**Ans.** **(d)**

A triangular notch is preferred to a rectangular notch due to following reasons:
1. The expression for discharge for a right angled V-notch is very simple.
2. For measuring low discharge, a triangular notch gives more accurate results than a rectangular notch.
3. In case of triangular notch, only one reading, i.e., H is required for the computation of discharge.
4. Ventilation of triangular notch is not necessary.

*End of Solution*

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**39.** Which one of the following statements is correct for flow in open channels?
(a) When the depth of flow in a channel is greater than the critical depth, the flow is said to be supercritical flow
(b) When the depth of flow in a channel is equal to critical depth, the flow is said to be super-critical flow
(c) When the depth of flow in a channel is less than the critical depth, the flow is said to be subcritical flow
(d) When the depth of flow in a channel is greater than the critical depth, the flow is said to be subcritical flow

**Ans.** **(d)**

Critical flow: $F_r = 1$, $v = v_c$, $y = y_c$
Sub-critical flow: $F_r < 1$, $v < v_c$, $y > y_c$
Super critical flow: $F_r > 1$, $v > v_c$, $y < y_c$
$F_r$ : Froude number
$v_c$ : critical velocity
$y_c$ : critical depth

<span style="color:red">*End of Solution*</span>

**40.** Water flows through a pipe of 200 mm in diameter 60 m long with a velocity of 2.5 m/s. What is the head loss due to friction using Darcy's formulae? (Assume $f$ = 0.005)
(a) 1.52 m                                    (b) 1.79 m
(c) 1.85 m                                    (d) 1.91 m

**Ans.** **(d)**

Head loss due to friction, $h_f = \dfrac{flv^2}{2gd}$

$$h_f = \frac{0.005 \times 60 \times (2.5)^2}{2 \times 9.81 \times 0.2} = 0.477 \text{ m}$$

No answer is matching.
Considering, 0.005 as Fannings friction coefficient, then darcy's friction factor
'$f$' = 4 × 0.005 = 0.02

$\therefore$ 
$$h_f = \frac{0.02 \times 60 \times (2.5)^2}{2 \times 9.81 \times 0.2} = 1.91 \text{ m}$$

<span style="color:red">*End of Solution*</span>

**41.** The pressure distribution in a liquid subjected to a constant horizontal acceleration is
(a) same as hydrostatic pressure distribution
(b) less than the hydrostatic pressure distribution
(c) more than the hydrostatic pressure distribution
(d) equal to hydrostatic pressure distribution minus weight of liquid

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**Ans.** **(a)**

Concept of acceleration vessel containing liquid:
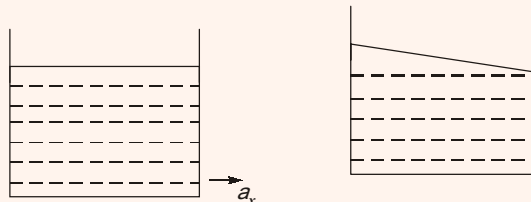


$$dP = \rho a_x\, dx - \rho(a_z + g)dz$$
$$dP = -\rho g dz$$

$$\frac{dP}{dz} = -\rho g$$

From the above equation, it is clear that pressure head at any point in a liquid subjected to a constant horizontal acceleration is equal to the height of the liquid column above that point. Therefore the pressure distribution in a liquid subjected to a constant horizontal acceleration is same as hydrostatic pressure distribution. Planes of constant pressure are therefore, parallel to the inclined surface.

*End of Solution*

**42.** A convergent mouthpiece is discharging water under a constant head of 5 metres. If the diameter of the mouthpiece is 75 mm, then what is the discharge?
(a) 38.2 litres/sec
(b) 40.4 litres/sec
(c) 43.8 litres/sec
(d) 46.1 litres/sec

**Ans.** **(c)**

Discharge through mouthpiece $= \dfrac{\pi}{4} \times (0.075)^2 \times \sqrt{2 \times 9.81 \times 5}$

$$= 0.04375 \text{ m}^3/\text{sec}$$
$$= 43.75 \text{ lit/sec}$$
$$\simeq 43.8 \text{ lit/sec}$$

*End of Solution*

**43.** A flat plate 1.5 m × 1.5 m moves at 45 km/hour in stationary air of specific weight 11.3 N/m³. If the coefficient of lift is 0.75, then what is the lift force?
(a) 120.4 N
(b) 151.9 N
(c) 180.4 N
(d) 225.9 N

**Ans.** **(b)**

Given: $\rho g = 11.3$ N/m³

$$\rho = \frac{11.3}{9.81} \text{kg/m}^3$$

∴ Lift force, $F_L = C_L \times \dfrac{1}{2} \times \rho \times A \times U_\infty^2$

$$= 0.75 \times \frac{1}{2} \times \frac{11.3}{9.81} \times (1.5 \times 1.5) \times \left(45 \times \frac{5}{18}\right)^2$$

$F_L = 151.86 \text{ N} \simeq 151.9 \text{ N}$

*End of Solution*

**44.** A submarine which may be supposed to approximate a cylinder 3 m in diameter and 15 m long travels submerged at 1.54 m/s in sea water at 4°C. What is the drag exerted on it? (Take $C_d = 0.7$ and $\rho = 1025$ kg/m³)
(a) 30129 N       (b) 34517 N
(c) 37112 N       (d) 38287 N

**Ans.** **(\*)**

Drag force, $F_D = C_D \times \dfrac{1}{2} \times \rho A U_\infty^2$

$$= 0.7 \times \frac{1}{2} \times 1025 \times \frac{\pi}{4} \times 3^2 \times 1.54^2$$

$$= 6014.03 \text{ N}$$

But, since none of the options matching.

Drag force, $F_D = C_D \times \dfrac{1}{2} \times \rho \times A \times U_\infty^2$

$$= 0.7 \times \frac{1}{2} \times 1025 \times (3 \times 15) \times 1.54^2$$

$F_D = 38286.516 \text{ N}$

*End of Solution*

**45.** If the pressure heads at the different sections of the pipe are plotted to scale as vertical ordinates above the axis of the pipe and all these points are joined by a slopping straight line, which is known as
(a) Hydraulic gradient line       (b) Total energy line
(c) Total head line       (d) Energy grade line

**Ans.** **(a)**
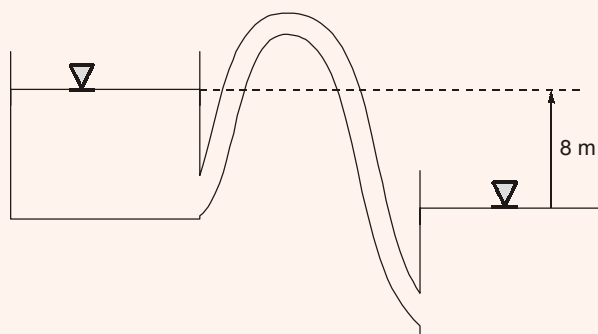
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**46.** The difference in the water surface level of two reservoirs which are connected by a siphon is 8 m. The length of siphon is 600 m and its diameter 0.3 m. If the siphon is running full, then what is the discharge? (Take $f = 0.02$)

(a) 3.242 m³/s
(b) 2.117 m³/s
(c) 1.842 m³/s
(d) 0.137 m³/s

**Ans.** **(d)**

$$L = 600 \text{ m}$$
$$D = 0.3 \text{ m}$$
$$f = 0.02$$
$$Q = ??$$



8 m

$$h_f = \frac{8Q^2}{\pi^2 g} \times \frac{f \cdot L}{D^5}$$

$$\Rightarrow \qquad 8 = \frac{8Q^2}{\pi^2 g} \times \frac{(0.02)(600)}{(0.3)^5}$$

$$\Rightarrow \qquad Q = 0.14 \text{ m}^3/\text{s}$$

*End of Solution*

**47.** The air vessel is not required for multicylinder pump because it has
(a) much smaller fluctuations of velocity in both the delivery and suction pipes
(b) large fluctuations of velocity in delivery pipes
(c) large fluctuations of the velocity in suction pipes
(d) moderate variation of speed of fluid reciprocating pump

**Ans.** **(a)**

The purpose of air-vessel is to minimize the flow fluctuation and smooth out pressure. In a multi-cylinder reciprocating pump typically number of cylinder work together to reduce the flow pulsations and vibration that can be occured in a single acting reciprocating pump.

Therefore if the fluctuation of velocity is already minimum in multi cylinder system, then air vessel may not be required.

*End of Solution*

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**48.** Which one of the following is the correct assumption for the derivation of Bernoulli's equation?
(a) The flow is compressible
(b) Viscosity is zero
(c) The flow is unsteady
(d) The flow is rotational

**Ans.** **(b)**

*End of Solution*

**49.** A fully penetrating well in a confined sand aquifer has a maximum discharge capacity of 1200 l/min. The aquifer is overlain and underlain by impervious formations. The thickness of the aquifer is 20 m. Assume the percentage of the open area of an available strainer to be 15% and bore hole diameter as 15 cm. What is the length of the well screen? (Take safe entrance velocity as 0.02 m/s)
(a) 10.5 m
(b) 12.3 m
(c) 13.1 m
(d) 14.1 m
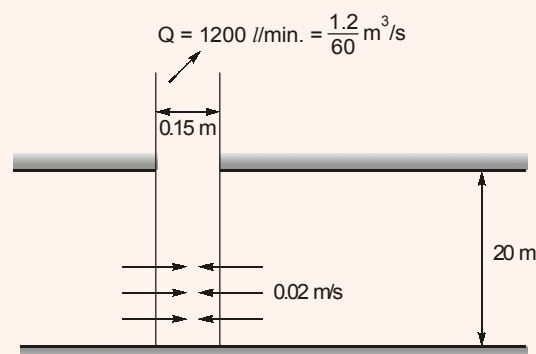
**Ans.** **(d)**



$\therefore \qquad Q = AV$

$\Rightarrow \qquad 1200 \text{ l/min} = \dfrac{1.2}{60}\text{m}^3/\text{s}$

$\qquad\qquad = \pi \times 0.15 \times L \times 0.15 \times 0.02 \text{ m/s}$

$\Rightarrow \qquad L = \left(\dfrac{1.2}{60 \times 0.02}\right) \times \dfrac{1}{\pi \times 0.15 \times 0.15}$

$\Rightarrow \qquad L = \dfrac{1}{\pi \times 0.15^2} = 14.147\text{m}$

Hence, length of well screen = 14.1 m.

*End of Solution*

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**50.** Which one of the following is the total area, bounded within the irrigation boundary of a project, which can be economically irrigated without considering the limitation of the quantity of available water?

(a) Gross command area       (b) Cultivable command area

(c) Net and gross sown area       (d) Net and gross irrigated area

**Ans.** **(a)**

*End of Solution*

**51.** Which one of the following techniques of water distribution in the farms is sometimes called wild flooding?

(a) Free flooding       (b) Check flooding

(c) Border flooding       (d) Furrow irrigation method

**Ans.** **(a)**

*End of Solution*

**52.** Which one of the following conditions is favourable for sprinkler irrigation method?

(a) When the land topography is regular

(b) When the soil is not easily erodible

(c) When the water tale is low

(d) When the land soil is excessively permeable

**Ans.** **(d)**

Sprinkler irrigation is more useful where:

i. The land cannot be prepared for surface methods.

ii. Slopes are excessive.

iii. Topography is irregular.

iv. Soil is erosive.

v. Soil is excessively permeable.

vi. Depth of soil is shallow over gravel or sand.

*End of Solution*

**53.** If the sodium ions increase to about 10% or more, the soil becomes

(a) less permeable and of poorer tilth

(b) more permeable

(c) good tilth

(d) more permeable and of better tilth

**Ans.** **(a)**

If the percentage of sodium is more, the aggregation of soil grains breakdown, and the soil becomes less permeable and of poorer tilth.

*End of Solution*

**54.** In drip irrigation method, the drip nozzles are fixed on laterals, discharging water at a very small rate of the order of
(a) 0.1 to 1 litre per hour
(b) 1 to 2 litre per hour
(c) 2 to 10 litre per hour
(d) 10 to 15 litre per hour

**Ans.** **(c)**

*End of Solution*

**55.** If the cultivation method is faulty and less efficient, resulting in the wastage of water, the duty of the water will naturally be
(a) less
(b) more
(c) average
(d) depending upon cultivators

**Ans.** **(a)**

$$\text{Duty} = \frac{A}{Q}\text{ha/cumec}$$

More losses $\Rightarrow$ More discharge required

$\therefore$ Duty will be less.

*End of Solution*

**56.** In which one of the following types of falls, the energy dissipation on a straight glacis remain incomplete due to vertical component of velocity remaining unaffected?
(a) Montage type falls
(b) Gravity falls
(c) Inglis falls
(d) Baffle falls

**Ans.** **(a)**

*End of Solution*

**57.** Which one of the following is the correct assumption made in two dimensional design of gravity dams?
(a) The loads are transferred to the abutments by beam action
(b) The foundation and dam behave as separate units
(c) The materials in the foundation and body of the dam are isotropic and homogeneous
(d) The stresses developed in the foundation and body of the dam are not within elastic limit

**Ans.** **(c)**
The assumptions made in the two dimensional gravity method are:
1. The dam is considered to be composed of a number of cantilevers, each of which is 1 m thick and acts independent of the other
2. No loads are transferred to the abutments by beam action
3. The foundation and the dam behave as a single unit
4. The materials in the dam body and foundation are isotropic and homogeneous; and
5. The stresses developed in the dam and foundation are within elastic limits and no movement of the foundation is caused due to transfer of loads.

*End of Solution*

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**58.** Which one of the following is the cause of water logging?
(a) Adequate natural drainage
(b) Adequate surface drainage
(c) Normal rains
(d) Submergence due to floods

**Ans.** **(d)**

**59.** Which of the following is a very effective method to control water logging?
(a) Lining of canal and water courses
(b) Flat topography
(c) Adequate natural drainage
(d) Adequate surface drainage

**Ans.** **(a)**

**60.** What should be done to dissipate the residual energy, if the tail water deficiency is small?
(a) Construction of baffle wall          (b) Sloping apron
(c) Stilling basin                       (d) Ski jump bucket

**Ans.** **(a)**

If the tailwater deficiency is small, baffle wall can be provided to increase its depth. subsidiary dams or rows of friction blocks can also be provided.

**61.** A sewage has a suspended solid contents as 250 mg/litre. The sedimentation tank removes 55% of the suspended solids and the water content of the sludge is 95%. What is the quantity of sludge produced after treating $6.5 \times 10^6$ litres of sewage? (Assume the specific gravity of sludge as 1.0)
(a) 11.875 cu.m          (b) 14.275 cu.m
(c) 17.875 cu.m          (d) 20.275 cu.m

**Ans.** **(c)**

Suspended solids,    $S_0$ = 250 mg/l

Efficiency of sedimentation tank,

$\eta$ = 0.55

So, concentration of suspendd solids in sludge,

= 137.5 mg/L

Therefore, suspended solids in $6.5 \times 10^6$ litres = $137.5 \times 10^{-6} \times 6.5 \times 10^6$

= 893.75 kg

Now, water content of sludge = 95%

$\therefore$ Total weight of water in sludge = $\dfrac{893.75 \times 0.95}{0.05} = 16981.25$ kg

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So, total weight of sludge = (16981.25 + 893.75) kg = 17875 kg

Hence, volume of sludge produces = $\dfrac{17875 \ kg}{1 \times 1000 \ kg/m^3}$

$= 17.875 \ m^3$

*End of Solution*

**62.** With standard notations, the total subsurface soil area required for the soak pits or dispersion trenches is given by

(a) $Q = 100/\sqrt{t}$   (b) $Q = 130/\sqrt{t}$

(c) $Q = 200/\sqrt{t}$   (d) $Q = 260/\sqrt{t}$

**Ans.** **(b)**

As per Cl: 21.2.4 of CPHEEO (1993)

For a dispersion trench, $Q = \dfrac{130}{\sqrt{t}}$

where, $Q$ is in $I/m^2/day$.

$t$ is percolation rate (min/cm).

*End of Solution*

**63.** Which one of the following is NOT the common method of disinfection of water?

(a) By boiling of water
(b) By ultra-violet rays
(c) By use of ozone
(d) By use of sodium chloride

**Ans.** **(d)**

**Minor methods of disinfection.**
i.   By boiling of water.
ii.  U-V rays.
iii. By use of ozone.
**Major method of disinfection.**
i.   Chlorination.

*End of Solution*

**64.** Which one of the following is an essential requirement of swimming pool water?

(a) It should not have disinfectant dissolved in it
(b) Minimum amount of chemical should be added in treating water of the swimming pools
(c) The water of the pool need not be visible at maximum depth
(d) The pool need not have an efficient surface water removal system

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**Ans.    (b)**

*End of Solution*

**65.**   The first stage of sewage purification by the action of anaerobic bacteria is termed as
(a)  Putrefaction                                   (b)  Liquefaction
(c)  Clarification                                    (d)  Oxidation

**Ans.    (a)**
The meaning of putrefaction is the anerobic decomposition of organic matter by bacteria and fungi that results in obnoxiously odorous product.

*End of Solution*

**66.**   Which one of the following is a measure of light-emitting properties of waste water?
(a)  Turbidity                                       (b)  pH
(c)  Alkalinity                                       (d)  Volatility

**Ans.    (a)**
Turbidity is the measure of extent to which light is either absorbed or scattered by suspended solids present in water.

*End of Solution*

**67.**   Which one of the following is defined as the oxygen required for the microorganisms to carry out biological decomposition of dissolved solids or organic matter in the water under aerobic conditions at standard temperature?
(a)  Biochemical oxygen demand           (b)  Chemical oxygen demand
(c)  Total oxygen demand                       (d)  Theoretical oxygen demand

**Ans.    (a)**

*End of Solution*

**68.**   Chlorination, liming and recarbonation are the part of which one of the following in the context of unit operations for waste water treatment?
(a)  Ion transfer                                     (b)  Solute stabilization
(c)  Solid transfer                                  (d)  Solid concentration

**Ans.    (b)**

*End of Solution*

**69.**   Which one of the following is the process of driving, pouring or forcing lead oakum plastic or other material into a joint to make it leak proof?
(a)  Caulking                                         (b)  Bedding
(c)  Benching                                         (d)  Haunching

**Ans.    (a)**

*End of Solution*

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**70.** Which one of the following is the ability of a material to absorb moisture from air and thus to dissolve and become liquid?
(a) Deliquescence
(b) Hygroscopicity
(c) Wilting
(d) Capillarity

**Ans.** **(a)**

*End of Solution*

**71.** The theoretical time taken by a particle of water to pass between entry and exit of a settling tank is known as
(a) Weir loading
(b) Detention period
(c) Velocity of flow
(d) Overflow rate

**Ans.** **(b)**

*End of Solution*

**72.** The most commonly adopted detention period of grit chambers may vary from
(a) 10 to 40 seconds
(b) 45 to 90 seconds
(c) 90 to 120 seconds
(d) 120 to 135 seconds

**Ans.** **(a)**

*End of Solution*

**73.** Match the following lists:

**List-I (Member)**
P. A member carrying compressive loads resulting from dead and imposed load.
Q. A member subjected to compression forces resulting only from combination with wind/earthquake actions, provided the deformation of such members does not adversely affect the stress in any part of the structure.
R. Compression flange of a beam against lateral torsional buckling.
S. Members always under tension (other than pre-tensioned members)

**List-II (Maximum effective slenderness ratio)**
1. 400
2. 180
3. 250
4. 300

Select the correct answer using the code given below:

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

**Ans.** **(a)**

*End of Solution*

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**74.** Thickness of flat lacing bars shall not be less than
(a) one-seventieth of the effective length for single lacings
(b) one-fortieth of the effective length for double lacings
(c) one-sixtieth of the effective length for double lacings
(d) one-fiftieth of the effective length for single lacings

**Ans.** **(c)**

*End of Solution*

**75.** An 18 mm thick plate is joined to a 16 mm plate by 200 mm long (effective) butt weld. What is the strength of joint if a double V butt weld is used? (Assume that Fe410 grade plates and shop welds are used)
(a) 605.987 kN
(b) 378.742 kN
(c) 467.535 kN
(d) 478.348 kN

**Ans.** **(a)**

$$L_e = 200 \text{ mm}, \quad \gamma_{mw} = 1.25 \text{ (shop welding)}$$
$$t_e = t_{min} = 16 \text{ mm}$$

$$\text{Strength of joint, } P_{dw} = \frac{f_y}{\gamma_{mw}} \times L_e \times f_c$$

$$= \frac{250}{1.25} \times 200 \times 16 = 640 \text{ W}$$

*End of Solution*

**76.** Consider the following statements related to principles of design of connections:
**1.** The centre of gravity of bolts should coincide with the centre of gravity of the connected members.
**2.** The length of connection should be kept as small as possible.
Which of the above statements is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2

**Ans.** **(c)**

*End of Solution*

**77.** Nominal shear capacity of a bolt is 82335 N. What is the design capacity of the bolt, if slip resistance is designated at service load?
(a) 82335 N
(b) 74850 N
(c) 449.099 N
(d) 395.208 N

**Ans.** **(b)**

$$\text{Design capacity} = \frac{\text{Nominal shear capacity}}{\text{Partial safety factor}}$$

$$= \frac{82335}{1.10} \text{ N} = 74850 \text{ N}$$

*End of Solution*

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**78.** Which one of the following is an advantage of welded connection?
   (a) Noise produced in welding process is relatively less.
   (b) Proper welding in field condition is difficult.
   (c) The inspection of welded joint requires non-destructive testing.
   (d) There is a greater possibility of brittle fracture in welding.

**Ans.** (a)

*End of Solution*

**79.** Consider the following statements related to lug angle:
   If the main member is an angle,
   **1.** the strength of lug angles and fastener connecting lug angle to gusset plate should be at least 20% more than the force in outstanding leg.
   **2.** the strength of the fastener connecting lug angle and main member should be at least 40% more than the force in outstanding leg.
   **3.** the whole area of the member is net area less deduction for bolt holes.
   Which of the above statements are correct?
   (a) 2 and 3 only                    (b) 1 and 3 only
   (c) 1 and 2 only                    (d) 1, 2 and 3

**Ans.** (c)
   Clause (10.12.2) of IS : 800

*End of Solution*

**80.** The shear force for which each lacing shall be designed if two parallel systems of lacing is there in the column is
   (a) 2.5% of axial force in the column
   (b) 1.25% of axial force in the column
   (c) 50% of axial force in the column
   (d) 25% of axial force in the column

**Ans.** (b)
   Clause 7.6.6.1 [IS : 800]

*End of Solution*

**81.** To account for shear deformation, the effective slenderness ratio of battened columns shall be taken as
   (a) 1.1 times the maximum actual slenderness ratio of the column
   (b) 2.5 times the maximum actual slenderness ratio of the column
   (c) 1.25 times the maximum actual slenderness ratio of the column
   (d) 0.9 times the maximum actual slenderness ratio of the column

**Ans.** (a)
   Clause 7.7.1.4 [IS : 800]

*End of Solution*

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**82.** The maximum pitch for tension and compression members respectively are
(a) $(12t$ or 200 mm, whichever is less) and $(16t$ or 200 mm, whichever is less)
(b) $(12t$ or 300 mm, whichever is less) and $(16t$ or 300 mm, whichever is less)
(c) $(16t$ or 200 mm, whichever is less) and $(12t$ or 200 mm, whichever is less)
(d) $(16t$ or 300 mm, whichever is less) and $(12t$ or 300 mm, whichever is less)

**Ans.** **(c)**

Clause 10.2.3.2 [IS : 800]

*End of Solution*

**83.** The maximum size of fillet weld for 20 mm to 32 mm plate is
(a) 3 mm                                (b) 5 mm
(c) 6 mm                                (d) 8 mm

**Ans.** **(c)**

Table 21 of IS800

*End of Solution*

**84.** What is the section modulus required to design an angle Purlin which experiences a maximum bending moment of 10 kNm, if the section is made with Fe250 grade steel?
(a) 4.55 cm$^3$                          (b) 45.57 cm$^3$
(c) 75.57 cm$^3$                         (d) 7.55 cm$^3$

**Ans.** **(b)**

As Purlins are subjected to wind load therefore the permissible stresses are required to be increased by 33.33%.

Permissible stress, $\sigma_{pb} = 1.33 \times 0.66 f_y$

$$Z = \frac{BM}{\sigma_{pb}} = \frac{10 \times 10^6}{1.33 \times 0.66 \times 250} = 45568.46 \text{ mm}^3 \simeq 45.57 \text{ cm}^3$$

*End of Solution*

**85.** A rectangular simply supported beam of span 4 m is 300 mm × 700 mm in cross-section and is reinforced with 3 bars of 20 mm on tension side at an effective cover of 50 mm. The beam experiences an imposed working load of 20 kN/m. Assume the density of concrete as 25 kN/m$^3$ (excluding self-weight). What is the maximum bending moment?
(a) 5.05 kNm                            (b) 50.5 kNm
(c) 55.0 kNm                            (d) 5.5 kNm

**Ans.** **(b)**

Simply supported beam
$$\text{Span} = 4 \text{ m}$$
$$B = 300 \text{ mm}$$
$$D = 700 \text{ mm}$$

$$A_{st} = 3 \times \frac{\pi}{4}(20)^2$$

$$d = 650 \text{ mm}$$
$$LL = 20 \text{ kN/m}$$
$$DL = 0.3 \times 0.7 \times 1.0 \times 25 = 5.25 \text{ kN/m}$$
$$w = 25.25 \text{ kN/m}$$
$$\text{Maximum BM} = \frac{wL^2}{8} = 25.25 \times \frac{4^2}{8} = 50.5 \text{ kNm}$$

*End of Solution*

**86.** A rectangular concrete cantilever beam is made of M25 grade concrete and Fe415 grade steel is used. What is the modular ratio of the section assuming the modulus of elasticity of steel as $2 \times 10^5$ MPa?

(a) $\dfrac{1}{8}$
(b) $\dfrac{1}{4}$

(c) 4
(d) 8

**Ans.** **(d)**
M25 concrete

$$E_C = 5000 \times \sqrt{25} = 25000 \text{ N/mm}^2$$
$$E_S = 2 \times 10^5 \text{ N/mm}^2$$

Modular ratio

$$m = \frac{E_S}{E_C} = \frac{2 \times 10^5}{25000} = 8$$

*End of Solution*

**87.** Consider the following statements related to the limit state design criterion for a safe design of the structure:
**1.** The structure or its elements should not collapse when subjected to the design loads.
**2.** The structure should not become unfit for use due to cracking or excessive deflection.
**3.** The structure should reach a limit state during its design life.
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

**Ans.** **(a)**

*End of Solution*

**88.** What is the theoretical value of effective length of a compression member when it is 'effectively held in position at both ends but not restrained against rotation'?
(a) 0.50 L
(b) 0.65 L
(c) 1.00 L
(d) 2.00 L

**Ans.    (c)**



Both are pin jointed

$$L_{eff} = 1.0L_0$$

**89.**    An RCC beam 200 mm wide and 450 mm deep, is reinforced with Fe415 grade steel of area 1000 mm$^2$ on tension side with an effective cover of 50 mm. If the shear reinforcement of 100 mm$^2$ stirrups is provided at a spacing of 150 mm centre to centre (c/c). What is the ultimate shear strength ($V_{us}$) corresponding to the shear reinforcement?
(a)  96.3 kN                                      (b)  90.6 kN
(c)  9.63 kN                                      (d)  9.06 kN

**Ans.    (a)**

$B$ = 200 mm        Fe415
$D$ = 450 mm        M20
$A_{st}$ = 1000 mm$^2$
$d_c$ = 50 mm
$d$ = 400 mm
$A_{sv}$ = 100 mm$^2$
$S_v$ = 150 mm$^2$
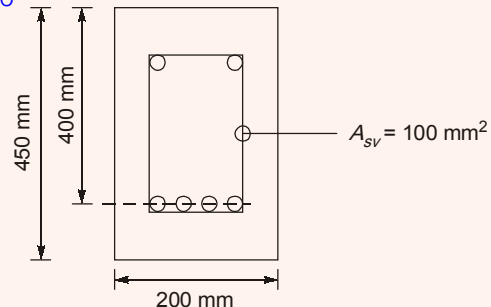
Shear strength of shear reinforcement



$A_{sv}$ = 100 mm$^2$

$$V_{su} = \frac{A_{sv} \times 0.87 f_y \times d}{s_v}$$

$$= \frac{100 \times 0.87 \times 415 \times 400}{150 \times 1000} = 96.28 \text{ kN say } 96.30 \text{ kN}$$

**90.**    An RCC beam having 200 mm wide and 400 mm effective depth is reinforced with Fe415 grade steel of area 1000 mm$^2$ in tension. Assume M20 grade concrete, what is approximate value of the depth of neutral axis for the equilibrium of forces at the limit state of collapse?
(a)  200 mm                                      (b)  250 mm
(c)  300 mm                                      (d)  350 mm

**Ans.    (b)**

$B$ = 200 mm
$d$ = 400 mm
$A_{st}$ = 1000 mm$^2$

Actual depth of neutral axis

$$x_u = \frac{0.87 f_y \cdot A_{st}}{0.36 f_{ck} \cdot B}$$

$$= \frac{0.87 \times 415 \times 1000}{0.36 \times 20 \times 200} = 250.73 \text{ mm say } 250 \text{ mm}$$

*End of Solution*

**91.** What is the percentage of reinforcement of an axially loaded short square column of 400 mm side to support a factored load of 1600 kN? (Use M20 concrete and Fe415 steel)

(a) 0.64 　　　　　　　　　　　(b) 7.40

(c) 0.74 　　　　　　　　　　　(d) 6.40

**Ans. (c)**

**Short column:**

$$B = 400 \text{ mm} \qquad \left[ \frac{\text{M20}}{\text{Fe415}} \right]$$
$$P_u = 1600 \text{ kN}$$

Assuming all provision/conditions of provision of IS 456 : 39.3 are fulfilled.

$$P_u = 0.40 f_{ck} \cdot A_c + 0.67 f_y \cdot A_{sc}$$
$$1600 \times 1000 = 0.40 \times 20 \times [400 \times 400 - A_{sc}] + 0.67 \times 415 \times A_{sc}$$
$$A_{sc} = 1185 \text{ mm}^2$$

$$P_c \% = \frac{A_{sc}}{B^2} \times 100$$

$$= \frac{1185}{400 \times 400} \times 100 = 0.74\%$$

*End of Solution*

**92.** A simply supported RCC one-way slab for an office floor has clear dimensions of 4 m × 10 m with 230 mm walls all-around. What is the effective length of the slab? (Take the effective depth of the slab as 160 mm)

(a) 2.23 m 　　　　　　　　　　(b) 4.16 m

(c) 6.84 m 　　　　　　　　　　(d) 10.23 m

**Ans. (b)**

$$L_x = 4 \text{ m}$$
$$L_y = 10 \text{ m}$$

$$\because \quad \frac{L_y}{L_x} = \frac{10}{4} = 2.5 > 2.0 \text{ so, One way slab}$$

$$L_{eff} = L_{x_{cl}} + d$$
$$= 4.0 + 0.16 = 4.16 \text{ m}$$

or $$L_{eff} = L_{x_{cl}} + w$$

$$\Bigg\} \text{minimum} = 4.16 \text{ m}$$

$$= 4.0 + 0.23 = 4.23 \text{ m}$$

So, Effective span $= L_{eff} = 4.16$ m

*End of Solution*

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**93.** The members in which the entire cross-section of concrete has a uniform compressive pressure is called
(a) Axial prestressing
(b) Concordant prestressing
(c) Eccentric prestressing
(d) Non-distortional prestressing

**Ans.** **(a)**
Cross-section subjected to uniform compressive pressure — Axial prestressing.

*End of Solution*

**94.** For M-45 concrete as per IS : 1343-2012, in prestressed concrete structures, which is the correct value for autogenous shrinkage ($\varepsilon_{ca} \times 10^{-6}$)?
(a) 45
(b) 65
(c) 75
(d) 95

**Ans.** **(b)**
As per Pr. 6.2.4.2 of IS : 1343
Autogeneous shrinkage for M45 concrete = $65 \times 10^6$

*End of Solution*

**95.** A prestressed concrete beam of section 120 mm × 300 mm is used over an effective span of 6000 mm to support a uniformly distributed load of 4 kN/m including the self-weight of the beam. The beam is prestressed by a straight cable carrying a force of 180 kN located at an eccentricity of 50 mm. What is the stress due to prestressing force?
(a) 500 N/mm$^2$
(b) 50 N/mm$^2$
(c) 5 N/mm$^2$
(d) 0.5 N/mm$^2$

**Ans.** **(c)**

$$B = 120 \text{ mm}$$
$$D = 300 \text{ mm}$$
$$L_{eff} = 6 \text{ m}$$
$$w = 4 \text{ kN/m including self weight}$$
$$P = 180 \text{ kN}$$
$$e = 50 \text{ mm}$$

Stress due to prestressing force.

1. Axial stress

$$\frac{P}{A} = \frac{180000}{120 \times 300} = 5 \text{ N/mm}^2$$

2. Stress due to Pe at top and bottom

$$\frac{P_e}{z} = \frac{180000 \times 50}{120 \times \dfrac{300^2}{6}} = 5 \text{ N/mm}^2$$

Stress at top = 5 – 5 = 0
Stress at top = 5 + 5 = 10
As, none of the answer is matching.

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So, considering only axial stress i.e.

$$\frac{P}{A} = 5 \text{ N/mm}^2$$

*End of Solution*

**96.** Consider the following statements:
1. The viscosity-modifying agents allow the concrete to remain cohesive even with a high degree of fluidity.
2. Self-consolidating concrete can be used for beam-column joints in earthquake resistant structures.
3. Self-consolidating concrete is not recommended for precast pre-stressed concrete.

Which of the above statements are correct?
(a) 2 and 3 only
(b) 1 and 2 only
(c) 1 and 3 only
(d) 1, 2 and 3

**Ans.** **(b)**

*End of Solution*

**97.** Which one of the following statements is correct?
(a) CPM is developed especially for scheduling of research and development work.
(b) PERT is developed for the quality control laboratory work at construction site.
(c) PERT is a method of statistically evaluating project duration over a time-sensitive domain.
(d) A project schedule is a rough time table of construction operation.

**Ans.** **(c)**

*End of Solution*

**98.** Which one of the following is NOT considered for the estimation of activity duration?
(a) Evaluate activities one at a time, independently of all others.
(b) For each activity, assume a normal level of manpower and or equipment.
(c) If time units of working days are being used, assume an exceptional day with maximum working hours.
(d) Normal weather conditions is considered for the estimation of duration of each activity.

**Ans.** **(c)**
Six essential rules apply to the estimation of activity durations:
1. Evaluate activities one at a time, independently of all others.
2. For each activity, assume a normal level of manpower and/or equipment.
3. If time units of working days are used, assume a normal workday.
4. Concentrate on estimating the duration of the individual activity and ignore all other time considerations.
5. Use consistent time units throughout.
6. Assume normal weather conditions to estimate the duration needed for each activity.

*End of Solution*

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**99.** Which one of the following statements is NOT correct related to total float?

(a) Total float of an activity is obtained by subtracting its early start time from its late start time.

(b) Subtracting the early finish from late finish provides total float.

(c) Activities with zero total float is called critical activities.

(d) Total float can be calculated by subtracting its early finish time from the earliest of the early start time of the activities directly following.

**Ans.** **(d)**

*End of Solution*

**100.** For heavy civil projects, examination of weight and dimension limit of the road is related to

(a) equipment planning          (b) support planning

(c) quality planning             (d) safety planning

**Ans.** **(a)**

*End of Solution*

**101.** The basic objective of which one of the following is to supply and support the field operations so that established time objectives can be met and costs can be kept within the construction budget?

(a) Time management            (b) Resource management

(c) Financial management        (d) Equipment management

**Ans.** **(b)**

*End of Solution*

**102.** Which one of the following is NOT the characteristic of equipment management and scheduling?

(a) Work should be planned and scheduled to achieve the fullest use of every equipment item, minimizing idle equipment time.

(b) To the maximum extent possible, equipment sent to the job should be of the type that will best perform the work under actual job conditions.

(c) The temptation to overload equipment in an effort to get more production is common but counterproductive.

(d) Examination of weight and dimension limit of the road for carrying heavy equipment.

**Ans.** **(d)**

Characteristics of Equipment Management and scheduling are as follows:

• To the maximum extent possible, equipment sent to the job should be the type that best performs the work under actual job conditions.

• Work should be planned and scheduled to achieve the fullest use of every equipment item, minimizing idle equipment time.

• Since equipment breakdowns not only idle the specific piece of equipment that is dysfunctional but also often disturb other operations, field maintenance must be a key part of the pre-job planning.

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- The production rate of an equipment unit depends not only on the physical characteristics of the piece of equipment but also on the operator and the field supervisors as well.
- The temptation to overload equipment in an effort to get more production is common but counterproductive.
- Actual production rates and costs need to be checked continually on the site for each major piece of equipment, as maintenance and repair vary greatly and affect the efficiency of operation.
- As with labor requirements, in order to achieve the greatest efficiency with an equipment spread, project managers regularly analyze operations to determine whether another unit of equipment is needed or should be removed.

*End of Solution*

**103.** Which one of the following statements is NOT correct according to Gantt chart?
(a) Activities are illustrated as bars on a horizontal time line.
(b) Beginning and end of a bar coincides with the activity's starting and ending dates.
(c) The time and operational concurrency aspects of the schedule is missed in this chart.
(d) Illustrations are given that how the activities are to be distributed over the project time line.

**Ans.** **(c)**

*End of Solution*

**104.** Which one of the following statements is NOT correct related to line-of-balance schedule?
(a) It represents both a presentation format and a scheduling technique.
(b) It is a very visual method of representing a particular type of project.
(c) It allows the planning team a single sequence without any option.
(d) Using a combination of sloping lines, bars and blocks, operations can be sequenced so that space and resource conflicts are quickly identified and addressed.

**Ans.** **(c)**

*End of Solution*

**105.** Which one of the following statements is correct?
(a) PERT is commonly used in the construction work.
(b) PERT is suitable for the estimation of activity duration where high levels of uncertainty is there.
(c) PERT does not provide time duration.
(d) PERT is a deterministic approach for estimating the time duration of an activity.

**Ans.** **(b)**

*End of Solution*

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**106.** Consider the following statements:
1. Building Information Modeling has the ability to produce 3D CAD model.
2. Sequencing of the construction operations can be studied and the schedule can be incorporated into the BIM model.
3. BIM has the capability of adding what some refer to as the fifth dimension, the verbal definition of installed items.

Which of the above statements are correct?
(a) 2 and 3 only
(b) 1 and 2 only
(c) 1, 2 and 3
(d) 1 and 3 only

**Ans.** **(c)**

Significant changes are occurring to traditional construction drawings with the advent of Building Information Modeling (BIM). Instead of paper drawings, the design of most projects has moved to digital models based on advanced versions of computer aided design (CAD) software. Currently, even though the design is in a digital format, the final product of the design is often still printed. But there is a growing trend toward digital?only documents. BIM has expanded the traditional two?dimensional CAD computer model to three dimensions, enabling the project to be rotated and moved so that it can be viewed from any point, internal or external. BIM then adds the fourth dimension of time so that sequencing of the construction operations can be studied and the schedule can be incorporated into the BIM model. Finally, BIM has the capability of adding what some refer to as the fifth dimension, the verbal definition of installed items. This includes specifications and other pertinent information, including installation guidelines and production costs. BIM is taking on the role of becoming a repository for all information about the project from all stakeholders in a single large digital model.

*End of Solution*

**107.** Match the following lists:

**List-I**
P. Resource management
Q. Manpower levelling
R. Supply chain management

**List-II**
1. Getting the correct materials to the workface when needed
2. Judicious allocation of the physical resources
3. Practical improvement of the allocation of labor resources.

Select the correct option using the code given below:

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

**Ans.** **(a)**
- Resource management is judicious allocation of the physical resources.
- Manpower levelling is the process of maintaining a balance in the manpower availability versus project requirement in all disciplines. It is practical improvement of the allocation of labour resources.
- Supply chain management is getting the correct materials to the workface when needed.

*End of Solution*

**108.** For repetitive operations, better information can be obtained from
(a) Gantt chart  (b) Line of balance
(c) Precedence diagram  (d) Bar Chart

**Ans.** **(b)**
A line of balance diagram comprises a series of inclined line which represents the rate of working between repetitive operations in a sequence of construction.

*End of Solution*

**109.** The density of wood used for construction in the ranges between
(a) 1.2 to 1.3 g/cm$^3$  (b) 1.5 to 1.6 g/cm$^3$
(c) 2.3 to 2.6 g/cm$^3$  (d) 2.6 to 2.9 g/cm$^3$

**Ans.** **(b)**

*End of Solution*

**110.** Which one of the following statements is NOT correct?
(a) Rustic Brick has mechanically textured finish, varying in pattern.
(b) Arch Bricks are over-burnt also known as clinker bricks obtained from inner portion of the kiln.
(c) Pale Bricks are over-burnt bricks obtained from outer portion of the kiln.
(d) Body Bricks are well burnt bricks occupying central portion of the kiln.

**Ans.** **(c)**
Pale bricks are under burnt bricks.

*End of Solution*

**111.** Consider the following statements related to the glass:
1. The addition of lime makes the glass fluid and suitable for blowing.
2. Excess of soda increases the safety.
3. Silica is used in the form of pure quartz.
Which of the above statements are correct?
(a) 2 and 3 only  (b) 1 and 2 only
(c) 1, 2 and 3  (d) 1 and 3 only

**Ans.** **(d)**

Silica is used in the form of pure quartz, crushed sandstone and pulverized flint; should be free from iron contents for best quality glass. Since it melts at very high temperatures (1710°C) carbonates of sodium or potassium are added to lower down the fusing temperature to about 800°C. These also make liquid silica more viscous and workable. Lime is used in the form of limestone, chalk or pure marble and sometimes marl. The addition of lime makes the glass fluid and suitable for blowing, drawing, rolling, pressing or spinning. It also imparts durability and toughness to glass. Excess of lime makes the molten mass too thin for fabrication.

Soda acts as an accelerator for the fusion of glass and an excess of it is harmful.

*End of Solution*

**112.** As per IS : 303 and 10701, the thickness of 5 ply plywood boards for structural purpose are available in

(a) 6 mm and 9 mm      (b) 12 mm and 16 mm

(c) 16 mm and 19 mm      (d) 10 mm and 15 mm

**Ans.** **(a)**

For 5 plywood boards, thickness of board will be 5 – 9 mm for general purpose and 6 – 9 mm for structural purpose.

*End of Solution*

**113.** As per IS 8112 : 1989, the minimum required compressive strength of 43 grade ordinary portland cement for 72 hours is

(a) 23 MPa      (b) 33 MPa

(c) 43 MPa      (d) 53 MPa

**Ans.** **(a)**

For OPC 43, compressive strength of 3 days {72 ± 1 hour} is 23 MPa.

*End of Solution*

**114.** Consider the following oxides:

1. $Al_2O_3$
2. $CaO$
3. $SiO_2$

Which one of the following is the correct sequence in increasing order of their percentage analysis for an ordinary portland cement?

(a) 2, 1, 3      (b) 2, 3, 1

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

**Ans.** **(d)**

For an OPC,

$CaO \rightarrow 60 – 67\%$

$SiO_2 \rightarrow 17 – 25\%$

$Al_2O_3 \rightarrow 3 – 8\%$

*End of Solution*

**115.** Excess of Silica makes the brick
(a) brittle on burning
(b) crack on drying
(c) melt on burning
(d) warp

**Ans.** **(a)**
Excess of silica makes brick brittle during burning and excess of alumina makes the brick weak during drying.

*End of Solution*

**116.** Match the following lists:

| List-I (Property of Cement) | List-II (Apparatus) |
|---|---|
| P. Specific gravity | 1. Blain's apparatus |
| Q. Setting time | 2. Le-Chatelier's flask |
| R. Soundness | 3. Autoclave |
| S. Fineness | 4. Vicat's apparatus |

Select the correct answer using the code given below:

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

**Ans.** **(c)**
- **Vicat's apparatus** is used for consistency of cement, initial and final setting time of cement.
- **Autoclave** is for unsoundness due to free lime and magnesia.
- **Blain's apparatus** is used to determine fineness of cement in terms of surface area per unit weight.
- **Le-Chatelier's flask** is used to determine specific gravity of cement.

*End of Solution*

**117.** Which of the following is/are used to measure the workability of lime?
(a) Standard Flow table and a truncated conical mould
(b) Autoclave apparatus
(c) Vicat's apparatus
(d) Slump cone test

**Ans.** **(a)**
Workability of time test is conducted on a standard flow table and a truncated conical mould as per IS 6932 : Part III.

*End of Solution*

**118.** Which one of the following is NOT correct for characteristics of lime?
(a) Lime possesses good plasticity and is easy to work with.
(b) It stiffens easily and is resistant to moisture.
(c) The excellent cementitious properties make it most suitable for masonry work.
(d) The shrinkage on drying is large because of its high water retentivity.

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Ans.   (b)
Lime sets slowly but it has better workability than cement paste.

*End of Solution*

119.   Consider the following statements:
1. Slaking takes place on adding water in lime.
2. Hardening takes place on adding water in cement.
Which of the above statements is/are correct?
(a) 1 only                                          (b) 2 only
(c) Both 1 and 2                                    (d) Neither 1 nor 2

Ans.   (c)
• When water is added to CaO, it results into increment in volume known as slaking.
• When water added into cement, formation of ettringite and C – S – H gel occurs which is responsible for setting and strength gaining known as hardening process.

*End of Solution*

120.   Which one of the following statements is NOT correct with respect to mix design?
(a) The mix must be workable so that it can be placed and finished easily.
(b) The cement is the most costly ingredient in the concrete mix.
(c) The strength and water tightness increase with the density of the mix.
(d) Increasing the water content beyond the required for plasticity cause the strength to increase constantly.

Ans.   (d)
Excess of water content always reduces strength in following manner:
• It may evaporate and causes shrinkage.
• It may cause bleeding, laitance, honey combing and segregation.
• It increases porosity of mix.

*End of Solution*

121.   The value of Poisson's ratio for cast iron is in the range of
(a) 0.09 – 0.19                                     (b) 0.20 – 0.30
(c) 0.31 – 0.41                                     (d) 0.42 – 0.52

Ans.   (b)

| Material | Poisson's ratio |
|---|---|
| Aluminium | 0.33 |
| Brass | 0.34 |
| Bronze | 0.34 |
| Cast iron | 0.2 – 0.3 |
| Concrete | 0.1 – 0.2 |
| Copper | 0.33 – 0.36 |
| Glass | 0.05 – 0.1 |
| Pure rubber and perfectly plastic material | 0.5 |

**122.** A cylindrical bar of 25 mm diameter and 1.20 m length is subjected to a longitudinal strain during a tensile test is four times the lateral strain, what is the value of shear modulus? (Take the modulus of elasticity as $1.2 \times 10^5$ N/mm$^2$)

(a) 5.8 kN/mm$^2$                 (b) 4.8 kN/mm$^2$

(c) 58 kN/mm$^2$                 (d) 48 kN/mm$^2$

**Ans.** **(d)**

Given: $E = 1.2 \times 10^5$ N/mm$^2$

Poisson ratio, $\mu = \dfrac{\text{Lateral strain}}{\text{Longitudinal strain}} = \dfrac{1}{4}$

As we know, $E = 2G(1 + \mu)$

$\Rightarrow \quad 1.2 \times 10^5 = 2 \times G \,(1 + 0.25)$

$\Rightarrow \quad G = 48 \times 10^3$ N/mm$^2$

So, Shear modulus $G = 48$ kN/mm$^2$

**123.** Which one of the following statements is NOT correct?

(a) For structural steel, the rupture strength is higher than the ultimate strength.

(b) Yield stress is the lowest stress at which extension of the test piece increases without further increase in load.

(c) The ultimate strength is commonly taken as the maximum stress of the material.

(d) Ultimate strength is the ratio of maximum load to the original cross-sectional area.

**Ans.** **(a)**

From stress-strain curve of mild steel, rupture (fracture) strength is lower than ultimate strength.

**124.** A prismatic bar has a cross-section of 25 mm × 50 mm and a length of 2 m. If the bar is subjected to an axial tensile force of 90 kN, the bar is elongated by 1.5 mm. What is the tensile stress?

(a) 3.6 N/mm$^2$                 (b) 7.2 N/mm$^2$

(c) 36 N/mm$^2$                 (d) 72 N/mm$^2$

**Ans.** **(d)**

Given, Tensile force, $P = 90$ kN

Cross-sectional area, $A = (25 \times 50)$ mm$^2 = 1250$ mm$^2$

So, Tensile stress, $\sigma = \dfrac{90 \times 10^3}{1250} = 72$ N/mm$^2$

**125.** The normal stress across the principal plane is known as
(a) Shear stress
(b) Maximum shear stress
(c) Principal stress
(d) Tangential stress

**Ans. (c)**

**126.** If the principal stresses at a point in an elastic material are $2f$ tensile, $1.5f$ tensile and $f$ compressive. What is the value of $f$ at failure using maximum principal stress theory? (Take the elastic limit in simple tension as 210 N/mm$^2$ and $\mu = 0.3$)
(a) 210 N/mm$^2$
(b) 420 N/mm$^2$
(c) 170 N/mm$^2$
(d) 105 N/mm$^2$

**Ans. (d)**

As per maximum principal stress theory,

$$\sigma_{P_1} = \frac{\sigma_y}{FOS}$$

where,  $\sigma_{P_1}$ = Maximum principal stress
$\sigma_y$ = Yield stress (elastic limit)

As, factor of safety is not given, so assume it as one.
Therefore,  $2f = 210$

$\Rightarrow$  $f = \dfrac{210}{2} = 105$ N/mm$^2$

**127.** Consider the following statements related to maximum shear stress theory (Guest's theory):
**1.** This theory is well justified for ductile materials.
**2.** It gives accurate results for the state of stress of pure shear in which maximum amount of shear is developed.
**3.** The results of this theory differ from the experimental results for materials having large differences in elastic stress limits in tension and compression.
Which of the above statements is/are NOT correct?
(a) 1 only
(b) 2 only
(c) 3 only
(d) 2 and 3 only

**Ans. (b)**
- Maximum shear stress theory is valid for ductile material.
- This theory is over safe for pure shear. Hence, uneconomical.
  A/c to test, in case of pure shear, failure occurs at $\tau = 0.577\sigma_y$ while, for pure shear, Tresca theory or maximum stress theory gives $\tau = 0.5\sigma_y$.
- Brittle material has large differences in elastic stress limits in tension and compression. So, this theory will give results differ from the experimental results as Guest's theory holds good for ductile material.

**128.** Which one of the following statements is correct for an isotropic material?
(a) Shear modulus is independent of Young's modulus only.
(b) Shear modulus is independent of Poisson's ratio only.
(c) Shear modulus is independent of Young's modulus and Poisson's ratio.
(d) Shear modulus is not independent of Young's modulus and Poisson's ratio.

**Ans.** **(d)**

As we know, for isotropic and homogenous material,
(i) $E = 2G(1 + \mu)$
(ii) $E = 3K(1 - 2\mu)$

where, $E$ is Young's modulus of elasticity
$G$ is shear modulus of elasticity
$K$ is bulk modulus of elasticity
$\mu$ is Poisson's ratio

*End of Solution*

**129.** A body is loaded elastically so that strain in $y$-direction $(e_y) = 0$ and $\sigma_z = 0$. Take $\sigma_x$ and $\sigma_y$ as finite. What is the value of strain in $z$-direction $(e_z)$ in terms of stress in $x$-direction $(\sigma_x)$, Young's modulus $(E)$, and Poisson's ratio $(\upsilon)$?

(a) $e_z = \dfrac{\sigma_x \upsilon (1 + 2\upsilon)}{E}$

(b) $e_z = \dfrac{\sigma_x \upsilon (1 - 4\upsilon)}{E}$

(c) $e_z = \dfrac{\sigma_x (1 + \upsilon)}{E}$

(d) $e_z = \dfrac{-\sigma_x \upsilon (1 + \upsilon)}{E}$

**Ans.** **(d)**

As we know,

Strain in $y$-direction $\qquad e_y = \dfrac{\sigma_y}{E} - \dfrac{\upsilon \sigma_x}{E} - \dfrac{\upsilon \sigma_z}{E}$

where $\sigma_x$, $\sigma_y$ and $\sigma_z$ are normal stresses in $x$, $y$ and $z$-directions.

So, $\qquad 0 = \dfrac{\sigma_y}{E} - \dfrac{\upsilon \sigma_x}{E} \qquad \begin{bmatrix} \because e_y = 0 \\ \sigma_z = 0 \end{bmatrix}$

$\Rightarrow \qquad \dfrac{\sigma_y}{E} = \dfrac{\upsilon \sigma_x}{E} \qquad\qquad\qquad ...(i)$

Now, strain in $z$-direction, $\qquad e_z = \dfrac{\sigma_z}{E} - \dfrac{\upsilon \sigma_x}{E} - \dfrac{\upsilon \sigma_y}{E}$

$= 0 - \upsilon \left( \dfrac{\sigma_x}{E} + \dfrac{\upsilon \sigma_x}{E} \right) \qquad [\because \text{ by equation (i)}]$

$= -\upsilon \sigma_x \left( \dfrac{1 + \upsilon}{E} \right)$

*End of Solution*

**130.** What are the three stress invariants (in MPa) respectively in a body under the stress states of, $\sigma_x = 10$, $\sigma_y = 8$, $\sigma_z = -5$, $\tau_{yz} = \tau_{zy} = 5$, $\tau_{zx} = \tau_{xz} = -4$ and $\tau_{xy} = \tau_{yx} = -8$, where all stresses are in MPa?

(a) 23, –128 and 125
(b) 13, 115 and –138
(c) 115, 13, –128
(d) –138, 23, 125

**Ans.** **(b)**

Stress invariants are defined as $A$, $B$ and $C$

where, $A = \sigma_x + \sigma_y + \sigma_z$

So, $A = 10 + 8 - 5 = 13$

$$B = \sigma_x\sigma_y + \sigma_x\sigma_z + \sigma_y\sigma_z - \tau_{xy}^2 - \tau_{xz}^2 - \tau_{yz}^2$$

$$B = 10 \times 8 + 8 \times (-5) + 10 \times (-5) - (-8)^2 - (-4)^2 - (5)^2$$
$$= 80 - 40 - 50 - 64 - 16 - 25 = -115$$

$$C = \sigma_x\sigma_y\sigma_z + 2\tau_{xy}\tau_{xz}\tau_{yz} - \sigma_x\tau_{yz}^2 - \sigma_y\tau_{xz}^2 - \sigma_z\tau_{xy}^2$$

$$= 10 \times 8 \times (-5) + 2 \times (-8) \times (-4) \times 5 - 10 \times 5^2 - 8 \times (-4)^2$$
$$- (-5) \times (-8)^2$$
$$= -138$$

*End of Solution*

**131.** A cantilever beam of 4 m span carries three point loads of 1 kN, 2 kN and 2 kN at 2 m, 3 m and 4 m from the fixed end respectively. What is the bending moment at 3 m from fixed support?

(a) 4 kNm (Anticlockwise)
(b) 6 kNm (Clockwise)
(c) 3 kNm (Clockwise)
(d) 2 kNm (Anticlockwise)

**Ans.** **(d)**

We have to find bending moment at $C$.
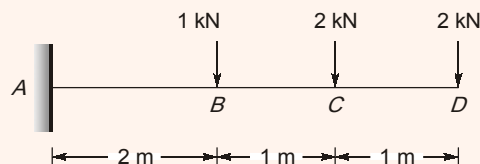


Let, B.M be $M_x$ clockwise at $C$
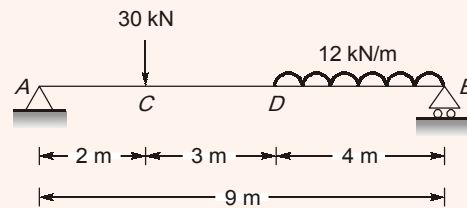
So, $M_x + 2 \times (1) = 0$

$M_x = -2$

Hence, bending moment will be 2 kNm anticlockwise.

*End of Solution*

**132.** A simply supported beam of 9 m span carries a point load of 30 kN at 2 m from the left end of the support. It also carries a UDL of 12 kN/m over 4 m span from the right support. What is the value of shear force at 5 m from the left support?

(a) 4 kN
(b) 44 kN
(c) 3 kN
(d) 33 kN

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**Ans.** **(a)**



Reaction forces at $A$ and $B$:

$$\Sigma M_A = 0$$
$$\Rightarrow \quad V_B \times 9 = 30 \times 2 + 12 \times 4 \times (7)$$
$$\Rightarrow \quad V_B = 44 \text{ kN}$$

So, $\quad V_A = (30 + 12 \times 4) - 44 = 34 \text{ kN}$

Shear force at 5 m from left support,

$$S_D = 34 - 30 = 4 \text{ kN}$$

*End of Solution*

**133.** What is the ratio of elongation of a rectangular bar due to self-weight to the elongation if total weight of the bar is applied at its end?

(a) $\dfrac{1}{2}$ 

(b) 2

(c) $\dfrac{1}{3}$ 

(d) 3

**Ans.** **(a)**

Elongation of a rectangular bar due to self weight (say, $W$) is given by

$$\delta_1 = \frac{WL}{2AE}$$

Elongation of a rectangular bar if weight ($W$) is applied at end is given by

$$\delta_2 = \frac{WL}{AE}$$

So, Required ratio $= \dfrac{\delta_1}{\delta_2} = \dfrac{\dfrac{WL}{2AE}}{\dfrac{WL}{AE}} = \dfrac{1}{2}$

*End of Solution*

**134.** The stresses on two perpendicular planes through a point are 60 N/mm$^2$ tension, 40 N/mm$^2$ compression and 30 N/mm$^2$ shear. What is the absolute normal stress on a plane at 60° to that of the tensile stress?

(a) 10.98 N/mm$^2$ 

(b) 17.63 N/mm$^2$

(c) 20.98 N/mm$^2$ 

(d) 32.63 N/mm$^2$

**Ans.** **(a)**



40 N/mm$^2$

30 N/mm$^2$

30 N/mm$^2$

60°

60 N/mm$^2$

60 N/mm$^2$

30 N/mm$^2$

30 N/mm$^2$

40 N/mm$^2$
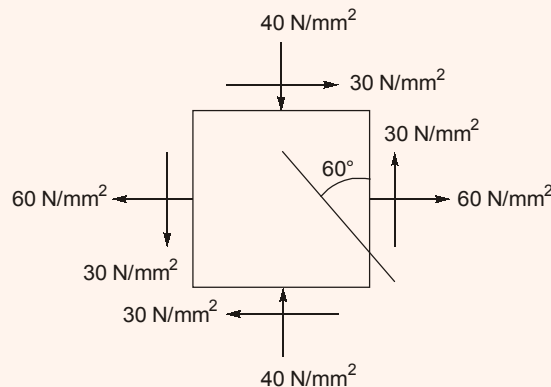
$$\sigma_x' = \left(\frac{\sigma_x + \sigma_y}{2}\right) + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\sigma_x' = \left(\frac{60 + (-40)}{2}\right) + \left(\frac{60 - (-40)}{2}\right)\cos 120° + 30\sin 120°$$

$$= 10 + 50\cos 120° + 30\sin 120°$$

$$= 10.98 \text{ N/mm}^2$$

*End of Solution*

**135.** Which one of the following statements is correct?
(a) The rate of change of shear force along the length of the beam is equal to bending moment.
(b) The bending moment is zero at the point where shear force changes sign.
(c) Shear force changes abruptly at the point of application of couple.
(d) Rate of change of bending moment changes abruptly at the location of point load.

**Ans.** **(d)**
As we know,
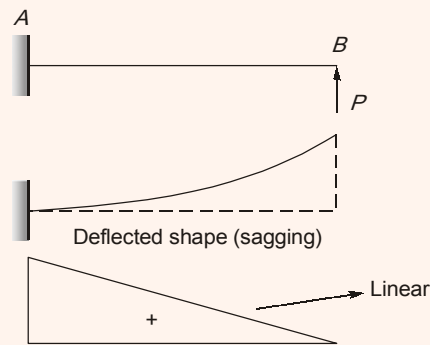
Rate of change of bending moment, $\dfrac{dM}{dx} = V$

where $V$ is shear force
Application of point load brings change in magnitude of shear force at location of application of load.

*End of Solution*

**136.** A cantilever beam is subjected to a point load against gravity at its free end. The variation and nature of the bending moment will be
(a) linear and hogging
(b) linear and sagging
(c) parabolic and hogging
(d) parabolic and sagging

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**Ans.** **(b)**



Deflected shape (sagging)

Linear

+

**137.** A cast iron pipe has 300 mm bore and 10 mm metal thickness, and is supported at two points 8 m apart. What is the internal area of pipe?
(a) 0.07069 m$^2$                    (b) 1.57059 m$^2$
(c) 2.67069 m$^2$                 (d) 3.47059 m$^2$

**Ans.** **(a)**

$$\text{Internal diameter} = 300 \text{ mm}$$
$$\text{External diameter} = 300 + 2 \times \text{Thickness}$$
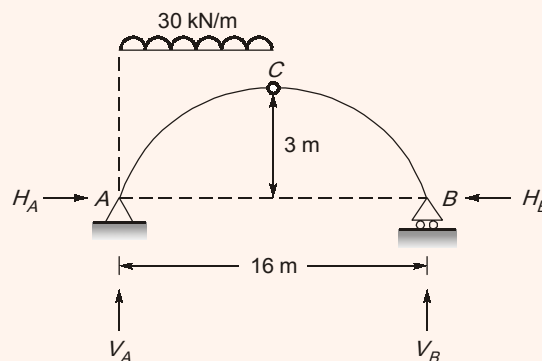$$= 300 + 2 \times 8 = 316 \text{ mm}$$

So, Internal area of pipe $= \dfrac{\pi}{4} \times 300^2$ mm$^2$

$$= 70685.83 \text{ mm}^2$$
$$= 0.07069 \text{ m}^2$$

**138.** A parabolic 3 hinged arch (*AB*) carries a u.d.l. of 30 kN/m on the left half of the span. It has a span of 16 m and a central rise of 3 m. What is the resultant thrust at '*A*' (left hand end)?
(a) 271 kN                       (b) 141 kN
(c) 241 kN                       (d) 171 kN

**Ans.** **(c)**

$$\Sigma M_A = 0$$

$$\Rightarrow \quad V_B \times 16 = 30 \times 8 \times 4$$

$$\Rightarrow \quad V_B = 60 \text{ kN}$$

So, $\quad V_A = (8 \times 30 - 60) = 180 \text{ kN}$

$$\Sigma M_{C, \text{ left}} = 0$$

$$\Rightarrow \quad V_A \times 8 = H_A \times 3 + 30 \times 8 \times 4$$

$$H_A = \frac{180 \times 8 - 30 \times 8 \times 4}{3} = 160 \text{ kN}$$

$$\text{Resultant thrust} = \sqrt{V_A^2 + H_A^2}$$

$$= \sqrt{180^2 + 160^2} = 240.83 \simeq 241 \text{ kN}$$

*End of Solution*

---

**139.** A fixed beam subjected to a central point load against gravity, the number of points of contraflexure and their positions respectively are

(a) 1 and $\dfrac{L}{2}$ from centre of the beam

(b) 2 and $\dfrac{L}{3}$ from both the supports

(c) 2 and $\dfrac{L}{4}$ from centre of the beam

(d) 3 and $\dfrac{L}{4}$ from both the supports and at centre of the beam

**Ans.** **(c)**



Deflected shape
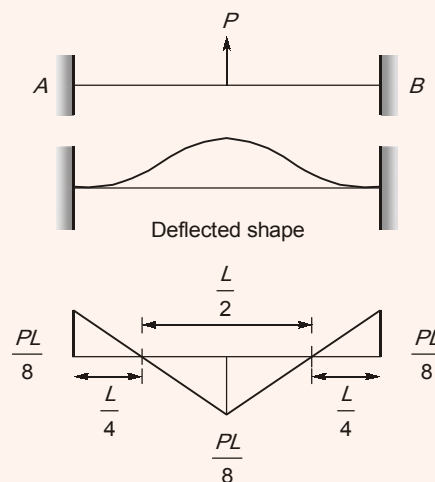
So, total number of point or contraflexure = 2

Location or point or contraflexure is $\dfrac{L}{4}$ distance from both the support.

*End of Solution*

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**140.** If one support of a fixed-ended beam settles, then what is the nature of the end moments?
(a) One will be clockwise and another will be anticlockwise.
(b) Both will be either clockwise or anticlockwise.
(c) No moments will be induced at the ends.
(d) The moments will be $\dfrac{3EI}{L}$ and in same sense.

**Ans.** **(b)**
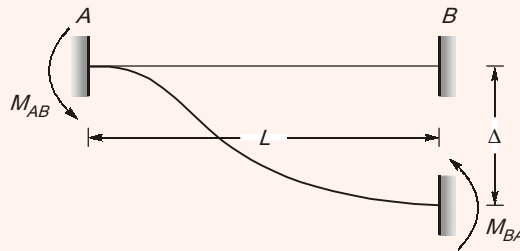


$$M_{AB} = M_{BA} = \frac{6EI\Delta}{L^2} \text{ (anticlockwise)}$$

Similarly, if the fixed joint $B$ is displaced upward by $\Delta$, then the fixed end moment will have same magnitude as above but in clockwise direction.

*End of Solution*

**141.** A rectangular c/s beam of size 300 mm × 500 mm is subjected to shear force of 20 kN. What is the shear stress at 150 mm above neutral axis?
(a) 0.30 MPa (b) 0.60 MPa
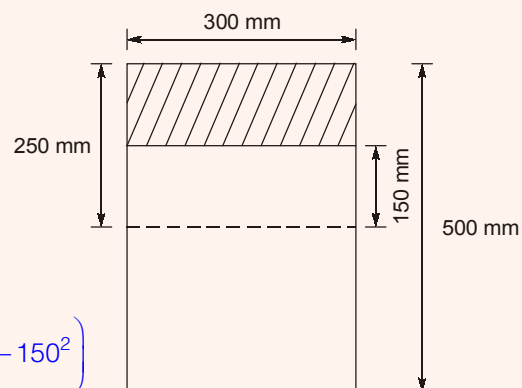(c) 0.36 MPa (d) 0.13 MPa

**Ans.** **(d)**

In a rectangular section,

Shear stress, $\tau = \dfrac{V}{2I}\left(\dfrac{d^2}{4} - y^2\right)$

where, $V$ = Shear force
$I$ = Moment of inertia
$d$ is depth of beam
$y$ is 150 mm



So, $\tau = \dfrac{20 \times 10^3 \times 12}{2 \times 300 \times 500^3} \times \left(\dfrac{500^2}{4} - 150^2\right)$

$= 0.128 \text{ MPa} \simeq 0.13 \text{ MPa}$

*End of Solution*

**142.** Which one of the following is NOT the assumption of Euler's column theory?
(a) The direct stress is very small compared to the bending stress.
(b) The self-weight of the column is considerable.
(c) The cross-section of the column is uniform throughout.
(d) The column will fail by buckling only.

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**Ans.** **(b)**

As per Euler's column theory, weight of column is neglected.
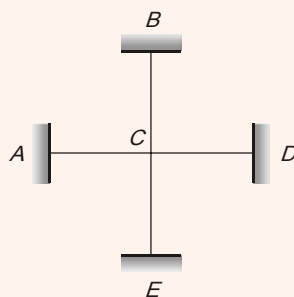
**143.** In a rigid joint plane frame structure, introduction of pins to all members at a joint produces additional equations equal to
(a) Number of members at the joint – 4
(b) Number of members at the joint – 2
(c) Number of members at the joint – 1
(d) Number of members at the joint – 3

**Ans.** **(c)**

Consider the example shown below:



When $C$ is a rigid joint, only one equilibrium equation is available which is summation of moment at $C$ is 0, i.e. $\Sigma M_C = 0$
When $C$ becomes a pin joint, equilibrium equation are four
($M_{CA} = 0$, $M_{CB} = 0$, $M_{CD} = 0$, $M_{CE} = 0$)
So, extra equations        4 – 1 = 3
Thus,            Extra equation = Number of member at the joint – 1

**144.** Consider the following statements:
1. The distribution factor for fixed and pin support is zero since any moment is resisted by an equal and opposite moment within the support and no balancing is required.
2. In the case of pinned supports, the distribution factor is equal to 1.0 since 100% of any applied moment must be balanced and a carry-over of $\frac{1}{2} \times$ the balancing moment transferred to the remote end at the internal support.
Which of the above statements is/are correct?
(a) 1 only                    (b) 2 only
(c) Both 1 and 2              (d) Neither 1 nor 2

**Ans.** **(b)**

Distribution factor for fixed support is 0 and for pin-support it is 1.

**Directions :** Each of the next Six (06) items consists of two statements, one labelled as the 'Statement (I)' and the other as 'Statement (II)'. You are to examine these two statements carefully and select the answers to these items using the codes given below :

**Codes :**
    (a)  Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
    (b)  Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
    (c)  Statement (I) is true but Statement (II) is false.
    (d)  Statement (I) is false but Statement (II) is true.

**145.**   **Statement I :** Wood is essentially an organic substance, made up of a skeleton of cellulose impregnated with lignin.
    **Statement II :** The organic substances are not susceptible to attack by both bacteria and fungi.

**Ans.**   **(c)**
    Wood is essentially an organic substance, made up of a skeleton of cellulose impregnated with lignin. The organic substances are susceptible to attack by both bacteria and fungi.

*End of Solution*

**146.**   **Statement I :** Any orthogonal set of axes are 180° to one another on Mohr's circle.
    **Statement II :** The distance between these axes is half the diameter of the circle.

**Ans.**   **(c)**
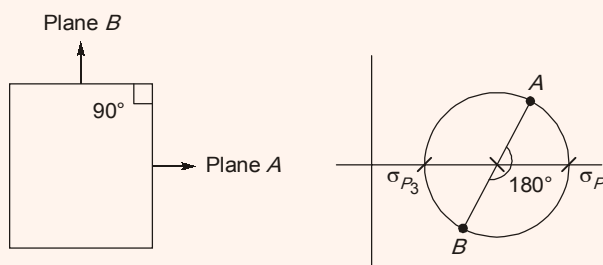


    The distance between, these axis is equal to diameter of Mohr's circle, (*AB* as shown in figure).

*End of Solution*

**147.**   **Statement I :** There may be as many unknown forces as there are equations of equilibrium; however, instability or movement of a structure or its members can develop because of improper constraining by the supports.
    **Statement II :** This can occur if all the support reactions are concurrent at a point and when the reactive forces are all parallel.

**Ans.**   **(a)**

*End of Solution*

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148. **Statement I :** The negative derivative of velocity potential function with respect to any direction gives the fluid velocity in that direction.
**Statement II :** The partial derivative of stream function in any direction gives the velocity component in that direction.

**Ans.** **(c)**
The partial derivative of stream function in any direction gives the velocity component perpendicular to that direction.

$$\left. \begin{array}{l} u = \dfrac{-\partial \phi}{\partial x} \\[6pt] v = \dfrac{-\partial \phi}{\partial y} \\[6pt] w = \dfrac{-\partial \phi}{\partial z} \end{array} \right\} \text{Statement I is correct}$$

$$\left. \begin{array}{l} u = -\dfrac{\partial \psi}{\partial y} \\[6pt] v = \dfrac{\partial \psi}{\partial x} \end{array} \right\} \text{Statement II is incorrect}$$

*End of Solution*

149. **Statement I :** In Hardy cross method, a trial distribution of discharges is made arbitrary.
**Statement II :** The continuity equation must satisfy at each junction.

**Ans.** **(b)**

*End of Solution*

150. **Statement I :** Cross drainage structure, aqueduct is constructed to negotiate an aligned channel over, below or at the same level of a stream.
**Statement II :** Aqueduct is constructed, when full supply level (FSL) of canal is much higher than high flood level (HFL) of a stream.

**Ans.** **(d)**
Aqueduct is a cross drainage work in which high flood level (HFL) of drain is much below the bed level of the canal. So that drainage water flows freely under gravity. Therefore most appropriate answer is (d).

*End of Solution*

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