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ESE 2024 : PRELIMS EXAM
CLASSROOM TEST SERIES

CIVIL ENGINEERING | Test No. 8 | BOOKLET SERIES A

Section A : CPM PERT + Hydrology & Water Resource Engineering [All Topics]

Section B : Design of Steel Structure-I + Surveying and Geology-I [Part Syllabus]

Topics: **Steel :** Connections, Tension Members, Compression Members; **Surveying & Geology :** Classification of surveys, various methodologies, instruments and analysis of measurement of distances, elevation and directions

Section C : Solid Mechanics-II [Part Syllabus]

Topics: Torsion, Principle stress, theories of failure & shear stress

Duration: 1½ hrs. Maximum Marks: 150

Read the following instructions carefully

1. Immediately after the commencement of the examination, you should check that this booklet **does not** have any unprinted or torn or missing pages or items etc. If so, get it replaced by a complete test booklet.
2. Encode clearly the test booklet series **A, B, C** or **D** as the case may be in the appropriate place in the answer sheet.
3. You have to enter your Roll Number on the Test Booklet in the Box provided alongside.
   DO NOT write **anything else** on the Test Booklet.
4. There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third (0.33)** of the marks assigned to that question will be deducted as penalty.
5. Use of Calculator is not permitted.
6. All items carry equal marks. Attempt **ALL** items. Your total marks will depend **Only** on the number of correct responses with corresponding reduction for wrong answers marked by you.
7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your admission Certificate.
8. After you have completed filling in all your responses on the Answer Sheet and the examination has concluded, you should hand over to invigilator **Only the Answer Sheet**. You are permitted to take away with you the Test Booklet.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE ASKED TO DO SO

Section A : CPM PERT + Hydrology & Water Resource Engineering

Q.1 PERT calculations yield a project length of 50 days with a variance of 9 days^2. What is the number of days required to complete the project with a probability of 95%? (Take probability factor as 1.647 corresponding to probability of 95%)

(a) 45.06 days (b) 54.94 days
(c) 56.85 days (d) 64.82 days

Q.2 If the free haul distance is 150 m, the cost of borrow (including excavation and hauling) is Rs. 5 /m^3 at a station, cost of haulage beyond free haul is Rs. 0.75/m^3 per station meter, then what is the limit of economical haul distance? [Assume one station meter is equal to 1 m^3 of excavated material hauled through one station (30 m)]

(a) 204.5 m (b) 350 m
(c) 312.5 m (d) 370 m

Q.3 Consider the following statements:

1. Depreciation is the functional loss in the value of property due to change in design, structure, fashion, utility, demand etc.
2. Obsolescene is the physical loss in the value of property due to wear and tear and decay etc.

Which of the above statement(s) is/are correct?

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

Q.4 Consider the following statements regarding the elements of planning:

1. The essence of planning is looking ahead. It is always concerned with the future.
2. It always has a dimension of time.
3. Its main objective is to achieve better results in the most economical way consuming maximum time possible.

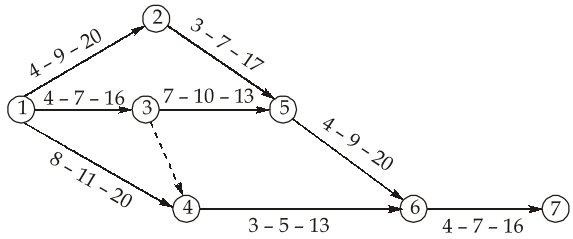
Which of the above statements are correct?

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

Q.5 A four wheel tractor whose operating weight is 15,000 kg is pulled along a haul road having a slope of 4% at a uniform speed. If the tension in the toe cable is 1000 kg then what is the rolling resistance of the haul road?

(a) 26.67 kg/tonne
(b) 18.33 kg/tonne
(c) 24.67 kg/tonne
(d) 33.33 kg/tonne

Q.6 For the given PERT network the critical path is along _____.



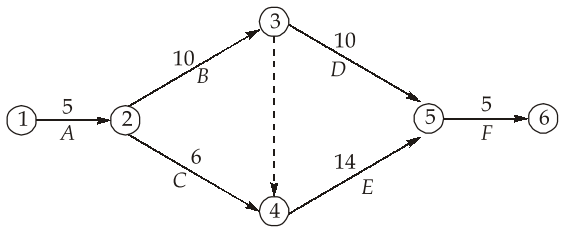
(Activity duration in days)

(a) 1 – 2 – 5 – 6 – 7
(b) 1 – 3 – 5 – 6 – 7
(c) 1 – 3 – 4 – 6 – 7
(d) 1 – 4 – 6 – 7

Q.7 Which one of the following project management techniques is deterministic in nature?

(a) PERT (b) LCES
(c) GERT (d) CPM

Q.8 From the network shown in the figure below. (the number above each arrow denotes the time duration of activity in days), the free float of activity *D* is _____.



(a) 1 day (b) 2 days
(c) 3 days (d) 4 days

Q.9 An equipment costs Rs. 20 lakhs with an estimated salvage value of Rs. 4 lakhs after 5 years of useful life. The annual cost for use of the equipment is _____.
(a) 10.7 lakhs (b) 13.6 lakhs
(c) 14.3 lakhs (d) 11.3 lakhs

Q.10 In which type of roller, compaction is done by kneading action?
(a) Vibratory roller
(b) Smooth wheel roller
(c) Pneumatic type roller
(d) Sheep foot roller

Q.11 In the tie-cost optimization, using CPM method for network analysis, the crashing of the activities along the critical path is done starting with the activity having
(a) longest duration
(b) highest cost slope
(c) least cost slope
(d) shortest duration

Q.12 For casting of beams in a residential building, total cost is Rs. 40,000 and it requires 15 days. Overhead cost is Rs. 400 per day and cost slope is Rs. 200 per day. If casting of beam will be completed in 12 days, then what is the total cost of the project?
(a) Rs. 40,6000 (b) Rs. 39,400
(c) Rs. 38,400 (d) Rs. 41,600

Q.13 The normal precipitation at stations *A*, *B* and *C* are 200 cm, 180 cm and 220 cm, respectively. In one of the year, the station B was not operative. Stations A and C recorded annual rainfall of 190 cm and 200 cm respectively. The annual rainfall of station B would be estimated as:
(a) 167.4 cm (b) 142.7 cm
(c) 182.25 cm (d) 130.2 cm

Q.14 The one day rainfall of 8 hours storm has a return period of 30 years. The probability of the same storm occurring atleast once in 30 years is:

(a) $\frac{29}{30}$ (b) $\left(\frac{1}{30}\right)^{30}$

(c) $1-\left(\frac{29}{30}\right)^{30}$ (d) $\left(\frac{29}{30}\right)^{30}$

Q.15 Consider the following statements regarding different types of precipitation
1. Cyclonic precipitation is caused by lifting of an air mass due to pressure difference.
2. Convective precipitation is caused due to temperature difference.
3. Orographic precipitation is caused due to presence of mountain barriers.

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

Q.16 In Horton's infiltration equation, the infiltration rate was observed to be 10 cm/hr at the beginning and it decreased exponentially to an equilibrium value of 1 cm/hr at the end of 10 hr of rain. If total of 18 cm water was infiltered, then the value of decay constant k_h is:
(a) 1.25 hr^{-1} (b) 1.5 hr^{-1}
(c) 0.8 hr^{-1} (d) 1.125 hr^{-1}

Q.17 Consider the following statements:
1. A stilling well is required in case of float gauge.
2. The areal spread of a rainfall is indicated by drainage density.
3. Slope area method is a direct method of stream flow determination technique.

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

Q.18 A 3-hour storm over a catchment had a rainfall depth of 25 mm. The resulting flood hydrograph was found to have a peak flow of 180 m^3/s and base flow of 20 m^3/s. If the loss rate is 0.3 cm/hr, then the peak of 3 hour unit hydrograph will be:

(a) 125 m^3/s (b) 100 m^3/s
(c) 110 m^3/s (d) 90 m^3/s

Q.19 Consider the following statements regarding unit hydrograph theory:

1. It is applicable for an area less than 10000 km^2.
2. Rainfall rate is assumed to be constant in this theory.
3. Parameters included in its assumptions are time invariance and linear response.

Which of the following statements is/are correct?

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

Q.20 The flood discharge with a return period of 300 years was estimated as 15000 m^3/s with a probable error of 1500 m^3/s. What are the 95% confidence limits of this flood? (Take $f(c) = 1.96$)

(a) 12060 to 17940 m^3/s
(b) 13085 to 16990 m^3/s
(c) 13500 to 16500 m^3/s
(d) 12000 to 18000 m^3/s

Q.21 For a catchment of area 53.6 km^2 in Western Ghat area, the maximum flood using Inglis formula comes out to be

(a) 920.4 m^3/s (b) 830.8 m^3/s
(c) 118.8 m^3/s (d) 721.2 m^3/s

Q.22 Consider the following statements:

1. The prism storage in a river reach is a function of outflow only.
2. The wedge storage in a river reach is positive during rising phase.

Which of the above statement(s) is/are correct?

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

Q.23 Consider the following statements relating to canal head works:

1. Divide wall is used to form a still water pocket to settle suspended silt.
2. Silt excluder is provided to remove fine silt particles.
3. Marginal embankment alongside river protects valuable agricultural lands.

Which of the above statement(s) are correct?

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

Q.24 A weir on a permeable foundation has a horizontal floor of length 50 m and retains 5 m of water. If downstream sheet pile is driven to a depth of 4 m below average bed level, then the exit gradient as per Khosla's method is

(a) 0.27 (b) 0.15
(c) 0.35 (d) 0.10

Q.25 The consumptive use of water for the growth of a crop is 2.5 mm/d. What is the depth of water to be applied when the amount of water depletes to 75% of maximum available moisture which is 80 mm. (Assume $\eta_{Irrigation} = 65\%$)

(a) 81 mm (b) 107 mm
(c) 93 mm (d) 113 mm

Q.26 Consider the following statements regarding outlets:

1. Non-modular outlets are very suitable for low head conditions.
2. In modular outlets, discharge depends only on the water level in the distributary.
3. Semi-modular outlet involves comparatively greater loss of head.

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

Q.27 An irrigation channel is designed to carry a discharge of 50 m^3/s. The river bed material has a median size of particles as 2 mm. What is the value of slope as per Lacey's theory? [Take $(2.49)^{5/3} = 4.57$, $(50)^{1/6} = 1.9$]
(a) 7.2×10^{-4} (b) 4×10^{-4}
(c) 8.4×10^{-4} (d) 3.7×10^{-4}

Q.28 When the tail water curve (TWC) is above the jump height curve (JHC) at all discharges, the protection work required is:
(a) providing sloping apron below the bed
(b) providing a horizontal apron
(c) providing a roller bucket type energy dissipator consisting of an apron upturned sharply.
(d) providing a subsidiary dam below the main dam.

Q.29 A launching apron is to be designed at downstream of a weir for a discharge intensity of 8 $m^3/s/m$. If the scour depth is taken as 1.5 times of Lacey's scour depth and tail water depth is 4.5 m and silt factor is unity, then the length of launching apron in launched position is:
(a) $3.6\sqrt{5}$ m (b) $3\sqrt{5}$ m
(c) 4.7 m (d) $5\sqrt{5}$ m

Q.30 The following data is available at the proposed site of a canal crossing:
Bed level of canal = 248 m
High flood level of drain = 250 m
Bed level of drain = 247 m
The most appropriate drainage work at the above site will be
(a) Aqueduct
(b) Syphon aqueduct
(c) Super passage
(d) Canal syphon

Q.31 An elementary triangular concrete gravity dam, supporting 40 m height of reservoir water and full uplift, should have a minimum base width so that no tension is developed at heel will be: [Take $G_c = 2.4$]
(a) 23.9 m (b) 42 m
(c) 30 m (d) 34 m

Q.32 Which of the following type of Groyne points downstream the direction of normal flow at an angle of 30° to 45° to the line normal to bank?
(a) Repelling groyne
(b) Attracting groyne
(c) Deflecting groyne
(d) Tree groyne

Q.33 Consider the following statements:
1. Silting and scouring are common phenomena in alluvial canals.
2. Non-scouring unlined canals having low flow velocity are said to be rigid.
3. Lined canals have lower initial cost and higher maintenance cost.

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

Q.34 The discharge required for different crops grown in a field is 0.5 m^3/s. If the capacity factor and time factor are 0.9 and 0.6 respectively, then the design discharge for the distributary will be
(a) 0.55 m^3/s (b) 0.83 m^3/s
(c) 0.93 m^3/s (d) 1.23 m^3/s

Q.35 For a given storm, other factors remaining same,
(a) basins with large drainage densities give smaller flood peaks

(b) low drainage density basins give shorter time bases of hydrographs
(c) the flood peak is independent of the drainage density
(d) basins having low drainage density give smaller peaks in flood hydrographs

Direction (Q.36 to Q.40): The following items consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a 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.36 **Statement (I):** With the tile lining of canals, permissible velocity of flow is lower than that with concrete lining.
Statement (II): The surface of the lining becomes rough due to loss of surface material with high velocity.

Q.37 **Statement (I):** Instantaneous unit hydrograph is drawn for unit duration and infinitely small rainfall excess.
Statement (II): IUHs can be derived by harmonic analysis and Laplace's transform.

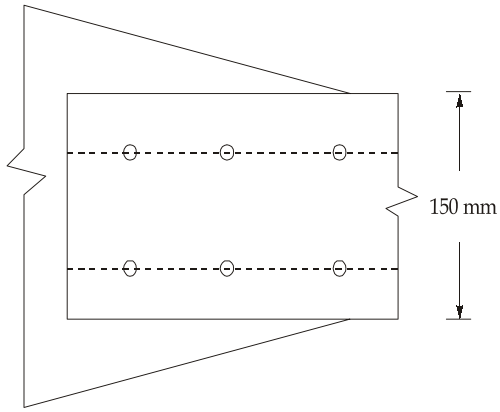
Q.38 **Statement (I):** The permanent wilting point is the moisture held by soil which can be extracted by roots for transpiration.
Statement (II): Hygroscopic water is retained as thin film of water on the surface of soil particles.

Q.39 **Statement (I):** Unlined canals may lead to enhancement of storage capacity of reservoir.
Statement (II): Duty of canal water is quite less in unlined canals.

Q.40 **Statement (I):** During updating, activities and their inter-relationship are maintained.
Statement (II): Activities can neither be added nor be removed from a network.

Section B : Design of Steel Structure-I + Surveying and Geology-I

Q.41 A mild steel flat of size 150 mm × 10 mm is used as a tension member in a roof truss. If it is connected at its ends to a gusset plate using 20 mm rivet by chain riveting as shown in figure below then the maximum tension which the flat can carry is _____. (Assume f_y = 250 MPa, Use WSM)



(a) 210.6 kN (b) 160.5 kN
(c) 187.3 kN (d) 145.7 kN

Q.42 Consider the following statements regarding assumptions of Euler's theory:
1. The axis of the column is perfectly straight when unloaded.
2. The line of thrust coincides exactly with the unstrained axis of the strut.
3. The flexural rigidity EI is uniform.

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

Q.43 Match **List-I** (Stress) with **List-II** (Factor of safety in WSM) and select the correct answer using the codes given below the lists:

List-I

A. Axial compressive stress
B. Bending compressive stress
C. Shear stress

List-II

1. 2.5
2. 1.5
3. 1.67

Codes:

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

Q.44 If the thickness of thinner plate is 12 mm, then what is the maximum edge distance? (Assume, f_y = 350 MPa)

(a) 144.0 mm (b) 118.50 mm
(c) 121.68 mm (d) 124.33 mm

Q.45 What is the strength of fillet weld of size 8 mm and length of 150 mm made between two flats each 12 mm thick?

(a) 159 kN (b) 169 kN
(c) 149 kN (d) 139 kN

Q.46 Consider the following statements regarding splices:

1. Where such members are not faced for complete bearing, splices should be designed to transmit all the forces to which these are subjected.
2. These are designed as long columns.
3. When shear force acts in addition of gravity loads, a splice plate will be provided on the web.

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

Q.47 As per IS 800 : 2007, the slenderness ratio of a tie member acting in a roof truss or a bracing system not considered effective when subjected to possible reversal of stress into compression resulting from action of wind or earthquake forces is limited to

(a) 145 (b) 350
(c) 250 (d) 300

Q.48 The effective length of a fillet weld is taken as the actual length

(a) plus twice the size of the weld
(b) minus twice the size of the weld
(c) plus the size of the weld
(d) minus the size of the weld

Q.49 The design shear capacity of bolts carrying shear through a packing plate in excess of 6 mm shall be decreased by a factor β_{pkg} where β_{pkg} is given as

(a) $\beta_{pkg} = 1 - 0.0225\, t_{pkg}$
(b) $\beta_{pkg} = 1 - 0.0125\, t_{pkg}$
(c) $\beta_{pkg} = 1 - 0.125\, t_{pkg}$
(d) $\beta_{pkg} = 1 - 0.225\, t_{pkg}$

Here t_{pkg} is thickness of packing plate in mm.

Q.50 Lug angles

(a) are necessarily unequal angles.
(b) are always equal angles.
(c) increases the shear resistance of joint.
(d) reduce the length of joint.

Q.51 Consider the following statements regarding random error:

1. For random errors, normal distribution curve is followed.
2. Random error of mean is directly proportional to $\frac{1}{\sqrt{N}}$, where N is the number of observations made.
3. For levelling, random error is directly proportion to $\sqrt{L}$.

Which of the above statements is/are correct?

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

Q.52 A plan of an old survey plotted to a scale of 10 m to 1 cm carried a note stating that the chain 20 m used was 50 cm too short. It was also found that the plan had shrunk so that a line originally 10 cm long was 9 cm. The area of a plot on the available plan was found to be 50 cm^2. The correct area of the plan is:

(a) 1.2 hectare (b) 0.6 hectare
(c) 0.9 hectare (d) 0.2 hectare

Q.53 A line AB had the magnetic bearing 45°30′ in 1920 when the declination was 4°30′W. The magnetic bearing of the same line in 2000 if the annual declination change observed was 6′ eastward, is:

(a) 37°30′ (b) 49°0′
(c) 41°30′ (d) 44°30′

Q.54 The transit rule for adjustment of traverse is eminently suited,

(a) When linear measurements are more precise than angular measurement
(b) When angular measurements are more precise than linear measurements
(c) When angular and linear measurements are of equal precision
(d) Irrespective of precision in linear and angular measurements

Q.55 The eye of an observer is 9 m above sea level and he was able to see a light house 49 m high just above the horizon. The distance between the observer and the lighthouse is:

(a) 40.7 km (b) 36.6 km
(c) 38.6 km (d) 42.2 km

Q.56 Consider the following statements regarding theodolite operations:

1. Swing of telescope is revolving it in the horizontal plane about its vertical axis.
2. Telescope is said to be normal when its vertical circle is to the left hand side of the observer.
3. Face left position of telescope is when the vertical circle of the theodolite is on the right hand side of the observer.
4. Collimation error in theodlight is eliminated by taking face left reading.

Which of the above statements is are correct?

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

Q.57 Consider the following statements regarding prismatic and Surveyor's compass :

1. In prismatic compass, graduated ring is attached to needle remains stationary when the compass is rotated while sighting.
2. Broad needle is used in Surveyor's compass.
3. The graduations on graduated ring are in between 0° to 90° in Surveyor's compass.
4. In prismatic compass, sighting and reading are done separately from different position.

Which of the above statements are incorrect?

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

Q.58 A rectangle of sides 100 m and 15 m has errors of ± 0.02 m and ± 0.03 m respectively. What will be the magnitude of most probable error in area of rectangle?

(a) $2\sqrt{3}\,m^2$ (b) $\sqrt{\frac{97}{2}}\,m^2$
(c) $2\sqrt{97}\,m^2$ (d) $3\sqrt{2}\,m^2$

Q.59 A road is planned on a 4% gradient. Contour map for this area is made with a scale of 1 cm = 250 m with contour interval of 50 m. The radius of arc to get point of alignment on next contour is,

(a) 12 cm (b) 5 cm
(c) 15 cm (d) 10 cm

Q.60 The index frame or Vernier frame in a theodolite is

(a) The A-frame attached to the telescope.
(b) The vernier circle of the horizontal circle.
(c) The T-shaped frame carrying the vernier of the vertical circle.
(d) The base of the theodolite having the levelling head.

Q.61 If the interval between ordinates is not constant, then the most appropriate rule to find the area is

(a) Average ordinate method
(b) Co-ordinate method
(c) Trapezoidal rule
(d) Parabolic rule

Direction (Q.62 to Q.64): The following items consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a 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.

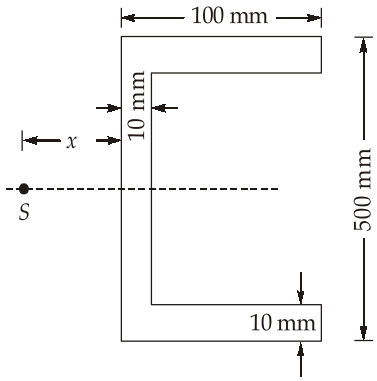
Q.62 **Statement (I):** In a theodolite, method of repetition is used to measure the vertical angles.
Statement (II): There is only one rotation possible in the vertical plane.

Q.63 **Statement (I):** Regardless of the direction in which load is applied, fillet weld fails by shear on throat.
Statement (II): In fillet weld, the weakest section is the throat of the fillet.

Q.64 **Statement (I):** In a slender section subjected to torsion, warping is confined to relatively small regions at the ends of the tube.
Statement (II): The assumption of cross-section remains plane does not hold good for rectangular bar subjected to torsion.

Section C : Solid Mechanics-II

Q.65 What is the distance of shear centre (x) from the outer face of channel section as shown in the figure below.
(Take $I = 2.12 \times 10^8$ mm^4)



(a) 28.2 mm (b) 25.5 mm
(c) 20.6 mm (d) 33.2 mm

Q.66 The cross-section of a beam is an equilateral triangle of side 0.4 m with one of its side horizontal. It is subjected to a shear force of 5 kN. The magnitude of the shear stress at neutral axis of section is _____.

(a) $\frac{1}{2\sqrt{3}}\text{N/mm}^2$

(b) $\frac{1}{8\sqrt{3}}\text{N/mm}^2$

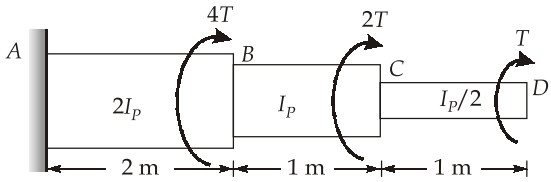
(c) $4\sqrt{3}\text{N/mm}^2$

(d) $\frac{1}{6\sqrt{3}}\text{N/mm}^2$

Q.67 For a machine component, the principal stresses are known to be 0.8σ, σ and 0. If yield stress is 240 MPa and μ = 0.3, then what is the maximum value of σ as per maximum principal strain theory?

(a) 212.21 N/mm^2
(b) 315.79 N/mm^2
(c) 280.36 N/mm^2
(d) 421.21 N/mm^2

Q.68 A stepped shaft is subjected to couples as shown in the figure below.

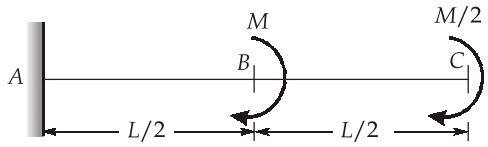


Total angle of twist of free end is

(a) $\frac{15T}{GI_p}$ (b) $\frac{12T}{GI_p}$

(c) $\frac{8T}{GI_p}$ (d) $\frac{9T}{GI_p}$

Q.69 For the beam shown in figure below, the deflection at mid-span of the beam is: (Assume uniform flexural rigidity EI)



(a) $\frac{ML^2}{4EI}$ (b) $\frac{3ML^2}{16EI}$

(c) $\frac{7ML^2}{16EI}$ (d) $\frac{ML^2}{8EI}$

Q.70 A circular column of length 3 m has Euler's crippling load of 4 kN. For the same end conditions if the diameter of the column is reduced by 10%, then the Euler's crippling load will be:

(a) 3.24 kN (b) 4 kN
(c) 2.62 kN (d) 2.97 kN

Q.71 A spring of force constant k is cut into three pieces such that one piece is double the length of other two. The length of long piece will have a force constant of:

(a) $\frac{3k}{2}$ (b) $2k$

(c) $\frac{k}{2}$ (d) $\frac{2k}{3}$

Q.72 Which of the following statement(s) are correct?

1. In case of pure shear, Tresca's theory gives safe result.
2. Maximum normal stress theory is valid in case of brittle materials.
3. For ductile materials, Von-mises theory is very close to experimental results.

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

Q.73 A plate is under tensile and compressive stress of 40 MPa in two mutually perpendicular directions. If shear stress of 30 MPa is also acting, then the magnitude of maximum principal stress in the plate is:

(a) 50 MPa (b) 40 MPa
(c) 30 MPa (d) 56.2 MPa

Q.74 A solid shaft is required to transmit a torque of $320\pi^2$ N-m without exceeding the allowable rate of twist of 0.75° /m. The required diameter of the solid shaft is _____ mm. (Take G = 80 GPa)

(a) $(2012)^{1/4} \times 10^2$
(b) $(2072)^{1/4} \times 10$
(c) $(1036)^{1/4} \times 10^2$
(d) $(3072)^{1/4} \times 10$

Direction (Q.75): The following items consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a 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.75 **Statement (I):** A beam of rectangular cross-section is stronger in shear as compared to circular section having same area of cross-section and subjected to same shear force.

Statement (II): The maximum shear stress in the web of a wide flanged beam occurs at the junction of web and flange.

■■■■

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Test 8

Section A : CPM PERT + Hydrology & Water Resource Engineering [All Topics]

Section B : Design of Steel Structure-I + Surveying and Geology-I [Part Syllabus]

Section C : Solid Mechanics-II [Part Syllabus]

1.	(b)	16.	(d)	31.	(d)	46.	(c)	61.	(b)
2.	(b)	17.	(c)	32.	(b)	47.	(b)	62.	(d)
3.	(d)	18.	(b)	33.	(a)	48.	(b)	63.	(a)
4.	(a)	19.	(c)	34.	(c)	49.	(b)	64.	(b)
5.	(a)	20.	(a)	35.	(d)	50.	(d)	65.	(c)
6.	(a)	21.	(b)	36.	(a)	51.	(d)	66.	(d)
7.	(d)	22.	(a)	37.	(d)	52.	(b)	67.	(b)
8.	(d)	23.	(c)	38.	(d)	53.	(a)	68.	(b)
9.	(b)	24.	(b)	39.	(d)	54.	(b)	69.	(b)
10.	(d)	25.	(c)	40.	(a)	55.	(c)	70.	(c)
11.	(c)	26.	(c)	41.	(b)	56.	(d)	71.	(b)
12.	(b)	27.	(a)	42.	(d)	57.	(d)	72.	(c)
13.	(a)	28.	(c)	43.	(b)	58.	(*)	73.	(a)
14.	(c)	29.	(a)	44.	(c)	59.	(b)	74.	(d)
15.	(d)	30.	(b)	45.	(a)	60.	(c)	75.	(*)

Q. No. 58 and Q. No. 75 (Marks to all)

DETAILED EXPLANATIONS

1. (b)

Given, $Z = 1.647$

Now, $Z = \dfrac{T_S - T_E}{\sigma}$

where $\sigma = \sqrt{\text{Variance}} = \sqrt{9} = 3$ days

$\therefore \quad 1.647 = \dfrac{T_S - 50}{3}$

$\Rightarrow \quad T_S = 54.94$ days

2. (b)

The limit of economical haul distance (L) in meter is given as

$$L = \frac{B}{O} + F$$

where B is cost of borrow = Rs. 5/m^3

O is cost of haulage = Rs. 0.75/m^3-station meter

F is free haul distance = 150 m

Now, $L = \left(\dfrac{5}{0.75}\right)$ station meter + 150

$= \dfrac{5}{0.75} \times 30 + 150 = 350$ m

3. (d)

- **Depreciation**: It is the physical loss in the value of property due to wear and tear and decay etc.
- **Obsolescene**: It is the functional loss in the value of the property due to change in design, structure, fashion, utility, demand etc.

4. (a)

The main objective of planning is to achieve better results in the most economical way consuming minimum time possible.

5. (a)

- Operating weight of tractor = $\dfrac{15000}{1000} = 15$ tonnes

Total grade resistance for the given +4% slope @ 10 kg per tonne per (+) 1% slope = 10 ×15 × 4

= 600 kg

- Required tractive effort available = 1000 – 600 = 400 kg

Now rolling resistance $= \dfrac{400\,\text{kg}}{15\,\text{tonne}}$

= 26.67 kg/tonne

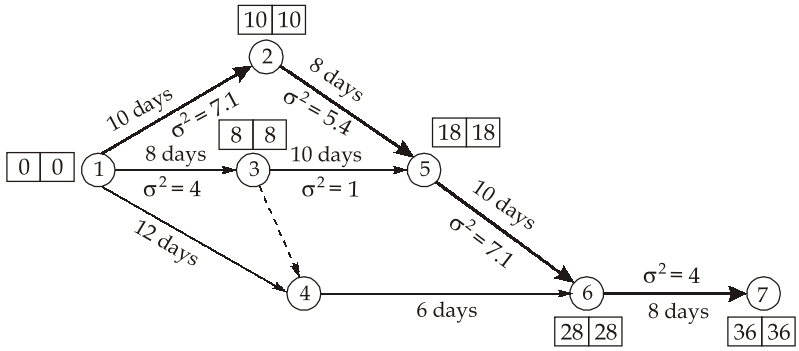
6. (a)

Expected mean time of each activity (t_e) is given as

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

and also variance (σ^2) of each activity is given as

$$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$$



Variance (σ^2) of project along path 1 – 2 – 5 – 6 – 7 is

$$7.1 + 5.4 + 7.1 + 4 = 23.6 \text{ days}^2$$

$\therefore$ Standard deviation, $\sigma = \sqrt{\sigma^2} = \sqrt{23.6} = 4.86$ days

Variance (σ^2) of project along path 1 – 3 – 5 – 6 – 7 is

$$4 + 1 + 7.1 + 4 = 16.1 \text{ days}^2$$

Standard deviation, $\sigma = \sqrt{16.1} = 4.01$ days

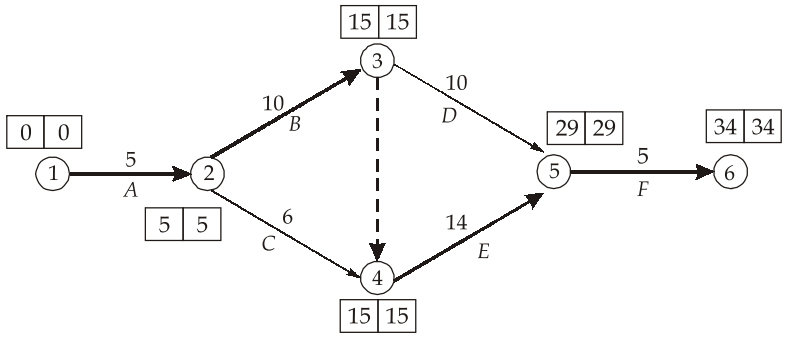
Hence critical path is that path along which maximum standard deviation and maximum time duration has occurred.

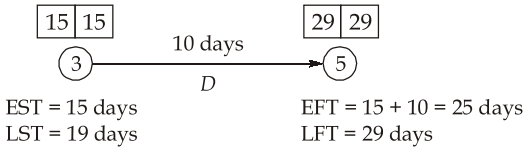
Hence critical path is along 1– 2 – 5 – 6 – 7 and project duration is 36 days.

7. (d)

Critical path method (CPM) is deterministic in nature while PERT is probabilistic in nature.

8. (d)





Free float, F_F = 29 – *EFT*
= 29 – 25 = 4 days

9. (b)

Annual cost is given as

$$P_{avg} = \frac{P(n+1)+S(n-1)}{2n}$$

$$= \frac{20(5+1)+4(5-1)}{2\times 5}$$

$$= \frac{20\times 6+4\times 4}{10}$$

= Rs. 13.6 lakhs

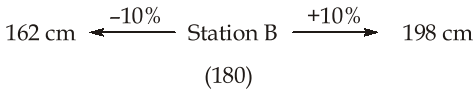
10. (d)

In sheep foot roller, compaction is done by kneading action.

12. (b)

Total cost of project = Rs. 40,000
Decrease in indirect cost = 400 × 3 = Rs. 1200
Increase in direct cost = 200 × 3 = Rs. 600
Now, Total cost = 40,000 – 1200 + 600
= Rs. 39400

13. (a)



As normal precipitations of neighbouring stations are not in the range of ± 10%. So, using normal ratio method

$$P_B = \frac{N_B}{n}\left[\frac{P_A}{N_A} + \frac{P_C}{N_C}\right]$$

$$= \frac{180}{2}\left[\frac{190}{200} + \frac{200}{220}\right]$$

$$= 90[0.95 + 0.91] = 90[1.86]$$

$$= 167.4 \text{ cm}$$

14. (c)

Return period, $T = 30$ years

$\therefore$ Probability of exceedance, $p = \frac{1}{T}$

$$= \frac{1}{30}$$

Probability of occurrence atleast once in 30 years

= 1 – (Probability of non occurrence in 30 years)

$$= 1 - (1-p)^{30}$$

$$= 1 - \left[1 - \frac{1}{30}\right]^{30}$$

$$= 1 - \left[\frac{29}{30}\right]^{30}$$

16. (d)

Horton's equation,

$$f_p = f_c + (f_0 - f_c)e^{-k_h t}$$

Total infiltration, $F_p = \int_0^t f_p dt$

$\Rightarrow$ $$F_P = \int_0^t \left[f_c + (f_0 - f_c)e^{-k_h t}\right] dt$$

For large value of t,

$$\lim_{t\to\infty} \int_0^t e^{-k_h t}\, dt = \frac{1}{k_h}$$

$\therefore$ $$F_P = f_c t + \frac{f_0 - f_c}{k_h}$$

Here, $F_p = 18$ cm

$f_c = 1$ cm/hr

and $f_0 = 10$ cm/hr

$$t = 10 \text{ hr}$$

$$\therefore \quad 18 = 1(10) + \frac{10-1}{k_h}$$

$$\Rightarrow \quad k_h = \frac{9}{8}\text{hr}^{-1}$$

$$= 1.125 \text{ hr}^{-1}$$

17. (c)

The areal spread of a rainfall is indicated by distribution coefficient.

18. (b)

Peak flow of direct runoff hydrograph

$$= 180 - 20 = 160 \text{ m}^3/\text{s}$$

$$\text{Effective runoff} = 2.5 - 0.3(3) = 1.6 \text{ cm}$$

$$\therefore \quad \text{Peak of 4 hr unit hydrograph} = \frac{160}{1.6} = 100 \text{ m}^3/\text{s}$$

19. (c)

Unit hydrograph theory is applicable for an area of catchment between 2 km^2 and 5000 km^2.

20. (a)

For confidence probability c, the confidence interval is

$$x_1 = x_T - f(c)\, S_e$$

$$x_2 = x_T + f(c)\, S_e$$

For 95% confidence probability, $f(c) = 1.96$

$$\therefore \quad x_1 = 15000 - 1.96(1500)$$

$$= 12060 \text{ m}^3/\text{s}$$

$$x_2 = 15000 + 1.96(1500)$$

$$= 17940 \text{ m}^3/\text{s}$$

21. (b)

As per Inglis formula,

$$\text{Peak flood, } Q_p = \frac{124A}{\sqrt{A+10.4}} \qquad \text{where A is catchment area in km}^2$$

$$= \frac{124 \times 53.6}{\sqrt{53.6+10.4}} = \frac{124 \times 53.6}{8} = 830.8 \text{ m}^3/\text{s}$$

23. (c)

Silt excluder is provided to eliminate the suspended heavy silt. Fine silt is allowed to enter the canal.

24. (b)

According to Khosla's theory,

$$\text{Exit gradient, } G_e = \frac{H}{d\pi\sqrt{\lambda}}$$

where $H = 5$ m

$b = 50$ m

$d = 4$ m

and $\lambda = \dfrac{1+\sqrt{1+\alpha^2}}{2}$

$$\alpha = \frac{b}{d} = \frac{50}{4} = 12.5$$

$$\therefore \quad \lambda = \frac{1+\sqrt{1+(12.5)^2}}{2} = 6.77$$

$$\therefore \quad G_e = \frac{5}{4\pi\sqrt{6.77}}$$

$$= \frac{5}{4\times 3.14\times 2.6} = 0.15$$

25. (c)

$$\text{Required depth of water} = 0.75 \times 80 = 60 \text{ mm}$$

For efficiency of 65%,

$$\text{Depth of water to be applied} = \frac{60}{0.65} = 92.31 \text{ mm} \simeq 93 \text{ mm}$$

26. (c)

In modular outlets, discharge is independent of the water levels in the distributary and water coarse. They are also called as rigid modules.

27. (a)

As per Lacey's theory,

Slope can be computed as,

$$S = 0.0003 \times \frac{f^{5/3}}{Q^{1/6}}$$

where silt factor, $f = 1.76\sqrt{d_{mm}}$

$$= 1.76 \times \sqrt{2}$$

$$\simeq 2.49$$

$$\therefore \quad S = \frac{0.0003 \times (2.49)^{5/3}}{(50)^{1/6}}$$

$$= \frac{0.0003 \times 4.57}{1.9}$$
$$= 3 \times 2.4 \times 10^{-4}$$
$$= 7.2 \times 10^{-4}$$

29. (a)

Given, $q = 8\ m^3/s/m$ and $f = 1$

Lacey's scour depth, $R = 1.35\left(\frac{q^2}{f}\right)^{1/3}$

$$= 1.35\left(\frac{8^2}{1}\right)^{1/3}$$
$$= 1.35 \times 8^{2/3} = 1.35 \times 4$$
$$= 5.4\ m$$

$\therefore$ Scour depth $= 1.5 \times 5.4 = 8.1\ m$

$\therefore$ $D = 8.1 - 4.5 = 3.6\ m$

$\therefore$ Length of launching apron in launched position

$$= D\sqrt{5} = 3.6\sqrt{5}\ m$$

30. (b)

Here,

Bed level of drain < Bed level of canal

HFL of drain > Bed level of canal

Therefore, the best drainage work will be syphon aqueduct.

31. (d)

For no tension,

$$B \geq \frac{H}{\sqrt{G_C - C}}$$

$\Rightarrow$ $B \geq \frac{40}{\sqrt{2.4 - 1}}$ [For full uplift, $C = 1$]

$\Rightarrow$ $B \geq \frac{40}{\sqrt{1.4}} \simeq \frac{40}{1.18}$

$\simeq 33.89\ m \simeq 34\ m$

33. (a)

Lined canals have higher initial cost and lower maintenance cost.

34. (c)

$$\text{Design discharge required} = \frac{\text{Discharge required in field}}{\text{Capacity factor} \times \text{Time factor}}$$

$$= \frac{0.5}{0.9\times0.6}$$
$$= 0.925 \simeq 0.93 \text{ m}^3/\text{s}$$

35. (d)

Drainage density is the ratio of total length of stream channels to the area of catchment. Large drainage density creates quick flowing off or runoff down the channel hence gives a faster response (shorter time base) and high peak discharge.

36. (a)

Limiting velocities in different type of linings:

Type of lining	Safe limiting velocity
Boulder lining	1.5 m/s
Burnt clay tile lining	1.8 m/s
Cement concrete lining	2.7 m/s

41. (b)

- Hole diameter of rivets, $d_o = 20 + 1.5 = 21.5$ mm
- Net area, $A_{net} = (B - nd_o)\cdot t$
$= (150 - 2 \times 21.5) \times 10$
$= 1070 \text{ mm}^2$

Now, maximum tension in the flat is given as

$$\text{Maximum tension} = (\sigma_{at})\cdot(A_{net})$$
$$= (0.6\, f_y)\ (1070)$$
$$= (0.6 \times 250)\ (1070)$$
$$= 160500 \text{ N}$$
$$= 160.5 \text{ kN}$$

44. (c)

$$\text{Maximum edge distance} \not> 12t\cdot \varepsilon$$

$$\text{where, } \varepsilon = \sqrt{\frac{250}{f_y}} = \sqrt{\frac{250}{350}} = 0.845$$

$$\text{Now, maximum edge distance} = 12t\cdot \varepsilon$$
$$= 12 \times 12 \times 0.845$$
$$= 121.68 \text{ mm}$$

45. (a)

Strength of fillet weld is given by,

$$F_{dw} = \left(k\, S\, l_{eff}\right) \times \frac{f_u}{\sqrt{3}\gamma_{mw}}$$

$$= (0.7 \times 8 \times 150) \times \frac{410}{\sqrt{3} \times 1.25} \times 10^{-3} \text{ kN}$$

$$= 159.07 \text{ kN} \simeq 159 \text{ kN}$$

46. (c)

Splices are designed as short columns.

48. (b)

Effective length of fillet weld = Actual length – 2 × weld size.

This deduction is made to compensate for craters to be formed at the end of welded length.

52. (b)

$$\text{Correct area of map} = \left[\frac{\text{Original length of tape}}{\text{Nominal length of tape}}\right]^2 \times \frac{\text{Area measured}}{(\text{Shrinkage factor})^2}$$

$$\text{Shrinkage factor} = \frac{\text{Shrunk length}}{\text{Original length}} = \frac{9}{10} = 0.9$$

Original length of tape, $l' = 20 - 0.5 = 19.5$ m

Nominal length of tape, $l = 20$ m

$$\therefore \quad \text{Corrected area on map} = \left[\frac{19.5}{20}\right]^2 \times \frac{50}{(0.9)^2}$$

$$= 58.68 \text{ cm}^2$$

$$\text{Corrected area on ground} = \text{Corrected area on map} \times \frac{1}{(\text{Scale})^2}$$

$$= 58.68 \times \frac{1}{\left(\frac{1}{1000}\right)^2} \text{cm}^2$$

$$= 58.68 \times 10^6 \text{ cm}^2 = 5868 \text{ m}^2 \simeq 0.6 \text{ hectare}$$

53. (a)

Total change in declination from 1920 to 2000 in

East direction = 80 × 6′

= 480′ = 8°Eastward

∴ Declination in 2000 = 8°E – 4° 30′ W = 3° 30′ E

In 1920, declination was 4° 30′ W

∴ True bearing in 1920 = 45°30′ – 4° 30′ = 41° 0′

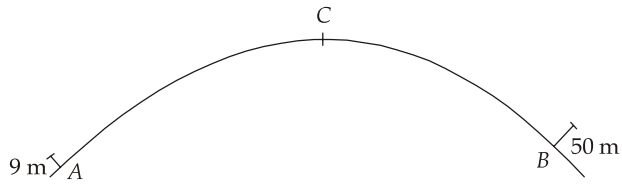
In 2000, declination is 3° 30′ E

∴ True bearing = M.B. + 3°30′

⇒ 41° = M.B. + 3°30′

⇒ Magnetic bearing = 37°30′

55. (c)



$$\text{Distance, } AC \text{ (in km)} = 3.855\sqrt{h}$$
$$= 3.855\sqrt{9} = 11.565 \text{ km}$$
$$\text{Distance, } CB \text{ (in km)} = 3.855\sqrt{h}$$
$$= 3.855\sqrt{49} = 26.985 \text{ km}$$

Distance of observer from the lighthouse = (11.565 + 26.985) km = 38.55 km $\simeq$ 38.6 km

56. (d)

- Face left means the vertical circle is on left hand side of the observer.
- Collimation error in theodolite is eliminated by taking both face readings.

57. (d)

- In Surveyor's compass, edge bar needle is used.
- Sighting and reading are done simultaneously from same position of observer in prismatic compass.

58. (*)

$$a = 100 \pm 0.02 \text{ m}$$
$$b = 150 \pm 0.03 \text{ m}$$
$$A = a \times b$$
$$\frac{\partial A}{\partial a} = b = 150$$
$$\frac{\partial A}{\partial b} = a = 100$$
$$e_A = \pm\sqrt{\left[\left(e_a \frac{\partial A}{\partial a}\right)^2 + \left(e_b \frac{\partial A}{\partial b}\right)^2\right]}$$
$$= \pm\sqrt{(0.02 \times 150)^2 + (0.03 \times 100)^2}$$
$$= \pm\sqrt{3^2 + 3^2}$$
$$= \pm 3\sqrt{2}\,\text{m}^2$$

59. (b)

Contour interval = 50 m
Gradient = 4%

which means horizontal equivalent is 25 m per 1 m vertical distance.

$\therefore$ Horizontal equivalent, H.E. = 25 × 50 = 1250 m

Scale used is 1 cm = 250 m

$\therefore$ Arc length $= \dfrac{H.E.}{\text{Scale}} = \dfrac{1250}{250} = 5\,\text{cm}$

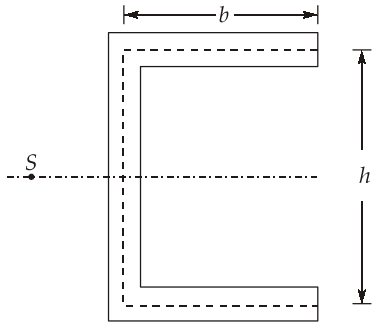
62. (d)

Method of repetition is used for horizontal angles.

65. (c)

Let shear centre is at a distance 'e' from centre line of web,

$$e = \frac{b^2h^2t_f}{4I}$$



$b = 100 - 5 = 95$ mm

$h = 500 - 2(5) = 490$ mm

$t_f = 10$ mm

$\therefore \quad e = \dfrac{95^2 \times 490^2 \times 10}{4 \times 2.12 \times 10^8} \simeq 25.6$ mm

So, $x = e - 5 = 25.6 - 5$

$= 20.6$ mm

66. (d)

$$\text{Shear stress at neutral axis, } \tau_{NA} = \frac{4}{3} \times \frac{\text{Shear force}}{\text{Area}}$$

$$= \frac{4}{3} \times \frac{5 \times 10^3}{\frac{\sqrt{3}}{4} \times 0.4^2 \times 10^6} = \frac{1}{6\sqrt{3}}\,\text{N/mm}^2$$

67. (b)

Given, $\sigma_y = 240$ MPa

$\sigma_1 = \sigma$

$\sigma_2 = 0.8\sigma$

$\sigma_3 = 0$

As the major principal stress is σ, so, major principal strain will be in direction of 'σ' only.

Now, as per maximum principal strain theory,

$$\frac{\sigma_1}{E} - \frac{\mu\sigma_2}{E} - \frac{\mu\sigma_3}{E} \le \frac{\sigma_y}{E}$$

$$\Rightarrow \quad \sigma - 0.3(0.8\sigma) - 0 \le 240$$

$$\Rightarrow \quad \sigma \le \frac{240}{0.76}$$

$$= 315.79 \text{ N/mm}^2$$

68. (b)

Torque in shaft, $AB = 4T + 2T + T$

$= 7T$

Torque in shaft $BC = 2T + T$

$= 3T$

Torque in shaft $CD = T$

Since shafts are in series

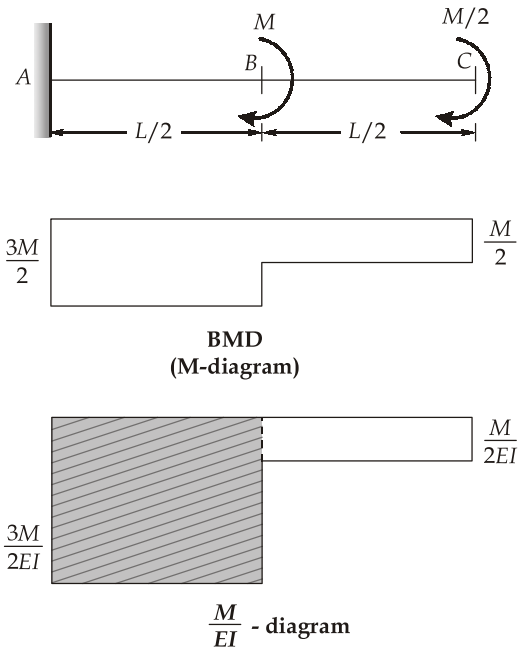
$$\therefore \quad \theta_{AD} = \theta_D - \theta_A = \theta_D = \theta_{AB} + \theta_{BC} + \theta_{CD} \qquad (\because \theta_A = 0)$$

$$\Rightarrow \quad \theta_D = \left(\frac{TL}{GI_p}\right)_{AB} + \left(\frac{TL}{GI_p}\right)_{BC} + \left(\frac{TL}{GI_p}\right)_{CD}$$

$$= \frac{7T(2)}{G(2I_p)} + \frac{3T(1)}{G(I_p)} + \frac{T(1)}{G\left(\frac{I_p}{2}\right)}$$

$$= \frac{12T}{GI_p}$$

69. (b)



From moment-area method,

$$\Delta_{BA} = \Delta_B - \Delta_A = \text{Moment of area of } \frac{M}{EI} \text{ diagram about } B$$

$$\Rightarrow \quad \Delta_B = \frac{3M}{2EI} \times \frac{L}{2} \times \frac{L}{4} \qquad [\because \Delta_A = 0]$$

$$= \frac{3ML^2}{16EI}$$

70. (c)

Euler's crippling load,

$$P_e = \frac{\pi^2 EI}{L_{eff}^2}$$

$$\Rightarrow \quad P_e = \frac{\pi^2 E\left(\frac{\pi D^4}{64}\right)}{L^2}$$

$$\Rightarrow \quad P_e = k \cdot D^4 \qquad \text{where } k = \frac{\pi^3 E}{64L^2}$$

$$\Rightarrow \quad 4 = k \cdot D^4 \qquad \ldots(1)$$

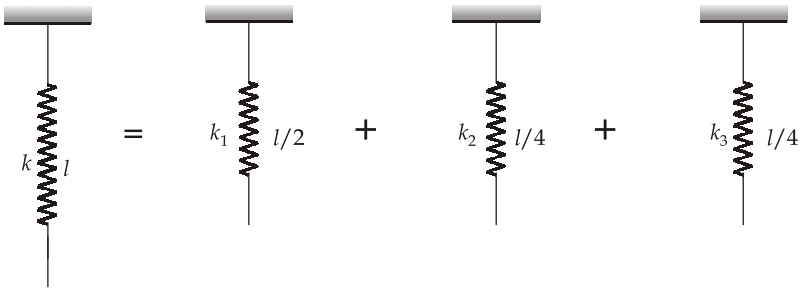
When diameter is reduced by 10%, let the crippling load is P_e'.

$$\therefore \quad P_e' = k(0.9D)^4 \qquad \ldots(2)$$

From (1) and (2),

$$P_e' = 4 \times 0.9^4$$
$$= 4 \times 0.6561$$
$$= 2.62 \text{ kN}$$

71. (b)



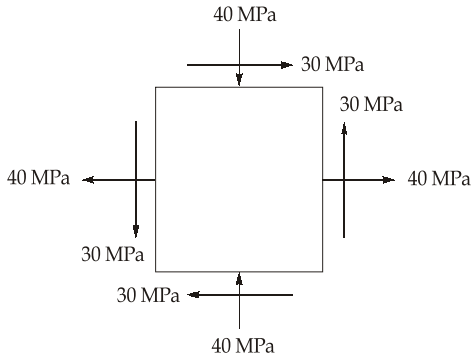
Force constant, $k \propto \frac{1}{\text{Length}}$

$$\therefore \quad \frac{k_1}{k} = \frac{l}{\frac{l}{2}}$$

$$\Rightarrow \quad k_1 = 2k$$

73. (a)

Given state of stress can be represented as,



Principal stresses,

$$\sigma_{p1}/\sigma_{p2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{40 - 40}{2} \pm \sqrt{\left(\frac{40 - (-40)}{2}\right)^2 + 30^2}$$

$$= 0 \pm \sqrt{40^2 + 30^2} = 50 \text{ MPa}, -50 \text{ MPa}$$

74. (d)

$$\text{Allowable rate of twist, } \theta_{Allow} = \frac{TL}{GJ}$$

$$\Rightarrow \frac{\theta}{L} = \frac{T}{GJ}$$

$$\Rightarrow 0.75° \times \frac{\pi}{180°} \times 10^{-3} = \frac{320\pi^2 \times 10^3 \times 32}{80 \times 10^3 \times \pi \times d^4}$$

$$\Rightarrow d^4 = \frac{320\pi^2 \times 10^3 \times 32 \times 180°}{80 \times 10^3 \times \pi \times \pi \times 0.75° \times 10^{-3}}$$

$$\Rightarrow d^4 = 3072 \times 10^4 \text{ mm}^4$$

$$\Rightarrow d = (3072)^{1/4} \times 10 \text{ mm}$$

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