MADE EASY PUBLICATIONS

POSTAL BOOK PACKAGE 2027

CIVIL ENGINEERING

OBJECTIVE PRACTICE SETS VOLUME - II

CONTENTS

ENGINEERING MECHANICS

OBJECTIVE PRACTICE SETS

Page No. 1 - 55

1 CHAPTER
FBD, Equilibrium, Plane Trusses and Virtual Work

Q.1 Varignon's theorem is applicable only when the forces are:
(a) coplanar (b) concurrent
(c) non-concurrent (d) parallel

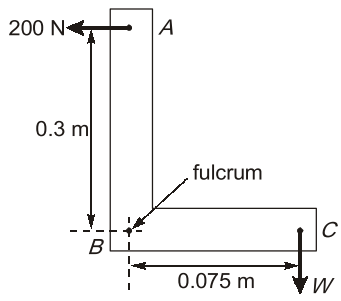
Q.2 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
A. Lami's theorem
B. Varignon's theorem
C. Newton's first law of motion
D. Polygon law of forces

List-II
1. Determination of the position of resultant of parallel forces.
2. Definitions of the general condition of equilibrium.
3. Determination of resultant of non-parallel forces.
4. Estimation of the three forces on a body in equilibrium.

Codes:
(a) 4 1 2 3
(b) 1 4 3 2
(c) 1 4 2 3
(d) 4 1 3 2

Q.3 A horizontal force of 200 N is applied at A to lift the weight *W* at *C* as shown in the figure. The value of weight *W*, will be



(a) 200 N (b) 400 N
(c) 600 N (d) 800 N

Q.4 If two forces P and Q act at an angle θ the resultant of these two forces would make an angle α with P such that

(a) $\tan\alpha = \dfrac{Q\sin\theta}{P - Q\sin\theta}$

(b) $\tan\alpha = \dfrac{P\sin\theta}{P + Q\sin\theta}$

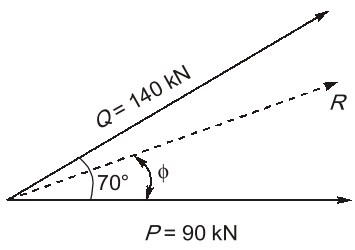
(c) $\tan\alpha = \dfrac{Q\sin\theta}{P + Q\cos\theta}$

(d) $\tan\alpha = \dfrac{P\sin\theta}{Q - P\cos\theta}$

Q.5 The sum of the magnitudes of two forces acting at a point is 18 and the magnitude of their resultant is 12. If the resultant is 90° with the forces of smaller magnitude, the magnitude of forces are
(a) 10 and 8 (b) 9 and 9
(c) 5 and 13 (d) 6 and 12

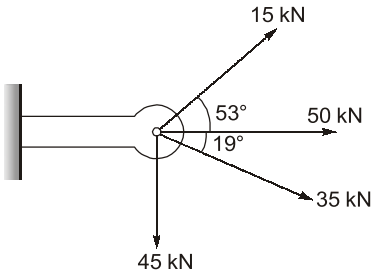
Q.6 If the magnitude of maximum and minimum resultant forces of the two forces acting on a particle are 40 kN and 10 kN respectively, then the two forces would be
(a) 25 kN and 15 kN
(b) 20 kN and 20 kN
(c) 20 kN and 10 kN
(d) 20 kN and 5 kN

Q.7 The resultant R and angle of resultant ϕ for the given system of force will be respectively:



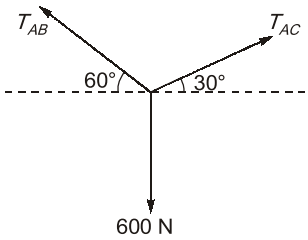
(a) 190.58 kN; 43° 39′ (b) 138.13 kN, 72°14′
(c) 166.43 kN; 47°51′ (d) 190.58 kN, 72°14′

Q.8 In the above figure, four cable exerts tension as indicated on the eyebolt. It is intended to replace these cables by a single cable. The tension on the single cable and angle at which it will be oriented w.r.t. the 50 kN (Assume coplanar force system).



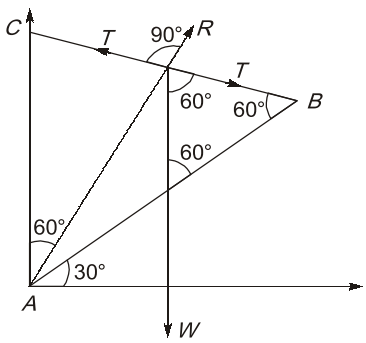
(a) 102.27 kN, 64.36° (clockwise)
(b) 102.27 kN, 25.74° (clockwise)
(c) 100.5 kN, 25.74° (clockwise)
(d) 100.5 kN, 64.26° (clockwise)

Q.9 If a point *A* is in equilibrium under the action of the applied forces, the value of tensions T_{AB} and T_{AC} are respectively

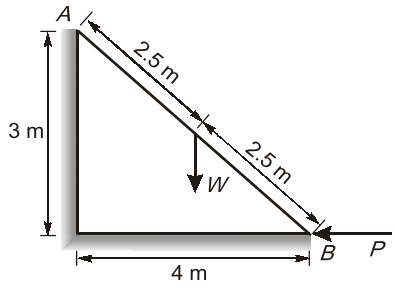


(a) 520 N and 300 N (b) 300 N and 520 N
(c) 450 N and 150 N (d) 150 N and 450 N

Q.10 A uniform beam *AB* as shown in figure below is pinned at *A* and is held by a cable *BC* in the position shown. If the tension in the cable is 20 kgf, then the reaction of the pin at A on the beam will be _____ kgf.

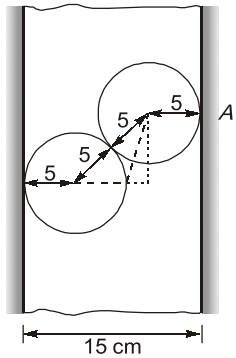


Q.11 A ladder *AB* of length 5 m and weight (W) = 600 N is resting against a wall. Assuming frictionless contact at the floor (B), and the wall (A), the magnitude of force P(in Newton) required to maintain equilibrium of ladder is _____.



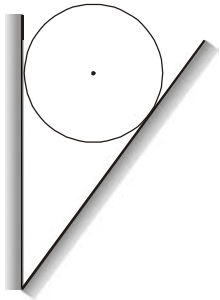
Q.12 Weight of 120 kN is being supported by a tripod whose each leg of length of 13 m. If the vertical height of the point of attachment of the load is 12 m, the force on the tripod leg would be
(a) 37.67 kN (b) 40 kN
(c) 43.3 kN (d) 46.6 kN

Q.13 In the figure shown, consider the two identical spheres with radius 5 cm, weight 100 N each and the distance between the two walls as 15 cm. What is the reaction force at point *A*?



(a) 173.2 N (b) 57.7 N
(c) 100 N (d) 0 N

Q.14 A ball of weight W is supported on smooth planes as shown in figure. The correct FBD will be given by:



Answers FBD, Equilibrium, Plane Trusses and Virtual Work

1. (b)	2. (a)	3. (d)	4. (c)	5. (c)	6. (a)	7. (a)	8. (b)	9. (a)	10. 346.4
11. 400	12. (c)	13. (b)	14. (a)	15. (b)	16. (b)	17. (b)	18. (c)	19. (a)	20. (b)
21. 57.74	22. (a)	23. 100	24. (c)	25. (b)	26. (a)	27. 50	28. 20	29. (d)	30. (d)
31. 1.5	32. (a)	33. (b)	34. (b)	35. (c)	36. (d)	37. (b)	38. (c)	39. (a)	40. (c)
41. 70.71	42. (d)	43. (a)	44. 0	45. 5	46. 20	47. (a)	48. (c)	49. (c)	50. (d)
51. 10.606		52. (a, b, c, d)							

Explanations FBD, Equilibrium, Plane Trusses and Virtual Work

2. (a)

Lami's theorem: In statics, lami's theorem is an equation relating the magnitudes of three coplanar, concurrent and non-collinear forces which keeps an object in static equilibrium, with the angles directly opposite to the corresponding forces,

$$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$$

Where,

A, B, C are the magnitude of three coplanar, concurrent and non-collinear forces which keeps the object in static equilibrium, and α, β and γ are the angles directly opposite to the forces A, B and C respectively.

Polygon Law's of forces: If a number of forces acting simultaneously on a particle be represented in magnitude and direction by the sides of a polygon taken in order, their resultant may be represented in magnitude and direction by the closing side of the polygon taken in opposite order.

Newton's first Law of Motion: When viewed in an inertial reference frame, an object either remains at rest or moves with constant velocity, unless acted upon by an external force.

Varignon's Theorem: The moment about any point of the resultant of several concurrent forces is equal to the sum of the moments of the particular forces about the same point.

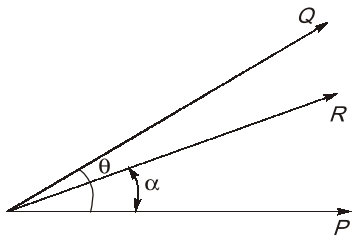
3. (d)

Taking moment about fulcrum B,

$200 \times 0.3 = W \times 0.075$

$$W = \frac{200 \times 0.3}{0.075} = 800 \text{ N}$$

4. (c)



$$R\sin\alpha = Q\sin\theta$$

$$R\cos\alpha = Q\cos\theta + P$$

$$\Rightarrow \quad \tan\alpha = \frac{Q\sin\theta}{Q\cos\theta + P}$$

5. (c)

Let P be the smaller force,

$$P + Q = 18 \quad \ldots(1)$$

$$R = (P^2 + Q^2 + 2PQ\cos\theta)^{1/2} = 12 \quad \ldots(2)$$

Also,

$$\frac{Q\sin\theta}{P + Q\cos\theta} = \tan\alpha = \tan 90^\circ = \infty$$

$$\Rightarrow P + Q\cos\theta = 0 \quad \ldots(3)$$

Subtracting eq. (3) eq. (1)

$$P + Q\cos\theta - P - Q = 0 - 18$$

$$Q(1 - \cos\theta) = 18 \quad \ldots(4)$$

Now, operating square of eq. (2- eq. (1)

$$18^2 - (12)^2 = 2PQ(1 - \cos\theta)$$

$$180 = 2PQ(1 - \cos\theta) \quad \ldots(5)$$

Operate eq. (4) subtract eq. (5)

$$\frac{Q(1-\cos\theta)}{2PQ(1-\cos\theta)} = \frac{18}{180}$$

$$2P = 10$$

$$P = 5$$

From eq. (1); $Q = 18 - 5 = 13$

So, magnitude of forces are 5 and 13.

6. (a)

Resultant of two forces,

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

R will be maximum when, $\cos\theta = 1$

$$R_{max} = \sqrt{P^2 + Q^2 + 2PQ} = \sqrt{(P+Q)^2} = P + Q$$

R will be minimum when, $\cos\theta = -1$

$$R_{min} = \sqrt{P^2 + Q^2 - 2PQ} = \sqrt{(P-Q)^2} = P - Q$$

$P + Q = 40$

$P - Q = 10$

$2P = 50$

$P = 25$ kN; $Q = 15$ kN

7. (a)

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$$= \sqrt{(90)^2 + (140)^2 + 2\times 140\times 90\times(\cos 70°)}$$

$= 190.58$ kN

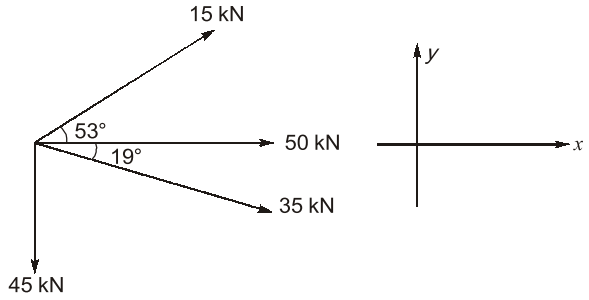
$$\tan\phi = \frac{Q\sin\theta}{P + Q\cos\theta}$$

$$= \frac{140\sin 70°}{90 + 140\cos 70°} = 0.594$$

$\phi = 43°39'$

8. (b)

Figure can be idealized as:



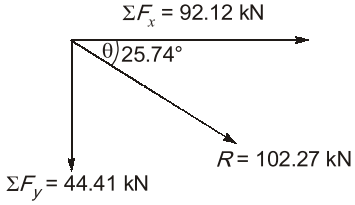
$\Sigma F_x = 50 + 15\cos 53° + 35\cos 19° = 92.12$ kN

$\Sigma F_y = 15\sin 53° - 45 - 35\sin 19° = -44.41$ kN

Resultant,

$$F_R = \sqrt{(92.12)^2 + (-44.41)^2} = 102.26 \text{ kN}$$

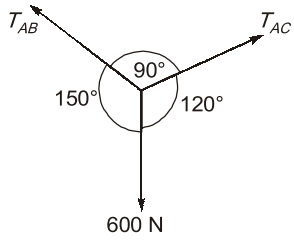
$$\tan\theta = \left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$



$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = \tan^{-1}\left(\frac{44.41}{92.12}\right) = 25.74°$$

9. (a)

Method : 1



$$\frac{T_{AB}}{\sin 120°} = \frac{T_{AC}}{\sin 150°} = \frac{600}{\sin 90°}$$

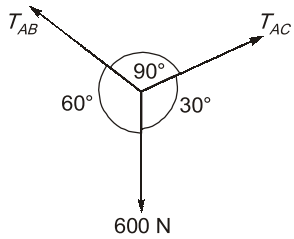
$T_{AB} = 600\sin 120° = 519.61$

$= 520$ N

$T_{AC} = 600\sin 150° = 300$ N

Method : 2

In equilibrium:



$\Sigma F_x = 0$

$T_{AC}\cos 30° - T_{AB}\cos 60° = 0$

$$T_{AC} = T_{AB}\frac{\cos 60°}{\cos 30°} = \frac{T_{AB}}{\sqrt{3}} \quad ...(i)$$

Vertical forces $\Sigma F_y = 0$

$T_{AC}\sin 30° + T_{AB}\sin 60° - 600 = 0$

$$T_{AC} + \sqrt{3}\cdot T_{AB} = (600 \times 2)$$

$$T_{AC} + \sqrt{3}\cdot T_{AB} = 1200 \quad ...(ii)$$

From eq. (i) and eq. (ii)

$$\frac{T_{AB}}{\sqrt{3}} + \sqrt{3}\cdot T_{AB} = 1200$$

$$4T_{AB} = 1200\sqrt{3}$$

$$T_{AB} = 300\sqrt{3} = 519.61 \text{ N}$$

$\simeq 520$ N

and $$T_{AC} = \frac{T_{AB}}{\sqrt{3}} = \frac{300\sqrt{3}}{\sqrt{3}} = 300 \text{ N}$$

10. 346.4(345 to 347)

From Lami's theorem:

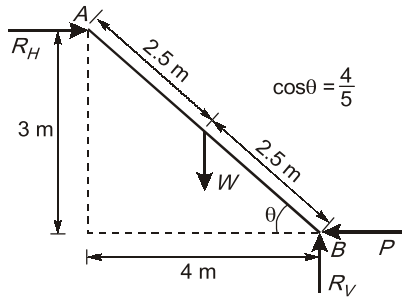
$$\frac{W}{\sin 90^\circ} = \frac{T}{\sin(90^\circ+60^\circ)} = \frac{R}{\sin(90^\circ+30^\circ)}$$

$$W = \frac{200\times 2}{1} = \frac{R\times 2}{\sqrt{3}}$$

$$R = 200\sqrt{3} \text{ kgf} = 346.4 \text{ kg(f)}$$

11. 400 (399 to 401)

FBD diagram of the ladder:



Taking moment about B

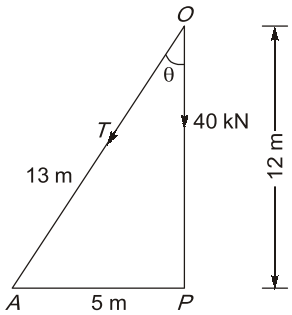
$$R_H \times 3 = W \times 2.5\cos\theta$$

$$R_H = \frac{600\times 2.5\times\frac{4}{5}}{3} = 400 \text{ N}$$

$$\Sigma F_H = 0$$

$$R_H = P = 400 \text{ N}$$

12. (c)



The weight $W = 120$ kN would be equally shared by all the three legs.

Since the vertical height $OP = 12$ m

Length of leg $OA = 13$ m

$$\therefore \quad AP = \sqrt{(13)^2-(12)^2} = 5\text{m}$$

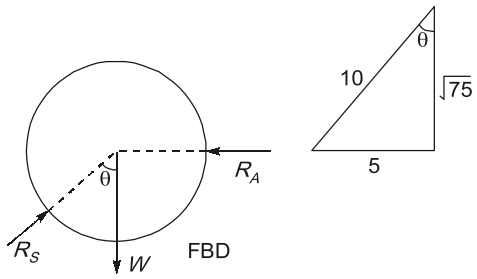
If the force on tripod leg is T, then

$$T\cos\theta + 40 = 0$$

$$T = \frac{-40}{\cos\theta} = \frac{-40}{\left(\frac{12}{13}\right)}$$

$$\Rightarrow \quad T = 43.3 \text{ kN} \quad \text{(Comp.)}$$

13. (b)



$$\cos\theta = \frac{\sqrt{75}}{10}$$

$$\sin\theta = \frac{5}{10}$$

$$\Sigma F_y = 0$$

$$W = R_s\cos\theta$$

$$R_s = \frac{W}{\cos\theta} = \frac{100\times 10}{\sqrt{75}} = \frac{1000}{\sqrt{75}}$$

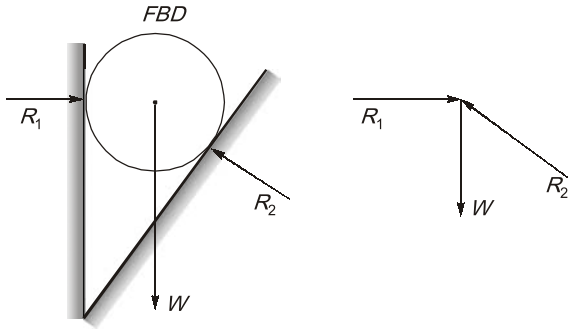
$$\Sigma F_x = 0$$

$$R_s\sin\theta = R_A$$

$$R_A = \frac{100}{\sqrt{75}}\times\frac{5}{10} = \frac{500}{\sqrt{75}}$$

$$= 57.735 \text{ N}$$

14. (a)



15. (b)

From geometry it is clear that the angle between R and T is $(\alpha+\beta)$

Angle between R and W is $(180^\circ-\alpha)$

Angle between T and W is $(180^\circ-\beta)$

Using Lami's theorem

$$\frac{W}{\sin(\alpha+\beta)} = \frac{T}{\sin(180^\circ-\alpha)} = \frac{R}{\sin(180^\circ-\beta)}$$

16. (b)

For equilibrium

$$P_1 + P_2 + P_3 + P_4 = 0$$

$$P_4 = -(P_1 + P_2 + P_3)$$

$$= -\left(3\hat{i}+6\hat{i}-1.5\hat{j}+4.5\hat{j}-10.5\hat{i}+1.5\hat{j}\right)$$

$$= -\left(-9\hat{i}+12\hat{j}\right) = \left(9\hat{i}-12\hat{j}\right)N$$

STRENGTH OF MATERIALS

OBJECTIVE PRACTICE SETS

1 CHAPTER
Properties of Materials

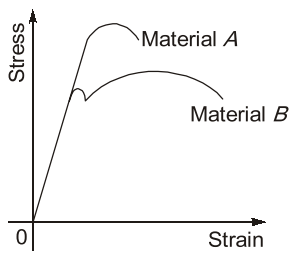
Q.1 In a tensile test, near the elastic limit zone
(a) tensile stress increases at a faster rate
(b) tensile stress decreases at a faster rate
(c) tensile stress increases in linear proportion to the strain
(d) tensile stress decreases in linear proportion to the strain

Q.2 Consider the following statements:
1. Mild steel is more elastic than rubber.
2. Young's modulus of a material is used to represent the elasticity of the material.
3. Greater the Young's modulus, greater the elasticity.

Which of the above statement(s) is/are correct?
(a) Only 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.3 Which of the following properties is more sensitive to increase in strain rate?
(a) Yield strength
(b) Elastic limit
(c) Proportional limit
(d) Tensile strength

Q.4 The stress-strain diagram for two materials *A* and *B* is shown below:



The following statements are made based on this diagram:
I. Material *A* is more brittle than material *B*.
II. The ultimate strength of material *B* is more than that of *A*.

With reference to the above statements, which of the following applies?
(a) Both the statements are false
(b) Both the statements are true
(c) I is true but II is false
(d) I is false but II is true

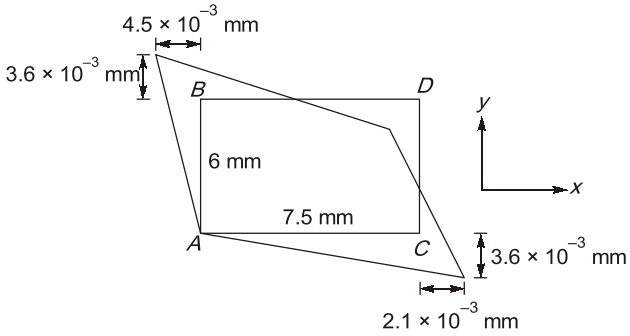
Q.5 As soon as the external forces causing deformation in a perfectly elastic body, are withdrawn, the elastic deformation disappears
(a) only partially
(b) completely over a prolonged period of time
(c) completely and instantaneously
(d) completely after an initial period of rest

Q.6 Which one of the following favours brittle fracture in a ductile material?
(a) Elevated temperature
(b) Slow rate of straining
(c) Presence of notch
(d) Circular cross-section

Q.7 Consider the following statements:
1. Strain-softening region in stress strain curve is also known as post ultimate stress.
2. Logarithmic strain given as $\bar{\varepsilon} = \ln\left(\frac{L_f}{L_0}\right)$ is same as true strain.
3. Value of elastic modulus is a definite property of a material.

Which of the above statements is(are) INCORRECT?
(a) 1 and 3 (b) 2 only
(c) 1 only (d) None of these

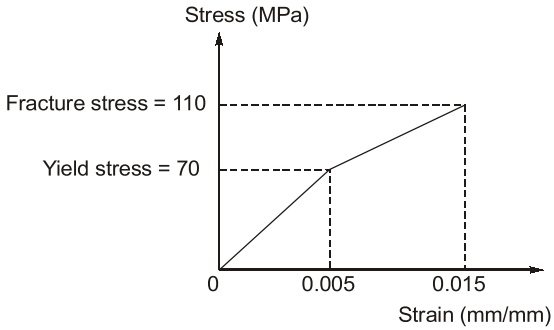
Q.8 An initially rectangular element of a material is deformed as shown in figure. The shear strain for the element (γ_{xy}), will be



(a) 1370×10^{-6} (b) 1500×10^{-6}
(c) 1230×10^{-6} (d) 900×10^{-6}

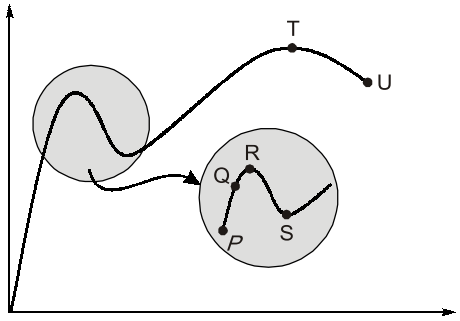
Q.9 If $\in$ is engineering strain in a tensile specimen. The value of true strain ($\in_t$) is given as
(a) $\in$ (b) $e^{\in} - 1$
(c) $ln(1 + \in)$ (d) $\left(\frac{1-\in}{6}\right)$

Q.10 The stress stain behaviour of a material is as shown in figure below. Its modulus of resilience and toughness in Nm/m^3 are respectively:



(a) 20×10^4 and 107.5×10^4
(b) 17.5×10^4 and 107.5×10^4
(c) 17.5×10^4 and 120×10^4
(d) 35×10^4 and 140×10^4

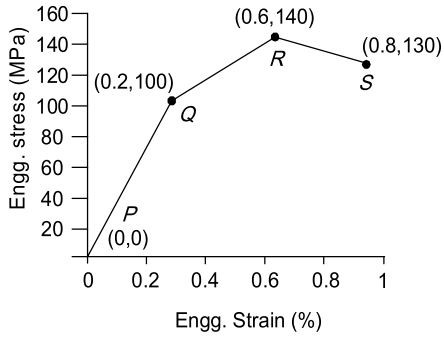
Q.11 The stress-strain curve for mild steel is shown in figure given below. Choose the correct option referring to both figure and table.



Point on the graph	Description of the point
P.	1. Upper yield point
Q.	2. Ultimate tensile strength
R.	3. Proportionality limit
S.	4. Elastic limit
T.	5. Lower yield point
U.	6. Failure

(a) P–1, Q–2, R–3, S–4, T–5, U–6
(b) P–3, Q–1, R–4, S–2, T–6, U–5
(c) P–3, Q–4, R–1, S–5, T–2, U–6
(d) P–4, Q–1, R–5, S–2, T–3, U–6

Q.12 A hypothetical engineering stress-strain curve shown in the figure has three straight lines *PQ*, *QR*, *RS* with coordinates *P*(0, 0), *Q*(0.2, 100), *R*(0.6, 140) and *S*(0.8, 130). *Q* is the yield point, *R* is the UTS point and *S* the fracture point.



The toughness of the material (in MJ/m^3) is_____.

Q.13 Which of the following are incorrect statements?
1. Linear elastic range in compression in larger as compared to that in tension for most brittle materials.
2. The brittle fracture is performed by separation and is not accompanied by noticeable plastic deformation.

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.14 Which of the following pairs is not correctly matched?
(a) Visco-elastic: Small plastic zone
(b) Orthotropic material: Different properties in their perpendicular directions

(c) Strain hardening material: Stiffening effect at some stage
(d) Isotropic material: Same physical property in all direction at a point

Q.15 Assuming a force of 18 kN is applied to a round metal test specimen with diameter of 9.6 mm. The original length of test specimen is 400 mm. Determine the engineering stress and strain at 401.5 mm

(a) $\sigma = 280$ MPa, $\varepsilon = 0.0037$ (b) $\sigma = 350$ MPa, $\varepsilon = 0.018$
(c) $\sigma = 200$ MPa, $\varepsilon = 0.002$ (b) $\sigma = 249$ MPa, $\varepsilon = 0.0037$

Q.16 Which of the following pairs are correctly matched?

1. Resilience ... Resistance to deformation
2. Malleability ... Deformation under compressive load
3. Creep ... Progressive deformation
4. Plasticity.... Permanent deformation

Select the correct option using the codes below:

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

Q.17 Fatigue test is carried out for

(a) Stresses varying between two limits of equal value, but of opposite sign
(b) Stresses varying between two limits of unequal value but of opposite sign
(c) Stresses varying between two limits of unequal value but of same sign
(d) All are the correct

Q.18 When plastic deformation occurs, then volume of a ductile specimen is essentially constant. If the initial radius of the specimen is $\frac{d_0}{2}$, then what will be the true strain when radius is $\frac{d}{2}$?

(a) $\varepsilon_t = 2\ln\left(\frac{d}{d_0}\right)$ (b) $\varepsilon_t = 2\ln\left(\frac{d_0}{d}\right)$
(c) $\varepsilon_t = \frac{1}{2}\ln\left(\frac{d_0}{d}\right)$ (d) $\varepsilon_t = \frac{1}{2}\ln\left(\frac{d}{d_0}\right)$

Q.19 Steel has its yield strength of 400 N/mm^2 and modulus of elasticity of 2×10^5 MPa. Assuming the material to obey Hooke's law up to yielding, what is its proof resilience?

(a) 0.8 N/mm^2 (b) 0.4 N/mm^2
(c) 0.6 N/mm^2 (d) 0.7 N/mm^2

Directions: Each of the next items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. 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

Q.20 **Statement (I):** Strain is a fundamental behaviour of the material, while stress is a derived concept.

Statement (II): Strain does not have a unit while stress has a unit.

Q.21 **Statement (I):** When a material is subjected to repeated tensile stress within elastic range, it is found that the material deteriorates and fractures after many but finite number of repeated application of stress.

Statement (II): The critical stress below which fluctuating stresses cannot cause a fatigue failure is termed as 'endurance limit'.

Q.22 **Statement (I):** For a given mean stress, there is a limiting value of stress below which failure will not take place for infinite number of cycles, known as endurance limit.

Statement (II): When a structure is subjected to fluctuating stresses, the fracture occurs at value of stress much lower than that in case of static loading.

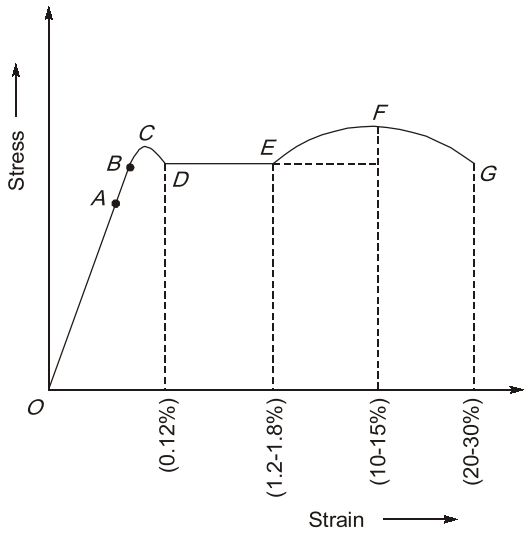
Q.23 In mild steel specimens subjected to tensile test cycle, the elastic limit in tension is raised and the elastic limit in compression is lowered. This is called

Answers Properties of Materials

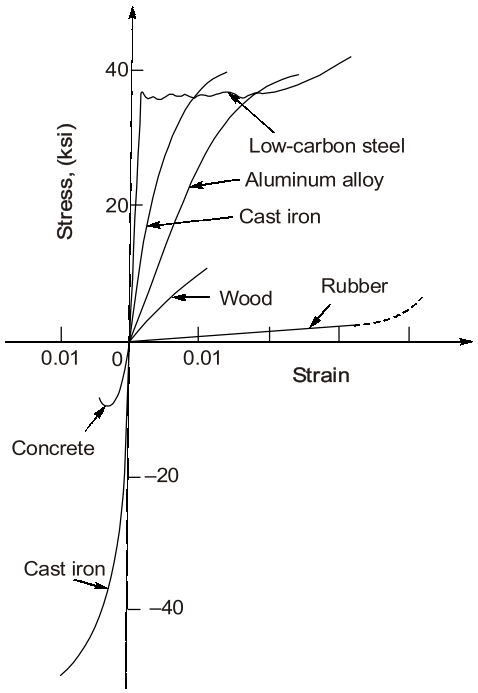
1. (c)	2. (d)	3. (b)	4. (c)	5. (c)	6. (c)	7. (c)	8. (c)	9. (c)	10. (b)
11. (c)	12. 0.85	13. (d)	14. (a)	15. (d)	16. (a)	17. (d)	18. (b)	19. (b)	20. (b)
21. (b)	22. (b)	23. (b)	24. (b)	25. (c)	26. (a)	27. (a, c)		28. (a, c)	
29. (a, b, d)									

Explanations Properties of Materials

1. (c)



2. (d)



4. (c)

Since strain in material *B* is more, hence it is more ductile than material *A* i.e., material *A* is more brittle than material *B*. Hence **statement I is true**. Material *A* can reach upto higher stress level hence ultimate strength of material *A* is more than that of material *B*. Hence **statement II is false**.

5. (c)

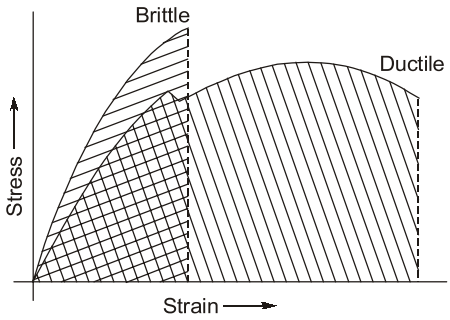
For perfectly elastic body, ideal deformation takes place. Ideal deformation means that the deformation takes place instantaneously upon application of force and disappears completely and instantaneously on the removal of force.

6. (c)

- When an elastic body of ductile material with a local geometrical irregularity such as on oil hole, a keyway or a notch is stressed, usually there is a localised variation in the stress state in the immediate neighbourhood of the irregularity.
- The peak stress level at the irregularity may be several times higher than the nominal stress levels in the bulk of the body.
- Under these circumstances the irregularity is said to cause a stress concentration. This leads to brittle fracture in the material.
- Also, the lower the temperature for a given steel, the greater the possibility that brittle fracture will occur.

Key Points:

- **Fracture :** The separation of a material into two or more pieces under the action of stress.
- Whether a material undergoes ductile fracture or a brittle fracture, it depends on the ability of the material to undergo plastic deformation before the fracture.



- **Brittle Fracture :** It is the sudden and rapid cracking of material under stress.
  - The material does not exhibits (or very little) evidence of ductility or plastic deformation.
  - It is often caused by low temperatures. If the steel temperature is at or below its brittle-to-ductile transition temperature, it will be susceptible to brittle fracture.
- **Ductile Fracture :** It is characterized by extensive plastic deformation or necking.
  - There is absorption of massive amounts of energy before fracture, unlike brittle fracture.

7. (c)

Strain-softening region in stress strain curve is also known as post ultimate stress.

8. (c)

The shear strain is angle of distortion (change in angle of a corner of element) measured in radian.

For corner A,

$$\gamma_{xy} = \frac{3.6\times10^{-3}}{7.5} + \frac{4.5\times10^{-3}}{6} = 1230\times10^{-6}$$

9. (c)

True strain for finite increment of loading such that length changes from L_0 to L is given by

$$\in_t = \int_{l_0}^{L} \frac{dL}{L} = \ln\left(\frac{L}{L_0}\right)$$

$$\in_t = \ln\left(\frac{L_0+\delta}{L}\right) = \ln\left[1+\frac{\delta}{L_0}\right]$$

$$\in_t = \ln(1+\in)$$

10. (b)

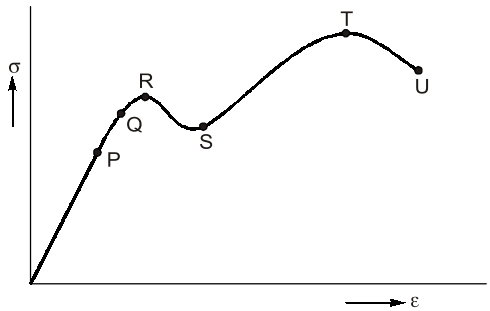
$$\text{Resilience} = \frac{1}{2}\times70\times0.005\times10^6$$

$$= 7.5\times10^4 \text{ Nm/m}^3$$

$$\text{Toughness} = 17.5\times10^4 + \left\{\frac{(70+110)}{2}\right\}\times0.01\times10^6$$

$$= 107.5\times10^4 \text{ Nm/m}^3$$

11. (c)



P : Proportional limit Q : Elastic limit
R : Upper Yield Point S : Lower Yield Point
T : Ultimate Tensile Strength
U : Failure/Rupture

12. (0.85)

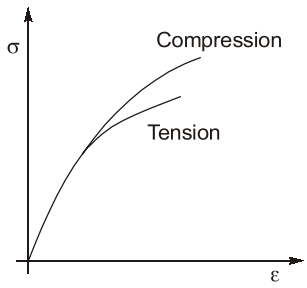
Toughness is area of curve upto *S* on strain axis

$$\left[\frac{1}{2}\times\frac{0.2}{100}\times100\right] + \left\{\frac{[100+140]}{2}\times\frac{0.4}{100}\right\} + \left\{\frac{140+130}{2}\right\}\times\frac{0.2}{100}$$

= 0.1 + 0.48 + 0.27 = **0.85 MJ/m³**

13. (d)

Brittle materials (in compression test): Brittle material in compression typically an initial linear region followed by a region in which the shortening increases at a higher rate than does the load for cast iron, the shape may be like this:



Brittle material in compression behave elastically upto certain load, and then fail suddenly by splitting or by cracking in the way as shown in figure, thus brittle fracture is performed by separation and is not accompanied by noticeable plastic deformation.

14. (a)

Visco-elastic material exhibit a mixture of creep and elastic after effects at room temperature. Thus their behaviour is time dependent materials with different properties in different directions are called Anisotropic orthotropic material is a special case of an anisotropic material in three mutually perpendicular directions. However there are symmetric about any axis.

15. (d)

Given, $P = 18\ kN = 18000\ N$

$$A_0 = \frac{\pi}{4}d^2 = \frac{\pi}{4}(9.6)^2 = 72.38\ mm^2$$

$$l_0 = 400\ mm$$
$$l'_0 = 401.5\ mm$$

$$\sigma = \frac{P}{A_0} = \frac{18000}{72.38} = 249\ MPa$$

$$\varepsilon = \frac{\Delta l}{l_0} = \frac{l'_0 - l_0}{l_0}$$

$$= \frac{401.5 - 400}{400} = 0.0037$$

16. (a)

Resilience: It is the property of a material to absorb energy when it is deformed elastically and then, upon unloading to have this energy recovered.

18. (b)

If the volume is constant,

L_0 = Initial length

L = Final length

$$\Rightarrow \quad \frac{\pi}{4}d^2L = \frac{\pi}{4}d_0^2L_0$$

$$\frac{L}{L_0} = \left(\frac{d_0}{d}\right)^2$$

True strain, $\varepsilon_t = \int_{L_0}^{L}\frac{dL}{L} = \ln\frac{L}{L_0}$

$$= \ln\left(\frac{d_0}{d}\right)^2 = 2\ln\left(\frac{d_0}{d}\right)$$

$$\varepsilon_t = 2\ln\left(\frac{d_0}{d}\right)$$

19. (b)

Proof resilience,

$$u_{max} = \frac{\sigma_y^2}{2E} = \frac{400^2}{2\times 2\times 10^5} = 0.4\ N/mm^2$$

20. (b)

When a force is applied to a material, it deforms. The deformation can easily be measured. Hence, strain can be measured. Whereas, the force that was applied cannot be measured directly and hence, stress cannot be measured directly.

Therefore, although it appears that first a force is applied and then strains are developed in the body due to the applied forces.

But, due to the fact that strain can be measured directly and stress cannot be, strain is a fundamental behaviour of the material while stress is a derived concept.

21. (b)

- Statement (A), i.e., Assertion describes fatigue failure.
- **Fatigue limit** is the limiting value of stress at which failure occurs as number of cycles becomes very large.
- **Endurance limit** is the stress below which failure never occurs, even for an indefinitely large number of loading cycles.

22. (b)

Material can withstand infinite number of cycles at or below endurance limit.

The stress which can be withstood for specified number of cycles is called fatigue strength of material.

When mean stress is zero, the ratio of endurance limit stress (σ_e) and ultimate stress (σ_{ult}) is

$\frac{\sigma_e}{\sigma_{ult}} \simeq 0.4$ (infinite life) for ferrous material

$\frac{\sigma_e}{\sigma_{ult}} \simeq 0.25$ (10^8 cycles) for nonferrous materials.

CONSTRUCTION MATERIALS

OBJECTIVE PRACTICE SETS

Page No. 200 - 251

1 CHAPTER
Cement

Q.1 Regarding the composition of raw materials used for manufacturing ordinary Portland cement, match **List-I** with **List-II** and select the correct answer by using the codes given below the lists:

	List-I		List-II
A.	Calcium oxide (CaO)	1.	2%
B.	Silica (SiO_2)	2.	3%
C.	Aluminium oxide (Al_2O_3)	3.	5%
D.	Ferrous oxide (Fe_2O_3)	4.	65%
E.	Magnesium oxide (MgO)	5.	25%

Codes:

	A	B	C	D	E
(a)	4	5	3	2	1
(b)	1	2	3	4	5
(c)	2	4	5	1	2
(d)	2	1	3	5	4

Q.2 The constituent compounds of cement in decreasing order of rate of hydration are
(a) C_2S, C_3S and C_3A
(b) C_3S, C_3A and C_2S
(c) C_3A, C_3S, and C_2S
(d) C_3A, C_2S and C_3S

Q.3 The tricalcium aluminate compound present in cement
(a) provides weak resistance against sulphate attack.
(b) is responsible for highest heat of evaluation.
(c) is characteristically fast reacting with water.
(d) all of the above.

Q.4 Match **List-I** with **List-II** and select the correct answer by using the codes given below the list:

	List-I		List-II
A.	Argillaceous	1.	Sand (silica SiO_2)
B.	Silicious	2.	Lime (CaO)
C.	Calcareous	3.	Clay (alumina Al_2O_3)

Codes:

	A	B	C
(a)	1	2	3
(b)	3	2	1
(c)	2	1	3
(d)	3	1	2

Q.5 Gypsum consists of
(a) H_2S and CO_2
(b) $CaSO_4$ and H_2O
(c) Lime and H_2O
(d) CO_2 and calcium

Q.6 A sample of cement is said to be sound when it does not contain free
(a) lime (b) silica
(c) iron oxide (d) alumina

Q.7 Low heat cement contains lower percentage of which of the following?
(a) C_3A (b) C_3S
(c) C_2S (d) None of these

Q.8 An excess of free lime in portland cement
(a) results in an increase in strength.
(b) increases the initial setting time.
(c) causes unsoundness in the product.
(d) improves the quality of the product.

Q.9 Initial setting time is maximum for
(a) portland-pozzolana cement
(b) portland-slag cement
(c) low-heat portland-pozzolana cement
(d) high strength portland cement

Q.10 The cement used in construction of docks and harbours is
(a) blast-furnace slag cement.
(b) water proof cement.
(c) hydrophobic cement.
(d) sulphate-resisting portland cement.

Q.11 The field test for the quality of cement consists in putting a small quantity of cement in a bucket c ontaining water. A good quality cement will
(a) immediately dissolve in the water.
(b) float on the water surface.
(c) sink to the bottom of the bucket.
(d) produce steam.

Q.12 Match **List-I** (Apparatus) with **List-II** (Purpose) and select the correct answer using the code given below the lists:

List-I
A. Le-Chatelier's apparatus
B. Vicat Needle
C. Vee-Bee apparatus
D. Briquettes test machine

List-II
1. Workability of concrete.
2. Soundness of cement.
3. Tensile strength.
4. Final setting time of cement.

Codes:

	A	B	C	D
(a)	1	3	2	4
(b)	2	4	1	3
(c)	1	4	2	3
(d)	2	3	1	4

Q.13 Match **List-I** with **List-II** and select the correct answer by using the codes given below the lists:

List-I
A. Water and cement
B. Tricalcium silicate
C. Di-calcium silicate
D. Tri-calcium aluminate

List-II
1. Fast in reaction
2. Slow in reaction
3. Slowest in reaction
4. Hydrates

Codes:

	A	B	C	D
(a)	4	2	3	1
(b)	1	3	2	4
(c)	4	1	2	3
(d)	3	2	1	4

Q.14 High alumina cement is produced by fusing together a mixture of
(a) limestone and bauxite.
(b) limestone, bauxite and gypsum.
(c) limestone, gypsum and clay.
(d) limestone, gypsum, bauxite, clay and chalk.

Q.15 Pick out the incorrect statement.
(a) For hydraulic structures, a cement with small percentage of C_3S and more C_2S is recommended.
(b) Setting and hardening of cement stop as soon as the concrete becomes dry.
(c) The product C - S - H get is known as tober morite gel.
(d) The stiffening of cement without strength development is caused because of C_4AF.

Q.16 Which one of the following statement regarding the cement fineness is NOT correct?
(a) Fine cement is more liable to suffer from shrinkage cracking than a coarse cement.
(b) Fine cement will show faster rate of hardening than coarse cement.
(c) Fine cement shows faster rate of heat evolution and total quantity of heat evolved is much larger than coarse cement.
(d) Fine cement shows the same setting time as coarse cement.

Q.17 If '*P*' is percentage of water required for standard consistency of cement, water to be added for determination of unsoundness due to lime is
(a) 0.65 *P* (b) 0.85 *P*
(c) 0.78 *P* (d) 0.5 *P*

Q.18 Match **List-I** (Cement mortar for different work) with **List-II** (Proportion of cement and sand in mortar) and select the correct answer using the codes given below the lists:

List-I
A. Cement mortar for normal brick work
B. Cement mortar for plastering works
C. Cement mortar for grouting the cavernous rocks
D. Cement mortar for guniting

Answers Cement

1. (a)	2. (c)	3. (d)	4. (d)	5. (b)	6. (a)	7. (a)	8. (c)	9. (c)	10. (d)
11. (b)	12. (b)	13. (a)	14. (a)	15. (d)	16. (c)	17. (c)	18. (b)	19. (c)	20. (d)
21. (d)	22. (d)	23. (c)	24. (c)	25. (a)	26. (c)	27. (b)	28. (c)	29. (c)	30. (b)
31. (b)	32. (a)	33. 33	34. 7.0 to 7.10		35. 3.10 to 3.20		36. 20	37. 5	38. (b)
39. (a)	40. (c)	41. (a)	42. (c)	43. (a, b, d)		44. (a, c)		45. (c, d)	
46. (b, c, d)		47. (a, b, c, d)		48. (b, c)		49. (a, b)		50. (b, c)	

Explanations Cement

1. (a)

Constituents of Portland cement (Raw Material)

Oxide	Composition	Average
Lime (CaO)	60-65	63
Silica (SiO_2)	17-25	20
Alumina (Al_2O_3)	3-8	6
Iron oxide (Fe_2O_3)	0.56	3
Magnesia (MgO)	0.5-4	2
Soda or Potash ($Na_2O + k_2O$)	0.5-1	1
Sulphur trioxide (SO_3)	1-2	1.5

2. (c)

The compound C_3A characteristically reacts fast with water and may lead to an immediate stiffening of paste. C_3A phase is responsible for the highest heat of evolution, both during the initial period as well as in the long run. In between C_3A and C_2S, C_3S results in rapid hardening and higher heat of hydration than C_2S.

3. (d)

The compound C_3A characteristically reacts fast with water and may lead to an immediate stiffening of paste, and this process is termed flash set. It provides weak resistance against sulphate attack and its contribution to the development of strength of cement is less significant than that of silicates.

4. (d)

Argillaceous	Calcareous
• Shale and Clay • Blast furnace slag • Slate	• Cement Rock • Lime stone • Chalk • Mrine cells • Marl

6. (a)

The unsoundness of cement is caused by the undesirable expansion of some of its constituents, sometimes after setting the unsoundness is due to the presence of free lime and magnesia in the cement.

7. (a)

Low heat cement is a Portland cement with relatively, lower contents of the more hydrating compounds C_3S and C_3A and more contents of C_2S.

8. (c)

Unsoundness in cement is due to excess of lime, excess of magnesia or excessive proportion of sulphates. Le Chatelier test detects unsoundness due to free lime only. Autoclave test is used to detect unsoundness due to magnesia and lime.

9. (c)

Low-heat Portland cement is less reactive than OPC and is obtained by increasing the proportion of C_2S and reducing the proportion of C_3S and C_3A. The initial setting time is about one hour, i.e., greater than that of OPC.

10. (d)

Sulphate resisting cement contains low C_3A and C_4AF contents and is very effective against sulphate attack. The use of sulphate resisting cement is recommended for concrete to be used in the marine environment, foundations in chemically aggressive soils etc.

11. (b)

If a small quantity of cement is thrown in a bucket of water. It should float for some time before they sink.

12. (b)
Le-Chatelier apparatus: Soundness of cement
Vicat needle: Final setting time of cement
Vee bee apparatus: Workability of concrete
Briquettes test machine: Tensile strength

13. (a)
Water and cement : Hydrates
Tri-calcium silicate: Slow in reaction
Di-calcium silicate: Slowest in reaction
Tri-calcium aluminiate: Fast in reaction

14. (a)
High alumina cement (IS : 6452)
The raw material used for its manufacture consists of 40% bauxite, 40% lime, and 15% Iron oxide, with a little % of ferric oxide and silica, magnesia etc. ground finely at a very high temperature.

15. (d)
The stiffening of cement with strength development is caused because of C_3A.

16. (c)
Fine cement shows faster rate of heat evolution and total quantity of heat evolved is same as than coarse cement.

17. (c)
In Le-chatelier method of soundness, the mould is placed on glass sheet and is placed with neat cement paste by gauging 100 g cement with 0.78 times the water required to give paste of standard consistency.

19. (c)
Gypsum is added to control flash setting.

20. (d)
Minimum specific surface of cements as per air permeability test is
2250 cm^2/g to 3500 cm^2/g
i.e., 225000 mm^2/fg to 350000 mm^2/g

21. (d)
If expansion is more than 10 mm, cement is said to be unsound.
In autoclave expansion should not be more than 0.8%.

22. (d)

	Methods of testing	Grade		
		33	43	53
Setting time Initial (min.) Final (max.)	Vicat apparatus	30 min 10 hr	30 min 10 hr	30 min 10 hr

23. (c)
The temperature range of cement kiln is
- For wet process — 1500-1600°C
- For dry process — 1400-1500°C

24. (c)

Type of cement	Specific surface not less than (cm^2/g)
Ordinary port land cement	2250
High alumina cement	2250
Portland pozzolana cement	3000
Low heat cement	3200
Rapid hardening cement	3250

25. (a)
The loss on ignition test is carried on portland cement to determine the loss of weight when the sample is heated to 900°C-1000°C. The loss in weight occurs as the moisture and carbon dioxide which are present is combination with free lime or magnesia evaporate.
The loss on ignition is determined by heating one gram of cement sample in a platinum crucible at a temperature of 900°C-1000°C for minimum of 15 minutes. Normally, the loss will be around two percent. Maximum allowable loss is four percent.

27. (b)
Gypsum is a retarder and prevents flash set. The rapid rate of development of strength is attributed to higher fineness and higher C_3S and lower C_2S content. Thus decreasing lime content will not result in rapid hardening or high early strength cement. The OPC has 63% CaO while rapid hardening cement has 64.5% CaO. A slight increase of CaO causes considerable increase in C_3S converting the OPC to a rapid hardening cement. A slight decrease in CaO and increase in SiO_2 decreases considerably the proportion of C_3S and increases proportion of C_2S thus forming low heat cement.

RCC & PRESTRESSED CONCRETE

OBJECTIVE PRACTICE SETS

1 CHAPTER
Fundamentals of RCC (Introduction)

Q.1 Consider the following statements regarding concrete mix constituents as given in IS 456:2000:
1. Total water-soluble sulphate content of concrete mix, expressed as SO_3, should not exceed 8% by mass of cement in the mix.
2. Use of super sulphated cement is generally restricted where the prevailing temperature is above 40°C.
3. Cement content not including fly ash and ground granulated blast furnace slag in excess of 450 kg/m^3 should be used.

Which of the above statement(s) is(are) CORRECT?
(a) 1 and 2 (b) 2 only
(c) 1 and 3 (d) 3 only

Q.2 Consider the following statements regarding testing of concrete:
1. The mean strength determined from any group of four consecutive test results should be more than or equal to $f_{ck} + 1.65\sigma$.
2. Minimum 30 samples are required to be tested for the establishment of value of standard deviation.
3. Individual test results should not fall below $f_{ck} - 3$.

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

Q.3 The characteristic strength of concrete is
(a) higher than the average cube strength
(b) lower than the average cube strength
(c) the same as the average cube strength
(d) higher than 90% of the average cube strength

Q.4 Stress-strain curve of concrete is
(a) A perfect straight line upto failure
(b) Straight line upto 0.002 strain value and then parabolic upto failure.
(c) Nearly parabolic upto 0.002 strain value and then a straight line upto failure
(d) Hyperbolic upto 0.002 strain value and then a straight line upto failure

Q.5 The target mean strength of M25 grade concrete which shows standard deviation of 4 N/mm^2 is equal to _____ N/mm^2.

Q.6 Creep in concrete increases when
(a) relative humidity is high
(b) temperature is high
(c) size of member is large
(d) loading is sustained over a short period

Q.7 For under water concrete, water cement ratio should not exceed
(a) 0.45 (b) 0.50
(c) 0.55 (d) 0.60

Q.8 Which of the following statements refer to correct purposes as regards testing of concrete by ultrasonic pulse velocity method?
1. To assess the quality of concrete in-situ.
2. To determine the dynamic modulus of elasticity of concrete.
3. To locate the presence of cracks in it.

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

Q.9 Consider the following statements:
1. In reinforced cement concrete, modular ratio is defined by the ratio (modulus of elasticity of steel)/(Modulus of elasticity of concrete).
2. Modulus of rupture of cement concrete is a function of its characteristic compressive strength.
3. The characteristic compressive strength of M 20 grade cement concrete at 7 days is 20N/mm^2.

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

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

Q.23 **Statement (I):** Design of concrete mix involves economical selection of relative proportions of various ingredients of concrete.
Statement (II): Nominal mix concrete is permitted only for concrete grades upto M15. For higher grade, design mix is adopted.

Q.24 **Statement (I) :** The stress block used in the limit state design method is obtained by testing of concrete cylinder under uniform rate of strain.
Statement (II) : If a uniform rate of strain is not adopted it is not possible to obtain the descending portion of stress and strain curve beyond maximum stress.

Q.25 **Statement (I):** As per IS 456:2000, under more adverse environmental exposure conditions, higher grades of concrete are recommended.
Statement (II): Higher grades of concrete possess higher compressive strength.

Q.26 **Statement (I):** Tensile strength of concrete is measured using flexure test or the cylinder splitting test.
Statement (II): It is difficult to perform direct tension test on a concrete specimen, as it requires a purely axial tensile force to be applied, free of any misalignment and secondary stresses in the specimen at the grips of the testing machine.

Q.27 **Statement (I):** The stress-strain curve for concrete in tension is generally approximated as a straight line from the origin to the failure point.
Statement (II): Concrete has a high failure strain in unaxial tension.

Multiple Select Questions (MSQ)

Q.28 Which of the following case(s) is/are considered for safe design of reinforced concrete members in flexure?

(a) Over-reinforced section

(b) Secondary compression failure

(c) Primary compression failure

(d) Under-reinforced section

Q.29 Which of the following statement(s) is/are correct?

(a) Modulus of elasticity of concrete increases with increase in workability

(b) Maximum compressive strength of structural concrete is taken as approximately 0.8375 times the strength of cylindrical specimen.

(c) Target mean strength is always greater than characteristic strength.

(d) The strength of concrete under biaxial compression is greater than uniaxial compression.

■■■■

Answers Fundamentals of RCC (Introduction)

1. (b)	2. (b)	3. (b)	4. (c)	5. 31.6	6. (b)	7. (d)	8. (d)	9. (b)	10. (d)
11. (c)	12. 3.5	13. (a)	14. (c)	15. (b)	16. (c)	17. (b)	18. (c)	19. (c)	20. (c)
21. (a)	22. 0	23. (c)	24. (a)	25. (b)	26. (a)	27. (c)	28. (b, d)	29. (b, c, d)	

Explanations Fundamentals of RCC (Introduction)

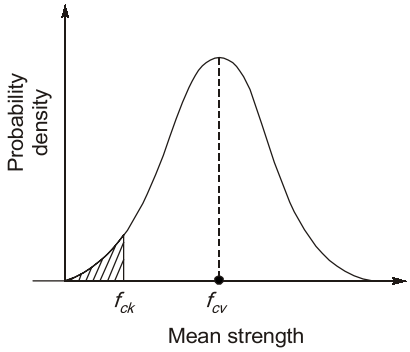
1. (b)
Refer clause 8.2.4.2, clause 8.2.5.3 and Table 4 of IS-456 : 2000.

2. (b)
Refer Clause 16.2 and Table 11 of IS 456 : 2000.

3. (b)
Characteristics strength = f_{ck}

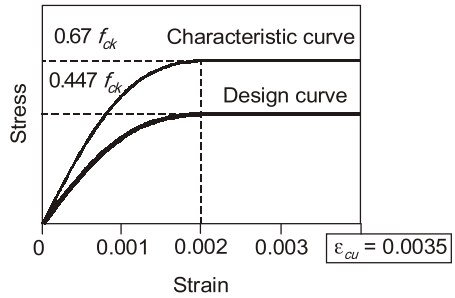
$f_{av} = f_{ck} + 1.65s$

$\therefore \quad f_{ck} < f_{av}$



4. (c)

The characteristic and design stress–strain curves specified by the Code for concrete in flexural compression are depicted in Figure below. The maximum stress in the concrete in the structure is restricted to 0.67 f_{ck}. The curves consist of a parabola in the initial region up to a strain of 0.002 (where the slope becomes zero), and a straight line thereafter, at a constant stress level up to an ultimate strain of 0.0035.



5. 31.6 (31 to 32)

Target mean strength,

$f_{cm} = f_{ck} + 1.65\sigma$

$= 25 + 1.65 \times 4$

$= 31.6\ \text{N/mm}^2$

6. (b)

Creep increases when

1. cement content is high
2. w/c ratio is high
3. aggregate content is low
4. air entrainment is high
5. relative humidity is low
6. temperature (causing moisture loss) is high
7. size/thickness of the member is small
8. loading is sustained over a long period

7. (d)

Refer clause 14.2.2 of **IS-456:2000**

8. (d)

Ultrasonic pulse velocity test is an in-situ test of hardened concrete when it is already acting as a structural member.

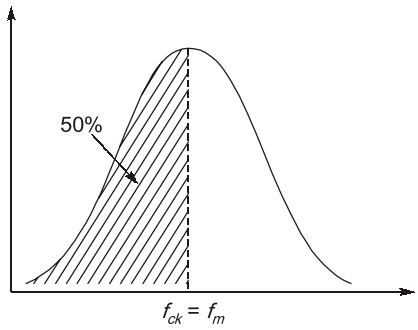
This test is based on the principle that the velocity of sound in a solid material is a function of the square root of the ratio of its modulus of elasticity E to its density, ρ.

Higher the velocity of pulses greater is the strength of concrete.

9. (b)

The characteristic compressive strength is measured at 28 days.

11 c)



If f_{ck} is the value below which not more than 50% of test results are expected then,

$f_m = f_{ck}$

[Mean strength = Characteristics strength]

So target mean strength of concrete to be considered in design mix.

= Mean strength

$= f_m = f_{ck} = 25$ MPa

12. (3.5)

Flexural strength = $0.7\sqrt{f_{ck}} = 3.5\ \text{N/mm}^2$

13. (a)

As per **Clause 6.2.2** of **IS 456:2000**, modulus of rupture, f_{cr} is given as

$f_{cr} = 0.7\sqrt{f_{ck}} = 0.7\sqrt{40} = 4.43$ MPa

14. (c)

Ultimate creep deformation = $\theta \times$ elastic deformation