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Important Questions for GATE 2022

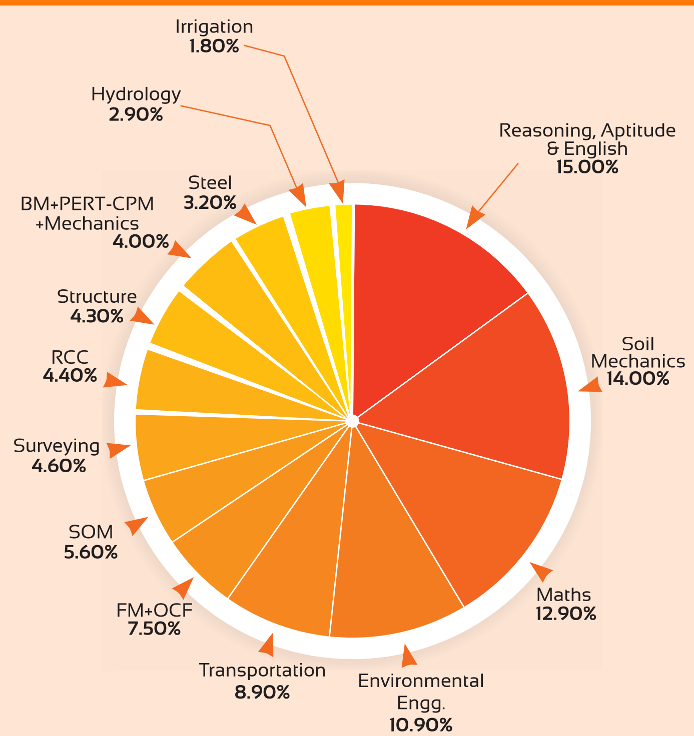
CIVIL ENGINEERING

Day 8 of 8

Q.176 - Q.200 (Out of 200 Questions)

Design of Steel Structures + Engineering Hydrology + Geomatics Engineering

SUBJECT-WISE WEIGHTAGE ANALYSIS OF GATE SYLLABUS



Subject	Average % (last 5 yrs)
Reasoning, Aptitude and English	15.00%
Soil Mechanics	14.00%
Engineering Mathematics	12.90%
Environmental Engineering	10.90%
Transportation Engineering	8.90%
Fluid Mechanics + OCF	7.50%
Strength of Materials	5.60%
Surveying Engineering	4.60%
Reinforced Cement Concrete	4.40%
Structural Analysis	4.30%
Building Materials+PERT-CPM+Mechanics	4.00%
Steel Structures	3.20%
Engineering Hydrology	2.90%
Irrigation Engineering	1.80%
Total	**100%**

Design of Steel Structures + Engg. Hydrology + Geomatics Engg.

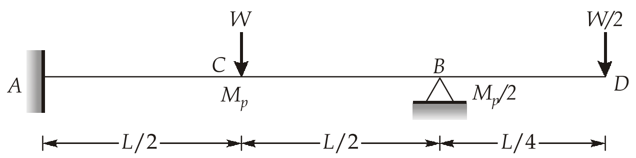
Q.176 The section properties of ISMB 550 is given below:
Overall depth (h) = 550 mm
Width of flange (b) = 190 mm
Thickness of flange (t_f) = 19.3 mm
Thickness of web (t_w) = 11.2 mm
If section is plastic then the design shear capacity of the section is [Use Fe 410 E(250) grade steel]
(a) 319 kN
(b) 560 kN
(c) 782 kN
(d) 808 kN

Q.177 A bolt is subjected to a shear force and tensile force of 30 kN and 25 kN respectively. The strength of bolt in shear is 45 kN. What should be the minimum design tensile strength of bolt?
(a) 15 kN
(b) 23 kN
(c) 34 kN
(d) 42 kN

Q.178 An ISA 40 × 25 × 6 mm is used as tension member with its longer leg connected by 14 mm diameter power driven rivet with a gusset plate. The strength of ISA 40 × 25 × 6 member is ________ kN.

Q.179 The design shear strength of 10 mm fillet weld is ______ kN/m. [Given welding is done in a shop by using Fe410 material]

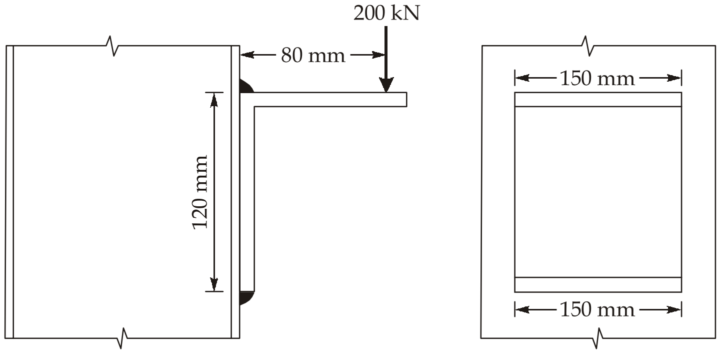
Q.180 A propped cantilever beam of different plastic moment capacity is shown below. All the loads are shown in figure. The collapse load for the beam is



(a) $\frac{2M_p}{L}$
(b) $\frac{4M_p}{L}$
(c) $\frac{6M_p}{L}$
(d) $\frac{8M_p}{L}$

Q.181 A rectangular section of width 'B' and depth 'H' is stressed up to f_y, to a depth of $\frac{H}{8}$ from top and bottom. Section is under action of moment 'M'. Magnitude of 'M' is
(a) $\frac{8f_yBH^2}{64}$
(b) $\frac{13f_yBH^2}{64}$
(c) $\frac{16f_yBH^2}{64}$
(d) None of these

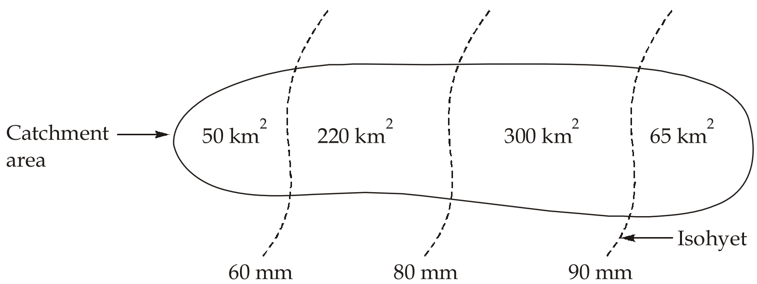
Q.182 A bracket carrying a load of 200 kN is connected to column by means of two horizontal fillet welds, each of 150 mm effective length and 10 mm thick. The load acts at 80 mm from the face of the column as shown in figure. The resultant stress in the weld is



(a) 95.24 N/mm^2
(b) 105.32 N/mm^2
(c) 145.62 N/mm^2
(d) 158.73 N/mm^2

Q.183 Potential evapo-transpiration is
(a) evaporation alongwith transpiration when there is sufficient moisture available to a fully vegetated area.
(b) the evapotranspiration of a forest area.
(c) actual evapotranspiration of a crop before application of irrigation water.
(d) amount of water needed to bring the moisture content of a soil to its field capacity.

Q.184 The equivalent uniform rainfall depth of the catchment (in mm, correct upto 2 decimal places) shown below is _______.



Q.185 There are four raingauge stations existing in the catchment of a river. The average annual rainfall values at these stations are 650, 700, 450, 500 mm respectively. If it is desired to limit the error in the mean value of rainfall in the catchment to 10% then the extra number of rain gauges required to be installed are
(a) 1
(b) 2
(c) 3
(d) 4

Q.186 The following are the ordinates of a flood hydrograph resulting from an isolated storm of 6 hour duration in a catchment of 450 km^2 area.

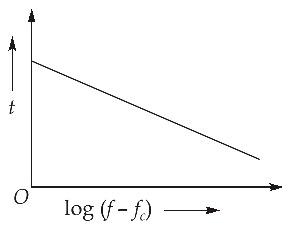
Time (hr)	0	12	24	36	48	60	72	84	96
Ordinates of flood hydrograph (m^3/s)	5	15	40	80	60	50	25	15	5

Assuming base flow of 5 m^3/s, the value of direct runoff depth (in cm, correct upto 1 decimal place) is ________.

Q.187 The rate of rainfall for successive 30 minutes period of a 4-hour storm are as follows: 3.5, 6.5, 8.5, 7.5, 6.4, 4, 4 and 6 cm/hr. If the value of ϕ-index is 4.5 cm/hr, then the value of W-index is ________ cm/hr.

Q.188 The rainfall in 3 successive 6 hours periods is 1.2, 4.0 and 3.0 cm. If the initial basin loss is 0.6 cm and the surface runoff resulting from this rain storm is 4 cm, then the ϕ-index for the storm is ________ cm/h.

Q.189 If the slope of infiltration capacity curve as shown in figure is –0.4605, the value of the constant k (i.e the rate of decay of the difference between initial and final infiltration rate) in the Horton's equation of infiltration capacity curve will be equal to ________ $time^{-1}$.



Q.190 A plan drawn to a scale of 1 : 4000 was measured by mistake by a scale of 1 : 5000. The percentage error in the measured area will be ________

Q.191 In a closed traverse XYZ, the following readings were taken:

Line	Fore bearing	Back bearing
XY	35°	216°
YZ	116°	293°
ZX	243°	65°

If station X is free from local attraction, the corrected bearing (in degree) of ZY is ________

Q.192 A bubble tube of a level has a sensitiveness of 24" per 2 division. The error in the reading on a staff held at a distance of 110 m from the level when the bubble is deflected by two divisions from the centre will be

(a) 19.96 mm
(b) 21.18 mm
(c) 23.67 mm
(d) 25.59 mm

Q.193 A steel tape 20 m long standardised at 55°F with a pull of 10 kg was used for measuring a base line. What is the correction per tape length if the temperature at the time of measurement was 80°F and the pull exerted was 16 kg?

Given the following data:
Weight of 1 cubic cm of steel = 7.86 g,
Weight of tape = 0.8 kg and E = 2.109×10^6 kg/cm^2
Coefficient of thermal expansion of tape per 1°F = 6.2×10^{-6}
(a) 0.000142 m
(b) 0.00406 m
(c) 0.00214 m
(d) 0.00635 m

Q.194 The magnetic declination at a place if the magnetic bearing of the Sun at noon is 350° 20′, will be
(a) 8° 20′ W
(b) 8° 40′ E
(c) 9° 40′ W
(d) 9° 40′ E

Q.195 A camera having focal length of 20 cm is used to take a vertical photograph of a terrain having an average elevation of 1500 m. The height above mean sea level at which an aircraft must fly in order to get the scale of 1 : 8000, is ____________ m.

Q.196 The following observations were taken during testing of a dumpy level:

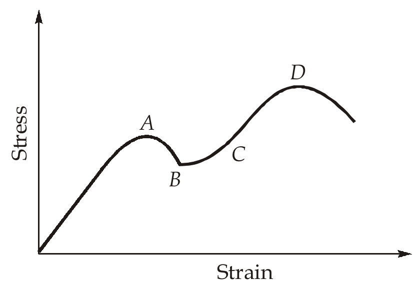
Instrument at	Staff reading on P	Staff reading on Q
P	1.475 m	2.205 m
Q	1.440 m	2.060 m

The collimation error in the instrument was ______ mm, if distance between P and Q is 2000 m.
(a) 214.11 mm (downward)
(b) 55 mm (upward)
(c) 214.11 mm (upward)
(d) 258 mm (downward)

Q.197 Aerial photographs are required to be taken to cover an area of 150 km^2. The longitudinal and side overlaps are to be 60% and 30% respectively. The scale of photograph is 1 cm = 100 m, and the size of each photograph is 20 cm × 20 cm. The minimum required number of photographs will be
(a) 170
(b) 158
(c) 146
(d) 134

Multiple Select Questions (MSQ)

Q.198 With reference to the stress strain diagram for mild steel subjected to tensile load, consider the following statements, identify the true one.



(a) The diagram represents average stress strain diagram.
(b) The diagram represents actual stress strain diagram.
(c) A represents upper yield point.
(d) B represents lower yield point.

Q.199 Consider the following statements.
In case of flood routing in a river channel by Muskingum method, the coefficient x represents:
(a) A dimensionless constant indicating the relative importance of inflow and outflow in determining storage.
(b) A storage constant having the dimension of time.
(c) In natural channels, x usually varies between 0.1 and 0.3.
(d) When the values of x equals 0.5, there exists the influence of both inflow and outflow on storage.

Q.200 Consider the following statements about the characteristics of contours:
(a) Closed contour lines with higher values inside show a lake.
(b) Contour is an imaginary line joining points of equal elevations.
(c) Closely spaced contours indicate steep slope.
(d) Contour lines can cross each other in case an overhanging cliff.

■■■■

Detailed Explanations

176. (d)

Given: Thickness of flange, $t_f = 19.3$ mm

Overall depth, $h = 550$ mm

Design shear strength, $$V_d = \frac{f_y \times t_w \times h}{\sqrt{3} \times \gamma_{mo}}$$

$$= \frac{250 \times 11.2 \times 550}{\sqrt{3} \times 1.1} \text{N}$$

$$= 808.29 \text{ kN} \simeq 808 \text{ kN}$$

177. (c)

As per IS 800 : 2007,

$\because$ For Bolt's subjected to both shear and tension

$$\therefore \quad \left(\frac{P_{T\,cal}}{P_T}\right)^2 + \left(\frac{P_{S,cal}}{P_S}\right)^2 \leq 1$$

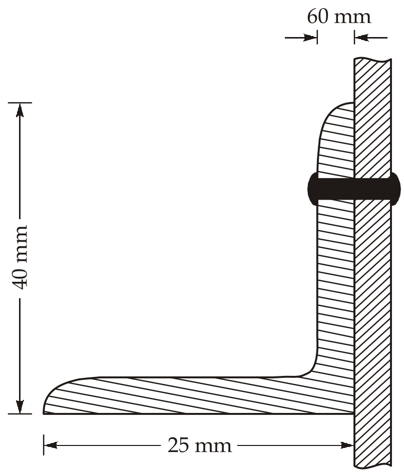
$$\Rightarrow \quad \left(\frac{30}{45}\right)^2 + \left(\frac{25}{P_T}\right)^2 \leq 1$$

$$\Rightarrow \quad \frac{25}{P} \leq 0.745$$

$$\Rightarrow \quad 33.56 \leq P$$

$$\therefore \quad P_{min} = 33.56 \text{ kN} \simeq 34 \text{ kN}$$

178. 34.12 (34 - 35)



Dia of hole, $d' = 14 + 1.5 = 15.5$ mm

Net sectional area of connected leg

$$A_1 = \left(l_1 - \frac{t}{2} - d'\right)t = \left(40 - \frac{6}{2} - 15.5\right)6 = 129 \text{ mm}^2$$

Area of outstanding leg

$$A_2 = \left(l_2 - \frac{t}{2}\right)t = \left(25 - \frac{6}{2}\right)6 = 132 \text{ mm}^2$$

$$k = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 129}{3 \times 129 + 132} = 0.746$$

∴ Net effective area, $A_{net} = A_1 + kA_2$

$= 129 + 0.746 \times 132 = 227.47 \text{ mm}^2$

∴ Strength of the member $= \frac{150 \times 227.47}{1000} = 34.12$ kN

179. 1325.6 (1324 to 1327)

Given: Size of weld = 10 mm

$f_u = 410 \text{ N/mm}^2$

$\gamma_{mw} = 1.25$

Strength of weld $= \frac{f_u \times (0.7 \times 10) \times 1000}{\sqrt{3} \times 1.25}$ (throat thickness = 0.7 × size of weld)

$= \frac{410 \times (0.7 \times 10) \times 1000}{\sqrt{3} \times 1.25}$

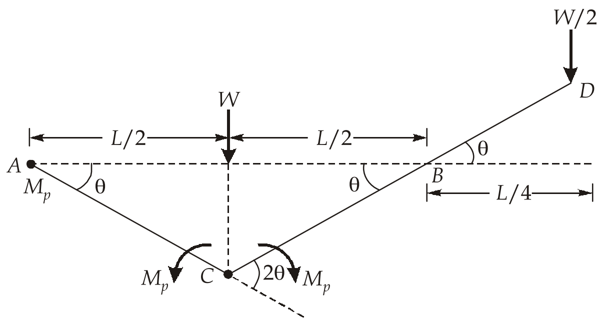
$= 1.325 \times 10^6$ N/m

$= 1325.59 \text{ kN/m} \simeq 1325.6 \text{ kN/m}$

180. (b)

In continuous spans, individual mechanism will prevail.

Collapse mechanism in span *AB*



External work $= \frac{WL\theta}{2} - \left(\frac{W}{2}\right) \times \frac{L}{4} \times \theta = \frac{3WL\theta}{8}$

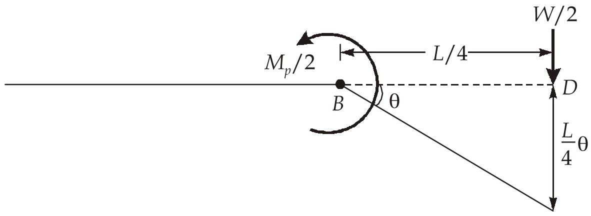
Internal work $= M_p\theta + 2M_p\theta = 3M_p\theta$

External work = Internal work

$\Rightarrow \frac{3WL\theta}{8} = 3M_p\theta$

$\Rightarrow W = \frac{8M_p}{L}$

Collapse mechanism in span BD



$$\Rightarrow \quad \text{External work} = \frac{W}{2}\times\frac{L}{4}\theta = \frac{WL\theta}{8}$$

$$\text{Internal work} = \frac{M_p\theta}{2}$$

$$\Rightarrow \quad \text{External work} = \text{Internal work}$$

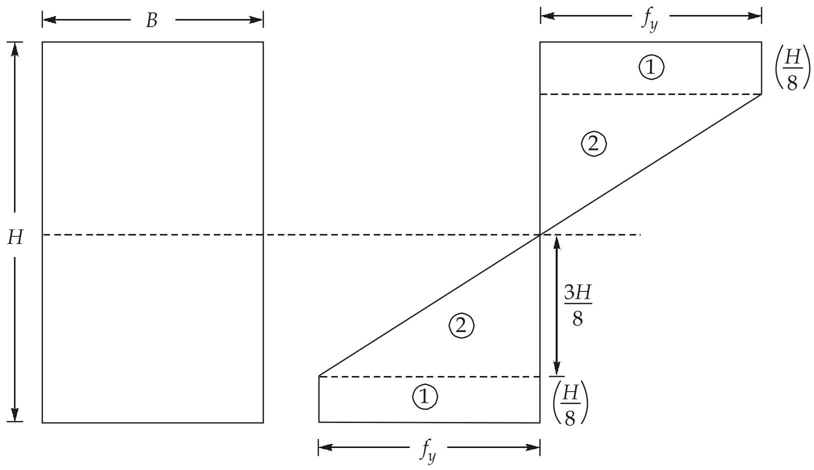
$$\frac{M_p\theta}{2} = \frac{WL\theta}{8}$$

$$W_u = \frac{4M_p}{L}$$

Minimum load is $\left(\frac{4M_p}{L}\right)$

So collapse load is $\frac{4M_p}{L}$.

181. (b)



We can split total moment of resistance is two parts viz.

$$M_1 = \text{MOR due to plastic section}$$

$$M_2 = \text{MOR due to elastic section}$$

$$M_1 = (\text{Stress} \times \text{Area}) \times \text{Lever arm}$$

$$= \left(f_y \times B \times \frac{H}{8}\right)\times\left(H - \frac{H}{16} - \frac{H}{16}\right)$$

$$= \left(f_y \times \frac{BH}{8}\right)\times\left(\frac{7H}{8}\right)$$

$$= \frac{7 f_y BH^2}{64}$$

$$M_2 = \text{(Stress × Area) × Lever arm}$$

$$= \frac{1}{2} \times f_y \times \left(\frac{H}{2} - \frac{H}{8}\right) \times B \times \left(\frac{2}{3} \times \left(\frac{3}{8}H\right)\right) \times 2$$

$$= \frac{1}{2} \times f_y \times B\left(\frac{3H}{8}\right) \times \frac{H}{2}$$

$$= \frac{3 f_y BH^2}{32} = \frac{6 f_y BH^2}{64}$$

$$\therefore \quad M = M_1 + M_2 = \left(\frac{6+7}{64}\right) f_y BH^2 = \frac{13}{64} f_y BH^2$$

182. (d)

Given:

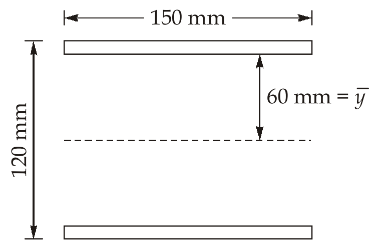
Load, P = 200 kN

Effective total length of weld = 150 mm × 2 = 300 mm

Throat thickness = 10 × 0.7 = 7 mm

$\therefore$ Direct stress, $f_1 = \frac{\text{load}}{\text{area}} = \frac{200 \times 1000}{7 \times 300} = 95.240 \text{ N/mm}^2$

$$M = 200 \times \frac{80}{1000} = 16 \text{ kNm} = 16 \times 10^6 \text{ Nmm}$$



$$I = \frac{bd^3}{12} + A\bar{y}^2$$

Since d = Throat thickness is negligible

So, $I = A\bar{y}^2 = 2 \times 150 \times 7 \times 60^2$

$= 7.56 \times 10^6 \text{ mm}^4$

$\because$ Bending stress $= \frac{M}{I} = \frac{f_2}{y}$

$$f_2 = \frac{16 \times 10^6 \times 60}{7.56 \times 10^6} = 126.98 \text{ N/mm}^2$$

Resultant stress $= \sqrt{f_1^2 + f_2^2} = \sqrt{126.98^2 + 95.24^2}$

$= 158.73 \text{ N/mm}^2$

183. (a)

184. 78.35 (77.5 to 79.5)

$$\text{Equivalent uniform rainfall depth} = \frac{50\times60+220\left(\frac{60+80}{2}\right)+300\left(\frac{80+90}{2}\right)+65\times90}{50+220+300+65}$$

$$= 78.35 \text{ mm}$$

185. (a)

Mean rainfall, $\bar{x} = \frac{\Sigma x}{n} = \frac{650+700+450+500}{4}$

$= 575$ mm

Standard deviation, $\sigma = \sqrt{\frac{(x-\bar{x})^2}{n-1}} = 119.02$ mm

Coefficient of variation, $C_v = \frac{\sigma}{\bar{x}}\times100 = \frac{119.02}{575}\times100 = 20.70$

Optimum number of raingauges,

$$N = \left(\frac{C_v}{\in}\right)^2 = \left(\frac{20.70}{10}\right)^2 \cong 4.28 \simeq 5 \text{ (say)}$$

Additional rain gauges required to be installed,

$= 5 - 4 = 1$

186. 2.4 (2.3 to 2.5)

Time (hr)	FH (m^3/s)	Base flow (m^3/s)	DRH (m^3/s)
0	5	5	0
12	15	5	10
24	40	5	35
36	80	5	75
48	60	5	55
60	50	5	45
72	25	5	20
84	15	5	10
96	5	5	0
			$\Sigma O = 250\ m^3/s$

Direct runoff depth, DRD $= \frac{0.36\times\Sigma O\times t}{A}$ [where A is in km^2, t is in hr, $\Sigma 0$ is in m^3/s]

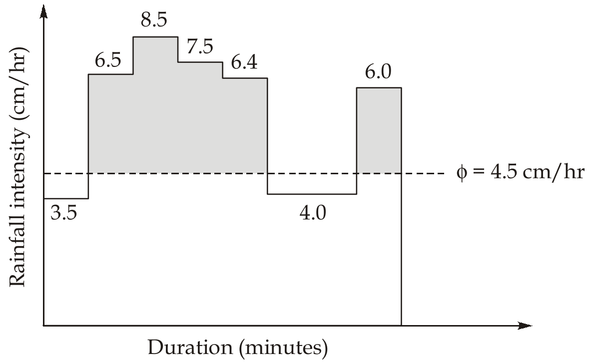
$= \frac{0.36\times250\times12}{450} = 2.4$ cm

187. 4.25 (4.2 to 4.3)

Total rainfall, $P = (3.5+6.5+8.5+7.5+6.4+4+4+6)\times\frac{30}{60}$

$= 23.2$ cm

For total rainfall excess,



Runoff, $R = [(6.5-4.5)+(8.5-4.5)+(7.5-4.5)+(6.4-4.5)+(6-4.5)]\times\frac{30}{60}$

$= (2+4+3+1.9+1.5)\times\frac{1}{2} = 6.2$ cm

∴ $W\text{-index} = \frac{P-R}{t}$

$= \frac{23.2-6.2}{4} = 4.25$ cm/hour

188. (0.25)

Total loss $= P - Q = 8.2 - 4 = 4.2$ cm in $18h$

∴ $\phi_{index} = \frac{4.2}{18}$ cm/h $= 0.233$ cm/h

The minimum potential infiltration per $6h = 6 \times 0.233 = 1.4$ cm. This shows that 1^{st} $6h$ period cannot contribute to runoff, and the 2^{nd} and 3^{rd} 6h periods will give rise to direct runoff.

$\phi_{index} = \frac{4-3-4}{12} = \frac{3}{12} = 0.25$ cm/hr

Minimum potential infiltration per 6 h

$= 0.25 \times 6 = 1.5$ cm

∴ $\phi_{index} = 0.25$ cm/hr

189. (5.0)

Horton's equation of I.C. curve,

$$f = f_c + (f_0 - f_c)e^{-kt}$$

$$\Rightarrow \quad (f - f_c) = (f_0 - f_c)e^{-kt}$$

$$\Rightarrow \quad \log(f - f_c) = \log(f_0 - f_c) - kt\log e$$

$$\Rightarrow \log(f - f_c) - \log(f_0 - f_c) = -kt \log e$$

$$\Rightarrow \quad t = \frac{-1}{k \log e}\left[\log(f - f_c) - \log(f_0 - f_c)\right]$$

$$= \frac{-1}{k \log e}\log(f - f_c) + \frac{1}{k \log e}\log(f_0 - f_c)$$

$$\text{Slope} = \frac{-1}{k \log e} = -0.4605$$

$$k = 5.0$$

190. 56.25 (55.50 to 57.40)

Let the length of line measured on plan be L.

Actual area, $A = (4000\ L)^2$

Measured area, $A_m = (5000\ L)^2$

$$\text{Percentage error in area} = \frac{(5000L)^2 - (4000L)^2}{(4000L)^2} \times 100 = 56.25\%$$

191. 295 (295 to 295)

In a closed traverse with no local attraction,

$$FB - BB = 180°$$

Since station 'X' is free from local attraction and therefore FB_{XY} and BB_{ZY} are correct.

$\therefore \quad FB_{XY} = 35°$ and $BB_{XY} = 216°$

But $\quad BB_{XY} - FB_{XY} = 216 - 35° = 181° \neq 180°$

$\therefore$ A correction of –1° is to be applied at station Y,

$\therefore \quad FB_{YZ} = 116° - 1° = 115°$

But $\quad BB_{YZ} - FB_{YZ} = 293° - 115° = 178° \neq 180°$

$\therefore$ A correction of +2° is to be applied at Z

$\therefore$ The correct FB of $ZY = 293° + 2° = 295°$

192. (d)

Sensitivity of bubble tube is given by,

$$\alpha' = \frac{S}{nD} \times \left(\frac{360°}{2\pi} \times 60 \times 60\right)$$

= 24 seconds (given)

S = ? (staff intercept)

n = 2 division, and

D = Distance of the staff from level = 110 m

$$\therefore \quad 24 = \frac{S}{2 \times 110}\left(\frac{360}{2\pi} \times 60 \times 60\right) = \frac{S}{2 \times 110} \times 206265$$

$$\Rightarrow \quad S = \frac{24 \times 2 \times 110}{206265} = 25.599 \times 10^{-3}\,\text{m}$$

$$\simeq 25.59\ \text{mm}$$

193. (c)

Correction for temperature = 20 × 6.2 × 10^{-6} (80 – 55) = 0.0031 m (additive)

$$\text{Correction for pull} = \frac{(P_m - P_0)L}{AE}$$

Now, weight of tape = A(20 × 100) (7.86 × 10^{-3}) kg = 0.8 kg

⇒ A = 0.051 cm^2

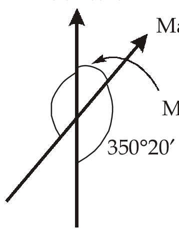
$$\text{Hence,} \quad C_p = \frac{(16-10)\times 20}{0.051\times 2.109\times 10^6} = 1.1156\times 10^{-3} \text{ m (additive)}$$

$$\text{Correction for sag} = \frac{l_1(wl_1)^2}{24P_m^2} = \frac{20(0.8)^2}{24(16)^2} = 0.00208 \text{ m (subtractive)}$$

∴ Total correction = +0.0031 + 0.00112 – 0.00208

= +0.00214 m

194. (d)



Since the magnetic bearing of the Sun is 350° 20′, it is at the North of the place and hence the true bearing of the Sun, which is on the meridian, will be 360°.

Now, True bearing = Magnetic bearing +Declination

360° = 350° 20′ + Declination

or Declination = 360° – 350° 20′

= 9° 40′ E

195. 3100 (3080 to 3120)

Scale of vertical photograph,

$$\text{Scale} = \frac{f}{H-h}$$

$$\Rightarrow \quad \frac{1}{8000} = \frac{(20/100)}{(H-1500)}$$

$$H - 1500 = \frac{20\times 8000}{100}$$

⇒ H = 1600 + 1500 = 3100 m

196. (a)

Using reciprocal levelling,

$$h = \frac{(Q_1 - P_1)+(Q_1 - P_2)}{2}$$

$$= \frac{(2.205 - 1.475) + (2.060 - 1.440)}{2}$$
$$= 0.675 \text{ m}$$

If instrument is kept at P reading at Q will be erroneous

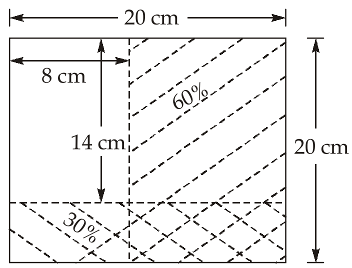
$$h = (2.205 - e) - 1.475$$
$$0.675 \text{ m} = (2.205 - e) - 1.475$$
$$e = 0.055\text{m}$$

Assume collimation error is in upward

$$e = e_{col} + e_{com}$$
$$0.055 = e_{col} + \frac{6}{7} \times \frac{(2000)^2}{2 \times 6370 \times 1000}$$

$\therefore$ $e_{col} = -0.2141$ m i.e., 214.11 mm downward

197. (d)



Area of ground = 150 km^2

Overlap: Longitudinal = 60%; Lateral = 30%

Scale : 1 cm = 100 m = 0.1 km

Photo size = 20 cm × 20 cm

Now l = length covered by 1 photo
= 8 × 0.1 = 0.8 km

b = width covered by 1 photo
= 14 × 0.1 = 1.4 km

a = Area covered by 1 photo
= $l \times b$ = 0.8 × 1.4 = 1.12 km^2

Min. no. of photographs

$$= \left(\frac{A}{a}\right) = \left(\frac{150}{1.12}\right) = 133.92$$
$$\approx 134 \text{ photos}$$

198. (a, c, d)

$$\text{Engineering stress or Average stress} = \frac{P}{A_0}$$
$$\text{True stress} = \frac{P}{A_f}$$
$$\text{Engineering strain or Average strain} = \frac{l_f - l_0}{l_0}$$
$$\text{True strain} = ln\left(\frac{l_f}{l_0}\right)$$

The given curve represents average stress-strain diagram.

$A_0 \rightarrow$ Initial cross-sectional area of specimen

$A_f \rightarrow$ Final

$l_0 \rightarrow$ Initial length of specimen

$l_f \rightarrow$ Final length of specimen

199. (a, c, d)

Muskingum equation relates the storage in a reservoir to the outflow (Q) and inflow (I)

$$S = K[x \cdot I + (1 - x) \cdot Q]$$

In this the parameter x is known as weighting factor and takes a value between 0 and 0.5. The coefficient K is known as storage-time constant and has the dimensions of time. Normally, for natural channels, the value of x lies between 0 to 0.3. For a given reach, the values of x and K are assumed to be constant. When $x = 0$, $S = KQ$, valid for linear reservoir. When $x = 0.5$, $S = K[0.5I + 0.5\,Q]$. There exists the influence of both inflow and outflow on storage.

200. (b, c, d)

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

■■■■