DETAILED SOLUTIONS

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ESE 2022 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 8

Section A : CPM PERT + Hydrology and Water Resource Engineering
Section B : Design of Steel Structures - 1 + Surveying and Geology -1
Section C : Solid Mechanics - 2

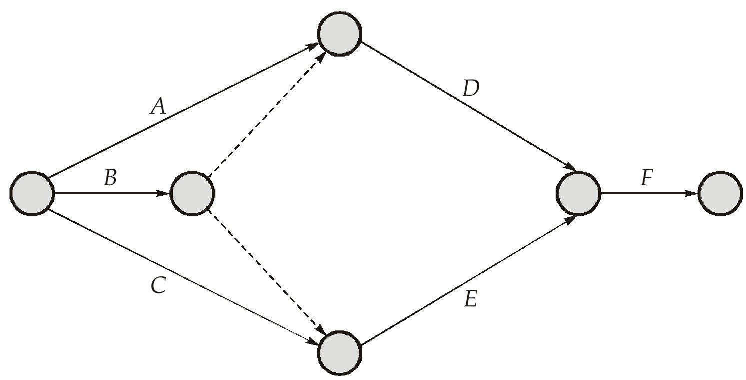
1.	(d)	16.	(a)	31.	(b)	46.	(b)	61.	(a)
2.	(b)	17.	(c)	32.	(b)	47.	(a)	62.	(d)
3.	(a)	18.	(c)	33.	(d)	48.	(d)	63.	(a)
4.	(c)	19.	(c)	34.	(a)	49.	(d)	64.	(b)
5.	(d)	20.	(b)	35.	(a)	50.	(c)	65.	(a)
6.	(d)	21.	(d)	36.	(a)	51.	(c)	66.	(b)
7.	(c)	22.	(b)	37.	(a)	52.	(c)	67.	(d)
8.	(c)	23.	(c)	38.	(c)	53.	(c)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

DETAILED EXPLANATIONS

1. (d)

No subsequent activity starts until its tail event is reached.

2. (b)



No. of dummy activities = 2

3. (a)

The bar chart cannot depict interdependencies of activities.

4. (c)

1. A-O-A : It can be used where a project has large number of activities and dummies.
2. A-O-N is useful as it can be understood by non-specialist persons because the network diagram is similar to common engineering flow diagrams.

5. (d)

Excavating equipments:

(i) Bulldozer
(ii) Power shovel
(iii) Dragline
(iv) Hoe
(v) Scraper
(vi) Trenchers
(vii) Clamshells

6. (d)

$$\text{Mean time, } t_E = \frac{t_o + 4t_m + t_p}{6}$$

$$t_o = 6 \text{ days}$$

$$t_m = 7 \text{ days}$$

$$t_p = 8 \text{ days}$$

$$\therefore \quad t_E = \frac{6 + 4 \times 7 + 8}{6}$$

$$= \frac{42}{6} = 7 \text{ days}$$

7. **(c)**

In PERT analysis, every activity is assumed to follow β-distribution curve.

8. **(c)**

$$\mu = (t_E)_{project} = (t_E)_P + (t_E)_Q + (t_E)_R + (t_E)_S$$

$$\Rightarrow \quad \mu = 8 + 5 + 12 + 9 = 34 \text{ days}$$

$$\sigma_{project} = \sqrt{\sigma_P^2 + \sigma_Q^2 + \sigma_R^2 + \sigma_S^2}$$

$$= \sqrt{2^2 + 1^2 + 2^2 + 2^2}$$

$$= \sqrt{4+1+4+4}$$

$$= \sqrt{13} \approx 3.6$$

$$\text{Range of project duration} = \mu \pm 3\sigma$$

$$= 34 \pm 3 \times 3.6$$

$$= 34 \pm 10.8$$

$$\therefore \quad \text{Maximum duration} = 34 + 10.8$$

$$= 44.8 \text{ days}$$

$$\approx 45 \text{ days}$$

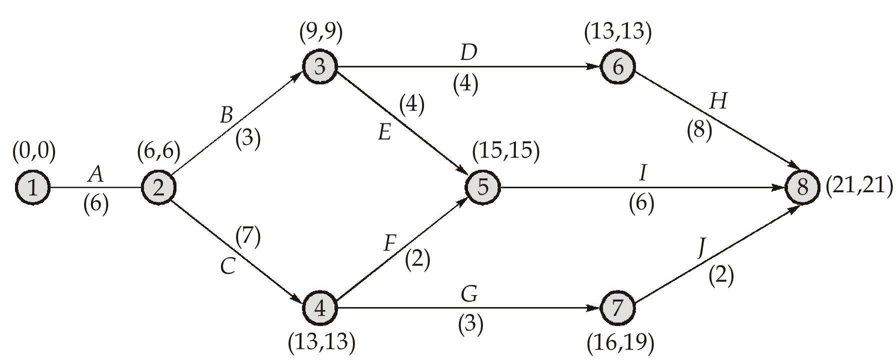
9. **(c)**

Total float for each activity is connected to all other activities in the project as the earliest start time of an activity is evaluated considering preceding activities and latest finish time of an activity is evaluated considering succeeding activities.

10. **(b)**

Path	Duration (days)
1 – 2 – 3 – 6 – 8	6 + 3 + 4 + 8 = 21
1 – 2 – 3 – 5 – 8	6 + 3 + 4 + 6 = 19
1 – 2 – 4 – 5 – 8	6 + 7 + 2 + 6 = 21
1 – 2 – 4 – 7 – 8	6 + 7 + 3 + 2 = 18

There are two critical paths. The critical path duration is 21 days (project completion duration).



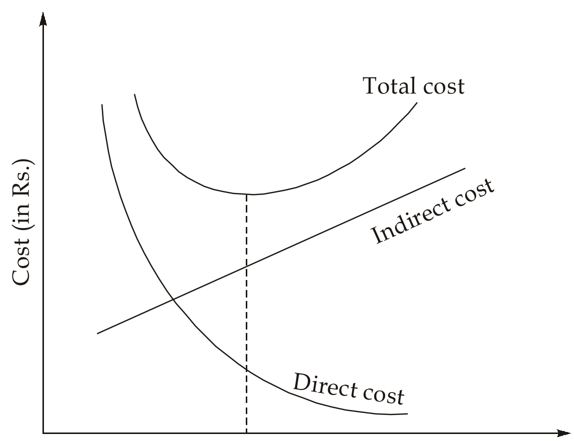
For activity *i-j*

$$\text{LST} = T_L j + t_{ij}$$

∴ For activity G,

Latest start time of activity G = 19 – 3 = 16 days

11. (c)



12. (a)

Resource levelling:

- Activities are rescheduled such that maximum demand of resources does not exceed availability of resources.
- Critical path may change.
- Project duration may change.

13. (b)

Project crashing by 1 day :

$$\text{Cost slope for activity } A = \frac{9600-7000}{7-3} = \text{Rs. } 650/\text{day}$$

$$\text{Cost slope for activity } B = \frac{6000-5000}{5-3} = \text{Rs. } 500/\text{day}$$

Since the cost slope of activity B is lesser than that of activity A and thus crash activity B by 1 day.

Crashing cost by one day = Rs. 500

Project duration = 11 days

Indirect cost = 11 × 600 = Rs. 6600

Direct cost = Rs. 12000

Crashing cost = Rs. 500

∴Total cost of project after crashing by one day

= 12000 + 6600 + 500

= Rs. 19100

14. (c)

The average annual cost as per straight-line depreciation method is given as

$$D = \frac{C_i - C_s}{n}$$

$$C_i = 20 \text{ lacs}, n = 8$$

$$C_s = 2 \text{ lacs}$$

$$\therefore \quad D = \frac{20-2}{8} = \frac{18}{8} = 2.25 \text{ lacs/year}$$

15. (b)

Raingauge should be kept at a distance more than twice the height of obstruction.

16. (a)

$$\text{Total rainfall in 6 hr storm} = 1 \text{ cm/hr} \times 6 \text{ hr} = 6 \text{ cm}$$

$$\text{Runoff} = 4 \text{ cm}$$

$$\phi\text{-index} = \frac{P-R}{t_e} = \frac{6-4}{6} = \frac{1}{3} \text{ cm/hr}$$

For runoff due to 9 hr storm, $\phi = \frac{P-R}{t_e}$

$$\Rightarrow \quad \frac{1}{3} = \frac{12-R}{9}$$

$$\Rightarrow \quad \text{R} = 9 \text{ cm}$$

17. (c)

Relationship curve between the stage and discharge at a particular section is known as rating curve.

18. (c)

Lysimeter is used to measure consumptive use or evapotranspiration while transpiration is measured by phytometer.

19. (c)

Dicken's formula, $Q_P = \text{C}_\text{D}\text{A}^{3/4}$

Ryves formula, $Q_R = \text{C}_\text{R}\text{A}^{2/3}$

Inglish forula, $Q_P = \frac{124A}{\sqrt{A+10.4}}$ $\quad A$ (in km^2)

For large catchment area, $\sqrt{A+10.4} \simeq \sqrt{A}$

$$\therefore \quad Q_P = 124A^{1/2}$$

20. (b)

Equilibrium discharge is expressed as

$$Q_s = 2.778 \times \text{Area} \times \text{Intensity}$$

Where, Q_s is in m^3/s

Area is in km^2
Intensity is in cm/hr

$$\therefore \quad 250 = 2.778 \times A \times \frac{1}{3} \text{ cm/hr}$$

$$\Rightarrow \quad A = 269.97 \text{ km}^2 \simeq 270 \text{ km}^2$$

21. (d)

Method of superposition is used to develop a unit hydrograph of nD hr from a D hr unit hydrograph. This is possible only because of the assumptions of hydrograph i.e., linear response and time-invariance.

22. (b)

Standard project flood is the flood that would result from a severe combination of hydrological and meteorological factors that are reasonably applicable to the region. In this, extremely rare combination of factors are excluded.

Probable maximum flood (PMF) is the flood that results from the severemost combinations of meteorological and hydrological factors. In this, extremely rare combination of factors are also included.

23. (c)

In a linear reservoir, outflow rate varies linearly with storage.
In Muskingum method,

Storage, $$S = k[xI + (1-x)Q]$$

Where I = Inflow rate and Q = Outflow rate

If $x = 0$, $\quad S = kQ$

$\therefore \quad S \propto Q$

$\therefore$ Linear reservoir.

24. (a)

Cultural command area, $\quad CCA = 1000$ ha

Intensity of irrigation, $\quad IOI = 70\%$

$$\text{Rice area under cultivation} = \frac{70}{100} \times 1000 = 700 \text{ ha}$$

Base period, $\quad B = 15$ days

Total depth of water required = 500 mm

Useful rainfall on the field = 68 mm

Delta, $\quad \Delta = 500 - 68 = 432 \text{ mm} = 0.432 \text{ m}$

$$\therefore \text{ Duly,} \quad D = \frac{8.64B}{\Delta} = \frac{8.64 \times (15)}{0.432} = 300 \text{ ha/cumecs}$$

$$\therefore \text{ Discharge,} \quad Q = \frac{\text{Area}}{D} = \frac{700}{300} = 2.33 \text{ cumecs}$$

25. (c)

$$[Na^+] = \frac{345\text{ mg}/l}{23} = 15\text{ meq}/l$$

$$[Ca^{2+}] = \frac{60\text{ mg}/l}{20} = 3\text{ meq}/l$$

$$[Mg^{2+}] = \frac{18\text{ mg}/l}{12} = 1.5\text{ meq}/l$$

$$\text{SAR} = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}} = \frac{15}{\sqrt{\frac{3+1.5}{2}}} = 10$$

Water having SAR = 10 is classified as medium sodium water.

26. (c)

- According to Lacey, true regime channel is semi-elliptical. However, for the ease of analysis, it is assumed trapezoidal.
- Garret's diagram for the design of irrigation channel is based on Kennedy's theory.

27. (c)

Since Kennedy's studies were based on the observations on the Upper Bari Doab Canal (UBDC) only, to validate his expression of critical velocity throughout India, he introduced a term called as critical velocity ratio (m). The value of m accounts for silt grade (type and size of silt).

Type of soil	m
UBDC	1
Coarser than UBDC	>1
Finer than UBDC	<1

28. (a)

Wind velocity, $V = 80$ km/hr

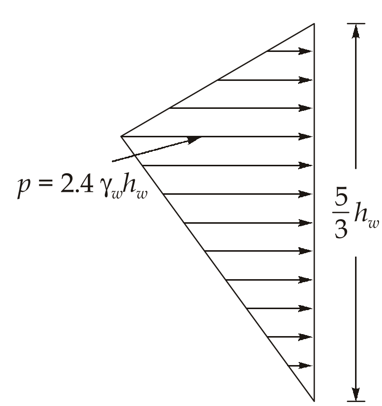
Fetch, $F = 50$ km

As fetch > 32 km,

Height of wave, $h_w = 0.032\sqrt{VF}$

$\Rightarrow h_w = 0.032\sqrt{80 \times 50} = 2.02$ m

Wave pressure distribution diagram,



Maximum wave pressure intensity,

$$p = 2.4\ \gamma_w h_w$$
$$= 2.4 \times 10 \times 2.02$$
$$= 48.48\text{ kN/m}^2$$

29. (c)

Increase in the length of the floor is very effective in reducing the risk of piping as its decreases, the energy at the exit and thus the exit gradient.

30. (b)

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

where, $\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}$

$\alpha = \frac{b}{d}$

Here, H = Maximum seepage head

b = Length of base

d = Vertical cutoff depth at downstream end

32. (b)

Ridge canal: A canal aligned along the ridge-line or watershed line of an area is said to be ridge canal or watershed canal.

Contour canal: A canal roughly parallel to the contours of the area is called a contour canal. A contour canal has to pass the drainages many times and hence, cross drainage works are maximum.

Side-slope canal: A canal aligned nearly perpendicular to the contour of the area is called side-slope canal. It is parallel to the natural drainage line and hence no cross-drainage works are required.

33. (d)

Gibb's module is a type of modular outlet which ensures constant discharge even if the water levels in the supply channel and water course fluctuate.

Flexibility, $F = \frac{dq/q \text{ (rate of change of discharge in the outlet)}}{dQ/Q \text{(rate of change of discharge in the distributary channel)}}$

So, for modular outlet or Gibb's module

$F = 0$

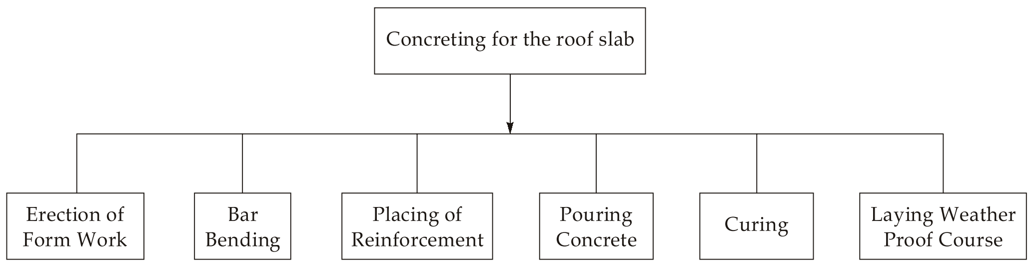
35. (a)

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

37. (a)

A typical work breakdown structure (WBS) is shown below:



38. (c)

Contract Agreement : Contract agreement is a legal document which binds the contractor and the contractee to follow the terms and conditions given in the agreement until the work entrusted to the contractor is completed/signed by both the parties.

The contract agreement normally contains

1. Title page with name of work and contract agreement number.
2. Index page giving the contents of the agreement with page references.
3. Tender notice with description of work, location, time, period of completion, etc.
4. Bill of quantities and total cost of work duly calculated.
5. Schedule of issue of materials/rates.
6. General specifications giving the clauses and type of work.
7. Detailed specification for each item of work and materials.
8. Major particulars for bricks, sand, jelly, etc.
9. Complete drawings with plan, elevation, site plan and other relevant detailed drawings.
10. Conditions of contract giving rate of labour, materials, tools and plants, progress rate, etc.
11. Special conditions regarding nature of work, taxes, royalties, labour amenities etc.

39. (b)

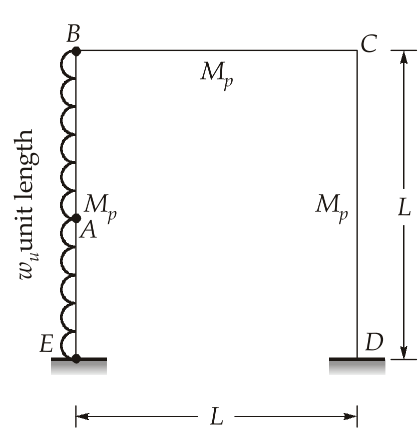
No. of possible location of plastic hinges A, B, C, D

$$N = 4$$

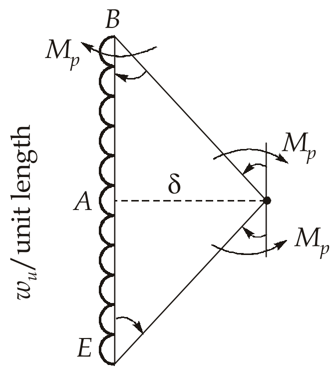
$$D_S = 2 + 3 - 3 = 2$$

$$n = N - D_S = 4 - 2 = 2$$

No. of independent mechanisms $= 2$



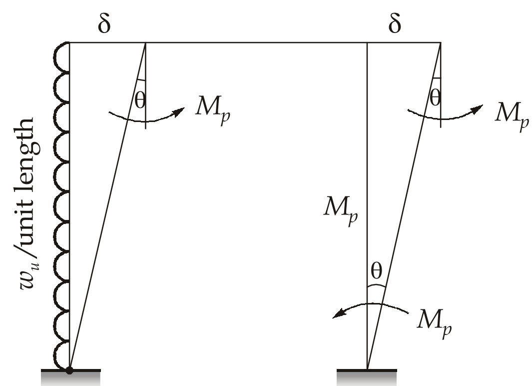
1. Consider beam mechanism in beam EAB



$$w_u = 11.656\frac{M_p}{L^2}$$

$$W_u = 11.656\frac{M_p}{L}$$

2. Consider sway mechanism



$$w_u \times \frac{1}{2} \times \delta \times L = 3M_p\theta$$

$$\Rightarrow \quad w_u \times \frac{1}{2} \times \delta \times L = 3M_p \times \frac{\delta}{L}$$

$$w_u = \frac{6M_p}{L^2}$$

$$\therefore \quad W_u = w_u \times L = \frac{6M_p}{L}$$

$$\text{Collapse load} = \min\left(\frac{11.656M_p}{L}, \frac{6M_p}{L}\right) = \frac{6M_p}{L}$$

41. (c)

The stress distribution for these sections is rectangular.

42. (a)

1. Above pattern is a diamond pattern, which is most efficient and economical as the cover plates can be proportioned proportional to the load transferred from main plate through bolts.

2. Critical section for main plate is bolt line closest to load zone. The main plates resist the total load at section A-A and lesser load at B-B, C-C successively. (Therefore lesser bolts at section nearer to load).
3. Reverse is the case with cover plate. Critical section is at C-C section as the maximum force is at C-C section.

44. (d)

Radiography method is not used in fillet weld because the parent material will also form part of the projected picture.

45. (c)

$$P = \frac{L_w \times t_e \times f_y}{\gamma_{mw}}$$

$$P = 450 \times 10^3$$

$$t_e = \frac{5}{8} \times 16 = 10 \text{ mm} \qquad \text{(For single-}V\text{ groove weld)}$$

$$f_y = 250 \text{ MPa}$$

$$\gamma_{mw} = 1.25$$

$$\therefore \quad 450 \times 10^3 = \frac{L_w \times 10 \times 250}{1.25}$$

$$\Rightarrow \quad L_w = 225 \text{ mm}$$

46. (b)

$$\beta = 1.4 - 0.076\left(\frac{w}{t}\right)\left(\frac{b_s}{L_c}\right)\left(\frac{f_y}{f_u}\right)$$

$$w = 75 \text{ mm}$$

$$t = 8 \text{ mm}$$

$$b_s = w + w_1 - t$$

$$= 75 + 50 - 8 = 117 \text{ mm}$$

$$L_c = 3 \times 65 = 195 \text{ mm}$$

$$\beta = 1.4 - 0.076 \times \frac{75}{8} \times \frac{117}{195} \times \frac{250}{410}$$

$$\Rightarrow \quad \beta = 1.139 \simeq 1.14 \geq 0.7$$

$$\geq \frac{0.9\dfrac{f_u}{\gamma_{m1}}}{\dfrac{f_y}{\gamma_{m0}}} = \frac{0.9 \times \dfrac{410}{1.25}}{\dfrac{250}{1.1}} = 1.3 \qquad \text{(OK)}$$

47. (a)

The following are the assumptions made while designing a compression member:

1. The ideal column is assumed to be absolutely straight having no crookedness, which never occurs in practice.
2. The modulus of elasticity is assumed to be constant in a built-up column.
3. Secondary stresses (which may be of the order of even 25%–40% of primary stresses) are neglected.

48. (d)

In general, beam deflection is a function of loading, span, modulus of elasticity and geometry of cross-section.

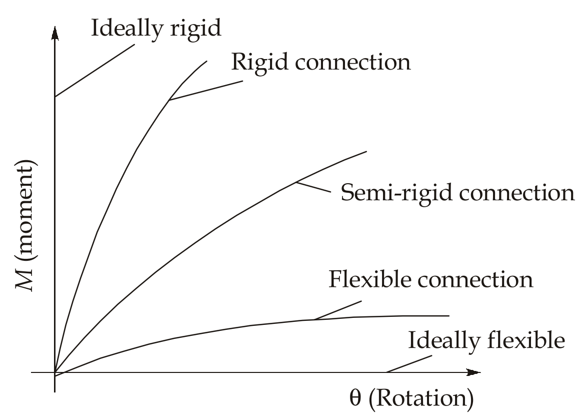
49. (d)

In a plate girder web is quite thin and deep and thus, possibility of vertical and diagonal buckling exist and therefore web is stiffened vertically.

50. (c)

Refer IS 800 : 700 Clause 8.4.2.2 (a)

51. (c)



52. (c)

$$1 \text{ link} = \frac{20}{100} = 0.2 \text{ m}$$

$$\text{Hypotenusal allowance} = l(\sec\theta - 1)$$

$$\Rightarrow \quad 0.2 = 20(\sec\theta - 1)$$

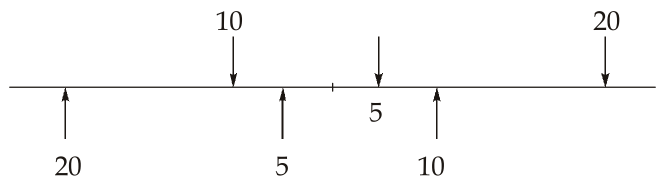
$$\Rightarrow \quad \sec\theta - 1 = \frac{0.2}{20} = \frac{1}{100}$$

$$\Rightarrow \quad \sec\theta = \frac{101}{100} = 1.01$$

$$\Rightarrow \quad \cos\theta = \frac{100}{101} = 0.99$$

$$\therefore \quad \theta \simeq 8°$$

53. (c)



From the above table, total shift of the bubble is

$$n = 10 \text{ divisions}$$

$\therefore$ Sensitivity,

$$\alpha = \frac{S}{nD} \times 206265''$$

$$= \frac{(1.865 - 1.785)}{10 \times 50} \times 206265''$$

$$= 33''$$

54. (c)

Given: Scale, 1 cm = 10 m

$$\text{Shrunk length} = 9.7 \text{ cm}$$

$$\text{Original length} = 10 \text{ cm}$$

$$\text{Shrinkage factor} = \frac{9.7}{10} = 0.97$$

$$\text{Original area on plan} = \frac{100.8}{(0.97)^2} = 107.13 \text{ cm}^2$$

$\therefore$

$$\text{Original area of survey} = 107.13 \times 10^2 = 10713 \text{ m}^2$$

$$\text{Faulty length of chain used} = 20 - 0.08 = 19.92 \text{ m}$$

$$\text{Correct survey area} = \left(\frac{19.92}{20}\right)^2 \times 10713$$

$$= 10627 \text{ m}^2 \simeq 1.06 \text{ ha}$$

55. (b)

For minor adjustments of horizontal angles measured using a theodolite, the tangential screw is adjusted after both the plates are clamped.

In a transit theodolite, any incidental error due to eccentricity of vernier is primarily counteracted by reading both the verniers.

56. (c)

True difference of levels between A and B

$$\Delta h_{AB} = \frac{(b_1 - a_1) + (b_2 - a_2)}{2}$$

$$= \frac{(2.097 - 0.656) + (2.298 - 0.867)}{2}$$

$$= 1.436 \text{ m}$$

But $(\Delta h_{AB}) = (b_1 - e) - a_1$

$\Rightarrow$ $1.436 = (2.097 - e) - 0.656$

$\Rightarrow$ $e = 5 \times 10^{-3}$

But $e = e_l + \underbrace{e_c + e_r}_{0.0673D^2 (\text{D in km})} = 5 \times 10^{-3}$

$\Rightarrow$ e_l (collimation error) $= 5 \times 10^{-3} - 0.0673 \times (0.95)^2$

$= -0.0557$ m

57. (a)

Closed contour lines with higher values inside represents a hill. Closed contour lines with lower values inside represents a depression without an outlet i.e. a lake.

58. (b)

The principle of plane tabling (or plane table method) is parallelism.

60. (d)

Sextant may be used:

1. To measure angle between two object points.
2. To measure vertical angle between two object points.
3. To determine the altitude of a point object.
4. To set out a given angle.
5. As an optical square.
6. To locate an inaccessible point by method of intersection.
7. To locate a point by method of radiation.

61. (a)

As per Trapezoidal formula,

$$\text{Volume} = \frac{5}{2}[2050 + 31500 + 2(8400 + 16300 + 24600)]$$

$$= 330{,}375 \text{ m}^3$$

62. (d)

From the subsequent position of the levelling instrument, the first staff reading B.S. is to be taken on the last point at which the F.S. was taken from the previous instrument station.

63. (a)

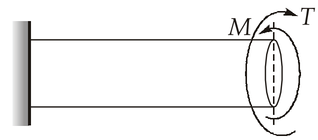
Isogonic line is the line drawn through the points of same declination. The distribution of earth's magnetism is not regular and consequently, the isogonic lines don't from complete great circles, but radiating from the north and south magnetic regions and they follow irregular path.

64. (b)

Both statements are true and independent.

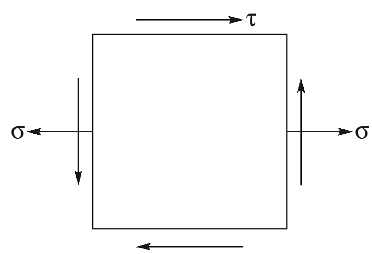
The shear strain induced due to loading influences the bending stress in flanges of beam and causes the section to warp. Due to this effect, the bending stresses determined by simple bending theory gets modified. This phenomenon is known as shear lag effect.

65. (a)



$$\sigma = \sigma_{max} = \pm \frac{M}{\left(\frac{\pi}{32} D^3\right)} = \pm \frac{32M}{\pi D^3}$$

$$\tau = \tau_{max} = \frac{T}{Z_P} = \frac{T}{\frac{\pi}{16} D^3} = \frac{16T}{\pi D^3}$$



$$\sigma_1/\sigma_2 = \frac{\sigma_x}{2} \pm \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau^2}$$

$$\Rightarrow \quad \sigma_1/\sigma_2 = \frac{32M}{2\pi D^3} \pm \sqrt{\left(\frac{32M}{2\pi D^3}\right)^2 + \left(\frac{16T}{\pi D^3}\right)^2}$$

$$= \frac{16}{\pi D^3}\left[M \pm \sqrt{M^2 + T^2}\right]$$

$$\therefore \quad \sigma_1 + \sigma_2 = \frac{32M}{\pi D^3}$$

66. (b)

$$\because \quad \frac{\tau}{R} = \frac{G\theta}{L}$$

$$\Rightarrow \quad G = \frac{100}{\frac{90}{\pi}} \times \frac{1.5 \times 10^3}{\frac{0.5}{180} \times \pi}$$

$$= 6 \times 10^5 \text{ N/mm}^2$$

67. (d)

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

$$\Rightarrow \quad 80 + 30 = 100 + \sigma_2$$

$$\Rightarrow \quad \sigma_2 = 10 \text{ MPa}$$

68. (b)

$$\tau_{abs,\ max} = \frac{\sigma_1 - \sigma_2}{2} \text{ or } \frac{\sigma_1 - \sigma_3}{2} \text{ or } \frac{\sigma_2 - \sigma_3}{2} \text{ whichever is greater}$$

$$= \frac{50-30}{2} \text{ or } \frac{50-(-20)}{2} \text{ or } \frac{30-(-20)}{2}$$

$$= 10 \text{ or } 35 \text{ or } 25$$

$$= 35 \text{ MPa}$$

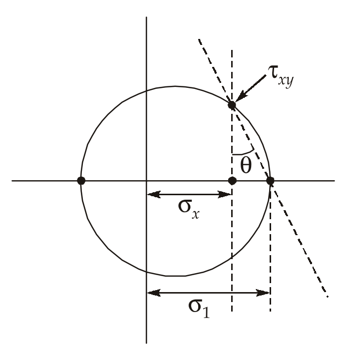
As per maximum shear stress theory

$$\tau_{abs,\ max} = \frac{\sigma_y / FOS}{2}$$

$$FOS = \frac{\sigma_y}{2\tau_{max}} = \frac{250}{2\times 35} = 3.57 \simeq 3.6$$

69. (d)

$$\text{Centre of Mohr's circle} = \left(\frac{\sigma_x + \sigma_y}{2}\right) = \frac{50+(-20)}{2} = 15 \text{ N/mm}^2$$



$$\text{Radius of Mohr's circle} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \sqrt{\left(\frac{50-(-20)^2}{2}\right)^2 + 30^2}$$

$$= \sqrt{35^2 + 30^2}$$

$$= 46.097 \text{ N/mm}^2$$

$$\sigma_1 = C + R = 15 + 46.097 = 61.097 \text{ N/mm}^2$$

From Mohr's circle,

$$\tan\theta = \frac{(\sigma_1 - \sigma_x)}{\tau_{xy}} = \frac{61.097 - 50}{30}$$

$$\therefore \quad \theta = 20.29°$$

Orientation of principal stress plane with respect to plane of σ_x.

70. (a)

$$\in_x + \in_y = \in_1 + \in_2 = \text{Constants}$$

$$\Rightarrow \quad 500 \times 10^{-6} + 150 \times 10^{-6} = 750 \times 10^{-6} + \in_2$$

$$\Rightarrow \quad \in_2 = -100 \times 10^{-6}$$

71. (a)

At section *X-X*

Shear force, $S_X = 50$ kN

At 150 mm from *NA*

$$q = \frac{S_X}{2I}\left(\frac{d^2}{4} - y^2\right)$$

$$= \frac{50000}{2 \times \left(\frac{1}{12} \times 200 \times 400^3\right)}\left(\frac{400^2}{4} - 150^2\right)$$

$$= \frac{0.234(17500)}{10^4} = 0.4095 \text{ N/mm}^2 \simeq 0.41 \text{ N/m}^2$$

72. (b)

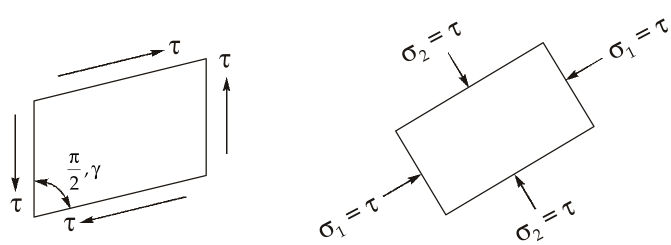
$$\sigma_n, \text{ at the plane of } \tau_{max} = \frac{\sigma_1 + \sigma_2}{2} = \frac{\sigma_x + \sigma_y}{2}$$

$$= \frac{80 + 10}{2} = 45 \text{ MPa}$$

73. (d)

Silver is ductile metal, plane of failure will be perpendicular to longitudinal axis as it is subjected to torsional test. Maximum shear strain is equal to the sum of the maximum and minimum principal strains.

75. (a)



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