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GATE 2017

Production and Industrial Engineering

Questions with Detailed Solutions

FORENOON SESSION

All Queries related to GATE - 2017 key are to be send to the following email address
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Production & Industrial Engineering

01. In Value Engineering approach, the value of the product is
(A) inversely proportional to its functions and directly proportional to its cost
(B) directly proportional to its functions and inversely proportional to its cost
(C) inversely proportional to its functions as well as its cost
(D) directly proportional to its functions as well as its cost

01. Ans: (B)

Sol: $\text{VALUE}=\frac{\text{WORTH}}{\text{COST}}$

02. If E is the modulus of elasticity in GPa, G is the shear modulus in GPa and v is the Poisson's ratio of a linear elastic and isotropic material, the three terms are related as
(A) E = G (1 – 2v) (B) E = 2G (1 – v)
(C) E = G (1 + 2v) (D) E = 2G (1 + v)

02. Ans: (D)

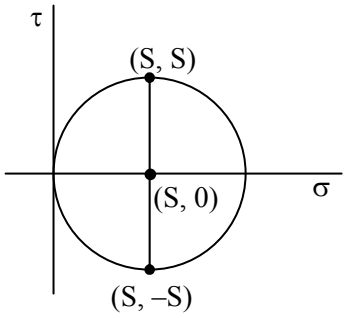
03. In powder metallurgy, the process 'atomization' refers to a method of
(A) producing powders (B) compaction of powders
(C) sintering of powder compacts (D) blending of metal powders

03. Ans: (A)

04. For a two dimensional state-of-stress defined as $\sigma_{xx} = \sigma_{yy} = \tau_{xy} = S$, the Mohr's circle of stress has
(A) center at (S, 0) and radius S
(B) center at (0,0) and radius S
(C) center at (S, 0) and radius 0
(D) center at (S/2,0) and radius 2S

04. Ans: (A)

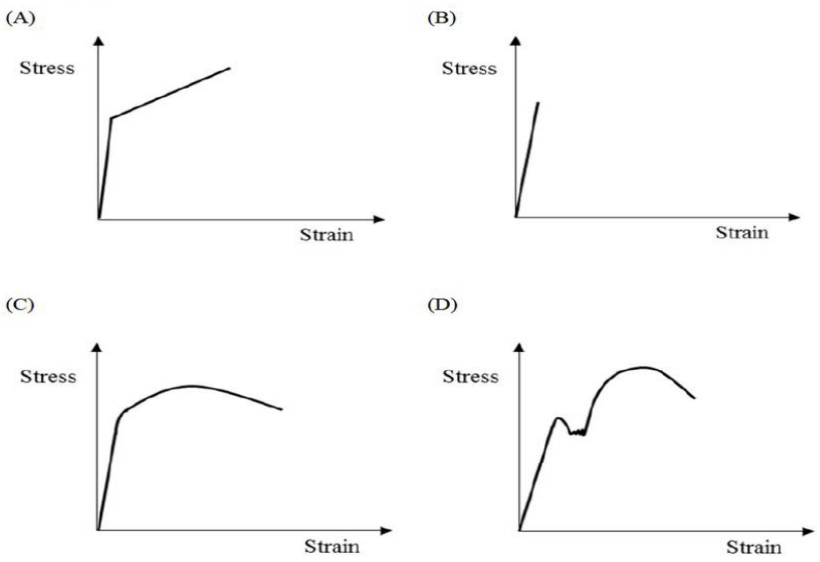
Sol:



Center → (S, 0)

Radius → S

05. The ideal stress-strain behavior for a completely brittle material during tensile testing up to failure is described by



05. Ans: (B)

06. In gas tungsten arc welding process, the material coated on pure tungsten electrode to enhance its current carrying capacity is

(A) Titanium (B) Manganese (C) Radium (D) Thorium

06. Ans: (D)

Sol: Pure tungsten electrodes are frequently coated oxides of Th, Zr, La, and Ce. These oxides are expected to perform two important functions a) increasing arc stability and b) increasing the current carrying capacity of the electrodes.

07. Using Simpson's 1/3 rule for numerical integration, the consecutive points are joined by a

(A) line (B) Parabola

(C) polynomial with power 3 (D) polynomial with power 1/3

07. Ans: (B)

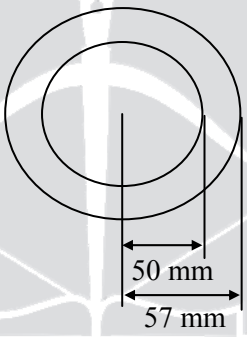
Sol: In simpson's $\frac{1}{3}$ rule, the curve is replaced by a second degree polynomial (parabola)

08. A metallic cylindrical casing of an exhaust pipe has inner radius 50 mm and wall thickness 7 mm. If the thermal conductivity of the material of the casing is 50 W/m-K, then the thermal resistance of the casing in K/kW is _____ (up to *three* decimal places).

08. Ans: 0.417

Sol: K = 50 W/m-K

Assume length of pipe = 1 m



$$\text{Thermal resistance} = \frac{\ell n\left(\frac{r_2}{r_1}\right)}{2\pi KL}$$

$$= \frac{\ell n\left(\frac{57}{50}\right)}{2\pi \times 50 \times 1}$$

$$= 4.17075 \times 10^{-4}\ \text{K/W} = 4.17075 \times 10^{-4} \times \frac{10^3\,\text{K}}{10^3\,\text{W}}$$

$$R_{Th} = 0.417\ \text{K/kW}$$

09. A steel wire of 2 mm diameter is to be drawn from a wire of 5 mm diameter. The value of true strain developed is _____ (up to *three* decimal places)

09. Ans: 1.832

Sol: True strain = $ln(A_0/A_1)$

$= 2\ ln\ (d_0/d_1) = 2\ ln(5/2) = 1.83258$

10. A specimen of steel has yield strength of 700 MPa. The specimen is subjected to a state of plane-stress with $\sigma_1 = \sigma_2 = 500$ MPa. The factor of safety according to the von-Mises theory of failure is _____

10. Ans: 1.4

Sol: According to von-Mises theory

For 2 – D

$$\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 \le \left(\frac{S_{yt}}{FS}\right)^2$$

$$\sigma_1 = \sigma_2 = \sigma = 500\,\text{MPa}$$

$$\sigma^2 + \sigma^2 - \sigma^2 \le \left(\frac{S_{yt}}{FS}\right)^2$$

$$\sigma^2 \le \left(\frac{S_{yt}}{FS}\right)^2$$

$$\sigma \le \frac{S_{yt}}{FS}$$

$$500 \le \frac{700}{FS}$$

$$FS \le \frac{700}{500}$$

For limiting case factor of safety = 1.4

11. Accuracy of a measuring instrument is expressed as

(A) true value – measured value

(B) measured value – true value

(C) $1 - \left|\frac{\text{true value} - \text{measured value}}{\text{true value}}\right|$

(D) $1 + \left|\frac{\text{true value} - \text{measured value}}{\text{true value}}\right|$

11. Ans: (A)

Sol: Accuracy is the difference between standard value and measured value.

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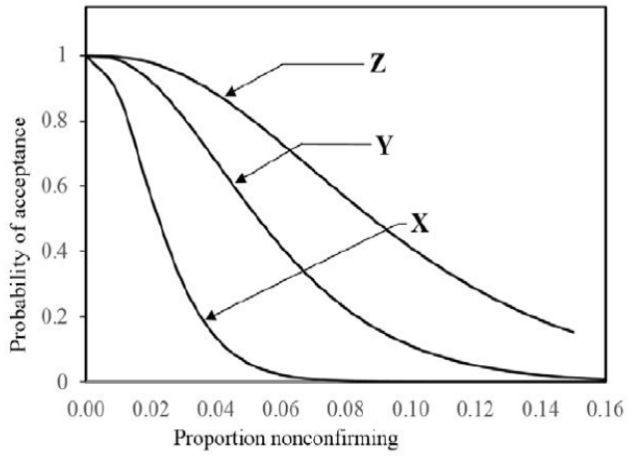
12. In chemical machining, the etch factor is expressed as

(A) $\frac{\text{undercut}}{\text{depth of cut}}$ (B) $\frac{\text{depth of cut}}{\text{undercut}}$ (C) $\frac{\text{workpiece wear}}{\text{tool wear}}$ (D) $\frac{\text{tool wear}}{\text{workpiece wear}}$

12. Ans: (A)

Sol: Etch Factor is the ratio of the undercut to the depth of cut. The undercut depends upon the depth of cut, the strength of the etchant solution and work piece material.

13. The operating characteristic curves of three single sampling plans X, Y and Z with same lot size and acceptance number are shown in the figure.



Considering the above operating characteristic curves, the correct relationship of the plans with respect to sample size is

(A) Sample size of X < sample size of Y < sample size of Z

(B) Sample size of X = sample size of Y = sample size of Z

(C) Sample size of X > sample size of Y > sample size of Z

(D) Sample size of X > sample size of Y < sample size of Z

13. Ans: (D)

14. The product of a complex number z = x + iy and its complex conjugate $\overline{Z}$ is

(A) x^2 (B) y^2 (C) $x^2 - y^2$ (D) $x^2 + y^2$

14. Ans: (D)

Sol: $\overline{Z} = (x + iy)(x - iy) = x^2 + y^2$

15. With reference to Iron-Carbon equilibrium phase diagram, the crystal structure of 0.3% plain carbon steel at 1,100°C is

(A) HCP (B) BCT (C) BCC (D) FCC

15. Ans: (D)

16. Match the ASME process chart symbols with their correct description

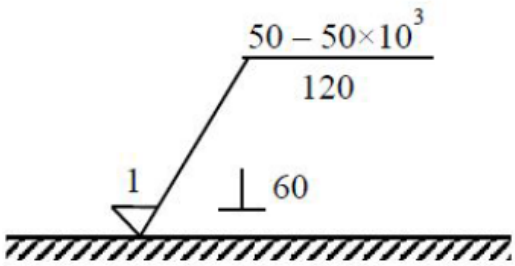
Symbols		Description
P.	◯	1. STORAGE
Q.	⇒	2. TRANSPORTATION
R.	□	3. OPERATION
S.	∇	4. DELAY
T.	D	5. INSPECTION

(A) P-3, Q-4, R-1, S-5, T-2 (B) P-4, Q-2, R-5, S-1, T-3

(C) P-3, Q-2, R-5, S-1, T-4 (D) P-1, Q-5, R-3, S-2, T-4

16. Ans: (C)

17. A machined surface with standard symbols indicating the surface texture is shown in the Figure. (All dimensions in the Figure are in micrometer).



The waviness height (in micrometer) of the surface is

(A) 1 (B) 50 (C) 60 (D) 120

17. Ans: (A)

Sol: It is the surface roughness value in microns.

18. A Shewhart $\overline{X}$-chart was developed for an in-control process. Considering the probability of a point falling outside the 3σ control limits as 0.0026, the value of average run length for this chart is _____.

18. Ans: 384.6

Sol: Average run length, $ARL = \frac{1}{p} = \frac{1}{0.0026} = 384.6$

$$= \frac{1}{P(\text{ONE POINT OUTSIDE CONTROL LIMIT})}$$

19. Divergence of the curl of a twice differentiable continuous vector function is
    (A) unity (B) infinity
    (C) zero (D) a unit vector

19. Ans: (C)

Sol: Let $\vec{F}$ be continuously differentiable vector point function

Div (curl $\vec{F}$) = 0 (vector identity)

20. In carbon dioxide molding process, the binder used is
    (A) Sodium bentonite
    (B) Calcium bentonite
    (C) Sodium silicate
    (D) Phenol formaldehyde

20. Ans: (C)

Sol: When carbon dioxide is supplied to the dry sand it is chemically reacting with sodium silicate and produces silica gel called as paste like material and on drying it gives high strength to the mold.

21. For two non-zero vectors $\overline{A}$ and $\overline{B}$, if $\overline{A}+\overline{B}$ is perpendicular to $\overline{A}-\overline{B}$, then

(A) the magnitude of $\overline{A}$ is twice the magnitude of $\overline{B}$

(B) the magnitude of $\overline{A}$ is half the magnitude of $\overline{B}$

(C) $\overline{A}$ and $\overline{B}$ cannot be orthogonal

(D) the magnitudes of $\overline{A}$ and $\overline{B}$ are equal

21. Ans: (D)

Sol: Let $\vec{A}$ & $\vec{B}$ be two non-zero vectors

$(\vec{A}+\vec{B}).(\vec{A}-\vec{B})=0$ $(\because (\vec{A}+\vec{B})$ & $(\vec{A}-\vec{B})$ are perpendicular to each other).

$\Rightarrow (\vec{A})^2-(\vec{A}.\vec{B}).(\vec{B}.\vec{A})-(\vec{B})^2=0$

$\Rightarrow (\vec{A})^2-(\vec{B})^2=0$ $(\because \vec{A}.\vec{B}=\vec{B}.\vec{A})$

$\Rightarrow |\vec{A}|^2-|\vec{B}|^2=0$

$\Rightarrow |A|^2=|\vec{B}|^2$

$\therefore |\vec{A}|=|\vec{B}|$

$\therefore$ The magnitudes of $\vec{A}$ & $\vec{B}$ are equal

22. For an orthogonal matrix Q, the valid equality is
(A) $Q^T = Q^{-1}$ (B) $Q = Q^{-1}$ (C) $Q^T = Q$ (D) det (Q) = 0

22. Ans: (A)

Sol: A matrix Q is said to be orthogonal if

$$QQ^T = Q^T Q = I \text{ (or) } Q^T = Q^{-1}$$

23. In Glass Fiber Reinforced Plastic (GFRP) composites with long fibers, the role of matrix is to
(P) Support and transfer the stresses to the fibers
(Q) Reduce propagation of cracks
(R) Carry the entire load
(S) Protect the fibers against damage
The correct statements are
(A) P, Q and R (B) Q, R and S (C) P, Q and S (D) P, R and S

23. Ans: (C)

24. Turning, drilling, boring and milling are commonly used machining operations. Among these, the operation (s) performed by a single point cutting tool is (are)
(A) turning only (B) drilling and milling only
(C) turning and boring only (D) boring only

24. Ans: (C)

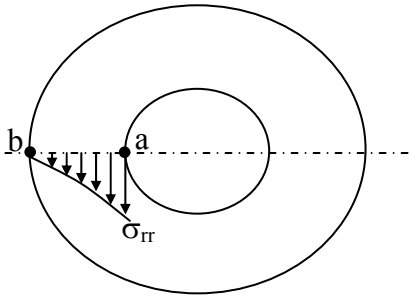
Sol: Turning and boring are the single point cutting tool operations because boring is nothing but internal turning operation.

25. The inside and outside radii of a thick-walled cylindrical pressure vessel are denoted by *a* and *b*, respectively. If the vessel is subjected to an internal pressure P, then the magnitude of the radial stress σ_{rr} is
(A) zero at r = a and maximum at r = b (B) maximum at r = a and zero at r = b
(C) constant over the entire thickness (D) zero at both r = a and r = b

25. Ans: (B)

Sol:

σ_{rr} { maximum at a; zero at b



26. An electron beam welding process uses 15 mA beam current at an accelerating voltage of 150 kV. The energy released per second by the beam (in J) is _____ (up to one decimal place).
(1 Ampere = 6.28×10^{18} electrons per second, 1 eV = 1.6×10^{-19} J)

26. Ans: 2250

Sol: $P = 15 \times 10^{-3} \times 150 \times 10^{3} = 2250$ J

27. The preparatory and miscellaneous codes used in CNC part programming and the functions are given in the Table

Group I	Group II
P. G01	1. Circular interpolation, counter-clock wise
Q. G03	2. End of program
R. M06	3. Tool change
S. M02	4. Linear interpolation

The correct combination of code and the respective function is

(A) P-4, Q-1, R-3, S-2 (B) P-4, Q-1, R-2, S-3

(C) P-1, Q-4, R-3, S-2 (D) P-2, Q-1, R-3, S-4

27. Ans: (A)

Sol: G01 – linear interpolation, G03 – circular interpolation CCW, M06 – tool change and M02 – end of main program written without use of sub program.

28. In a machining operation with turning tool, the tool life (T) is related to cutting speed v (m/s), feed f (mm) and depth of cut d (mm) as

$$T = C\, v^{-2.5} f^{-0.9} d^{-0.15}$$

where, C is a constant. The suggested values for the cutting parameters are: v = 1.5 m/s, f = 0.25 mm and d = 3 mm for normal rough turning. If the operation is performed at twice the cutting speed and the other parameters remain unchanged, the corresponding percentage change in tool life is _____.

28. Ans: 82.4 %

Sol: Because there is no change in the feed and depth of cut, the tool life equation can be written as

$$T = C.\, V^{-2.5} \Rightarrow T = (C/V^{2.5}) \Rightarrow V^{2.5} T = C$$

Hence $V_1^{2.5} T_1 = V_2^{2.5} T_2$, also given that $V_2 = 2V_1$

$$T_2 = T_1(V_1/V_2)^{2.5} = 0.176\, T_1$$

% change in tool life = $(T_1 - T_2) / T_1 = 0.824 = 82.4\%$

29. The local minima of the function $f(x) = x^2 - x^4$ in the range $-0.8 \le x \le 0.8$ is located at

(A) $x = 0$ (B) $x = \frac{1}{\sqrt{2}}$ (C) $x = -\frac{1}{\sqrt{2}}$ (D) $x = \frac{1}{2}$

29. Ans: (A)

Sol: Given $f(x) = x^2 - x^4$

$f'(x) = 2x - 4x^3$, $f''(x) = 2 - 12x^2$

$f'(x) = 0$

$\Rightarrow 2x - 4x^3 = 0$

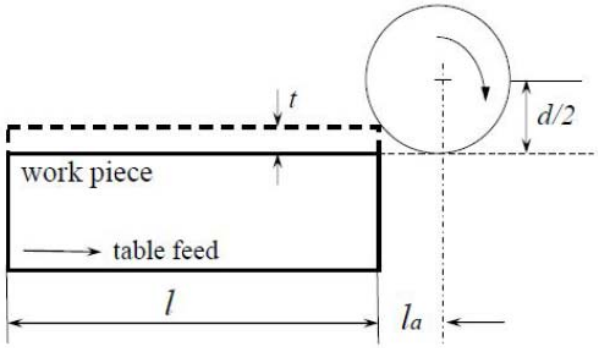
$\Rightarrow 2x(1 - 2x^2) = 0$

$\Rightarrow x = 0, \frac{1}{\sqrt{2}}, \frac{-1}{\sqrt{2}}$ are critical points

$f''(0) > 0$

$\therefore$ f(x) has local minimum at x = 0

30. A schematic diagram of peripheral milling is shown in the Figure.



If t is the depth of cut and d is the diameter of the milling cutter, then the length of approach (l_a) is expressed as

(A) $\sqrt{d(t-d)}$ (B) $\sqrt{d(d-t)}$ (C) $\sqrt{t(d-t)}$ (D) $\sqrt{t(t-d)}$

30. Ans: (C)

Sol: l_a = compulsory approach = distance to be travelled by milling cutter for complete depth of material to be removed

31. A solid circular shaft is subjected to a bending moment M and torque T simultaneously. Neglecting the effects of stress concentration, the equivalent bending moment is expressed as

(A) $\frac{1}{2}\left(M+\sqrt{M^2+T^2}\right)$ (B) $\left(\frac{M}{2}+\sqrt{M^2+T^2}\right)$

(C) $\frac{1}{2}\left(M+\sqrt{M^2+4T^2}\right)$ (D) $\left(\frac{M}{2}+\sqrt{M^2+4T^2}\right)$

31. Ans: (A)

32. In a machine shop, four jobs need to be assigned to four different machines. Each of the jobs is to be assigned to one machine only at a time. The time taken to complete the job in different machines is given in the Table.

Jobs \ Machines	M_1	M_2	M_3	M_4
J_1	15	13	14	17
J_2	11	12	15	13
J_3	13	12	10	11
J_4	15	17	14	16

In order to ensure that the total time required to complete all the jobs in minimum, the optional assignment of the job is

(A) $J_1 \Rightarrow M_4$, $J_2 \Rightarrow M_2$, $J_3 \Rightarrow M_3$, $J_4 \Rightarrow M_1$

(B) $J_1 \Rightarrow M_2$, $J_2 \Rightarrow M_1$, $J_3 \Rightarrow M_4$, $J_4 \Rightarrow M_3$

(C) $J_1 \Rightarrow M_2$, $J_2 \Rightarrow M_1$, $J_3 \Rightarrow M_3$, $J_4 \Rightarrow M_4$

(D) $J_1 \Rightarrow M_4$, $J_2 \Rightarrow M_2$, $J_3 \Rightarrow M_1$, $J_4 \Rightarrow M_3$

32. Ans: (B)

Sol: Time Matrix → Minimize

	M_1	M_2	M_3	M_4	
J_1	15	13	14	17	
J_2	11	12	15	13	
J_3	13	12	10	11	
J_4	15	17	14	16	
J_1	2	0	1	4	row Transaction
J_2	0	1	4	2	
J_3	3	2	0	1	
J_4	1	3	0	2	
J_1	2	0	1	3	column transaction
J_2	0	1	4	1	
J_3	3	2	0	0	
J_4	1	3	0	1	

$\Rightarrow$ **$J_1 \rightarrow M_2$; $J_2 \rightarrow M_1$, $J_3 \rightarrow M_4$, $J_4 \rightarrow M_3$**

33. An air conditioner unit is expected to run continuously. The mean time between failures (MTBF) for this unit is 2,000 hours and the mean time to repair (MTTR) is 48 hours. The availability of the air conditioning unit is _____ (up to *three* decimal places).

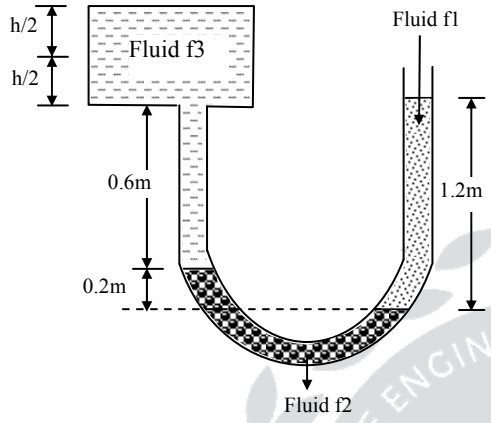
33. Ans: 0.976

Sol: MTBF = 2000 hours

MTTR = 48 hours

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}} = \frac{2000}{2000 + 48} = 0.976$$

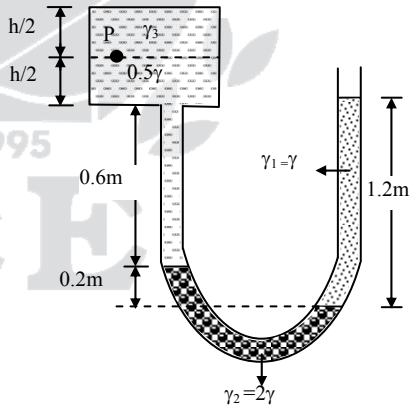
34. A manometer is used for the pressure measurement in a closed tank. The three fluids f1, f2 and f3 have specific weights γ, 2γ and 0.5γ, respectively. The schematic arrangement with manometric readings and other dimensions are shown in the Figure. In order to ensure zero gauge pressure in the tank at the mid-height level (h/2), the height of the tank *h* (in m) is _____



34. Ans: 2

Sol: Let P be the point at the mid-height level of the tank.

The pressure at point P can be written as,



$$P_p = P_{atm} + \gamma \times 1.2 - 2v \times 0.2 - 0.5\gamma\left(0.6 + \frac{h}{2}\right)$$

or $(P_p) - P_{atm} = \gamma[1.2 - 0.4 - 0.3 - 0.25h]$

$$(P_p)_{gauge} = \gamma[0.5 - 0.25h]$$

According to problem, $(P_p)_{gauge} = 0$

or $0.5 - 0.25\,h = 0$

or $h = 2$ m

35. In a gear manufacturing company, three orders P, Q and R are to be processed on a hobbing machine. The orders were received in the sequence P – Q – R. The Table indicates the process time remaining and production calendar due date for each other.

Order	Process Time Remaining (day)	Due date
P	4	Day 20
Q	16	Day 30
R	6	Day 19

Considering today as the Day 10 in the production calendar of the Hobbing Shop, the sequence of the orders scheduled using the 'Critical Ratio' rule is

(A) P – Q – R (B) P – R – Q (C) Q – P – R (D) Q – R – P

35. Ans: (D)

Sol:

ORDER	Process time Remaining, PTR (days)	$CR = \frac{DD - TDD}{PTR}$
P	4	(20 – 10) / 4 =2.5
Q	16	(30 – 10) / 16 = 1.25
R	6	(19 – 10) / 6 = 1.5

CR → critical ratio

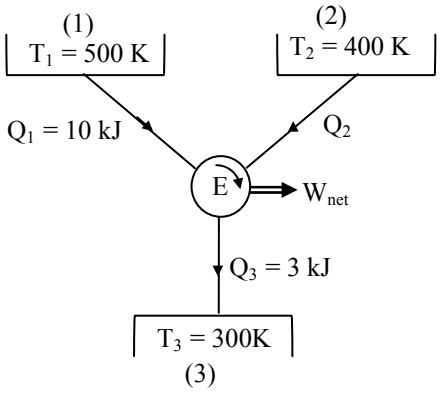
DD → due date

TDD → today's date

PTR → process time remaining

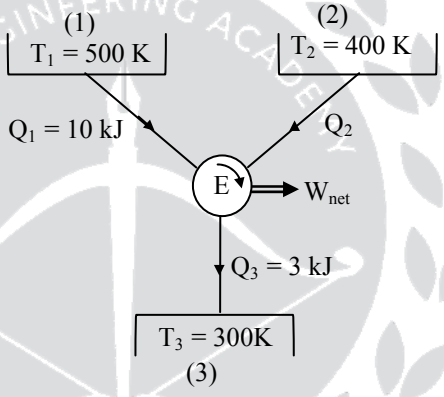
Schedule the job with least critical ratio first, Q-R-P

36. A reversible heat engine (E) operating in a cycle interacts with three reservoirs 1, 2 and 3 maintained at temperature T_1 = 500 K, T_2 = 400 K and T_3 = 300 K, respectively. The engine receives 10 kJ of heat from reservoir 1 and rejects 3 kJ to reservoir 3. The net work output, W_{net} (in kJ) from the engine is _____



36. Ans: 3 kJ

Sol:



Reversible Engine

$$\oint \frac{\delta Q}{T} = 0$$

$$\frac{Q_1}{T_1} + \frac{Q_2}{T_2} - \frac{Q_3}{T_3} = 0$$

$$\frac{10}{500} + \frac{Q_2}{400} - \frac{3}{300} = 0$$

$$0.01 + \frac{Q_2}{400} = 0$$

$Q_2 = -4$ kJ = 4 kJ (heat rejected)

$W_{net} = Q_1 - Q_2 - Q_3$

$= 10 - 4 - 3$

$= 3$ kJ

37. A surface of 30 mm × 30 mm of an iron block is machined using electrochemical machining process. The atomic weight and valency of iron is 55.85 and 2, respectively. The density of iron is 7,860 kg/m^3. If input current is 1,000 A and Faraday's constant is 96,540 Coulombs, then the feed rate (in mm/min) is _____ (up to *two* decimal places).

37. Ans: 2.453

Sol: MRR = A.I. / ρ.Z.F. = A_c . f

Feed = f = MRR / A_c = A.I. / ρ. Z. F. A_c

= (55.85 × 1000) / (7860 × 10^{-6} × 2 × 96540 × 30 × 30)

= 0.04089 mm/sec = 2.453mm/min.

38. In a calendar year, the demand forecast of motorbikes for the month of June is 200. The actual demand of motorbikes for the month of June and July are 300 and 350, respectively. If single exponential smoothing method with smoothing constant 0.7 is used, then the demand forecast for the month of August is _____

38. Ans: 326

Sol: F_{JUNE} = 200 units

D_{JUNE} = 300 units

D_{JULY}= 350 units

$\alpha = 0.7$

$F_{JULY} = F_{JUNE} + \alpha (D_{JUNE} - F_{JUNE}) = 200 + 0.7 (300 - 200) = 270$ units

$F_{AUGUST} = F_{JULY} + \alpha(D_{JULY} - F_{JULY})$

= 270 + 0.7 (350 – 270)

= 270 + 56 = 326 units

39. A metallic strip having a thickness of 12 mm is to be rolled using two steel rolls, each of 800 mm diameter. It is assumed that there is no change in width of the strip during rolling. In order to achieve 10% reduction in cross-sectional area of the strip after rolling, the angle subtended (in degrees) by the deformation zone at the center of the roll is

(A) 1.84 (B) 3.14 (C) 6.84 (D) 8.23

39. Ans: (B)

Sol: $\Delta H = 10\%$ of $12 = 1.2mm$,

$\text{Tan}\alpha = (\Delta H/R)^{0.5} = (1.2/400)^{0.5}$

$\Rightarrow \alpha = 3.138$

40. The annual demand of wrist watches produced on an assembly line is 1,03,125 units. The line operates 50 weeks/year, 5 shifts/week and 7.5 hours/shift. The uptime efficiency of the line is 99%. The cycle time (T_c) of the assembly line (in minutes/unit) is _____ (up to *two* decimal places).

40. Ans: 1.08

Sol: Number of units required = N = 1,03,125 units

Available time for production,

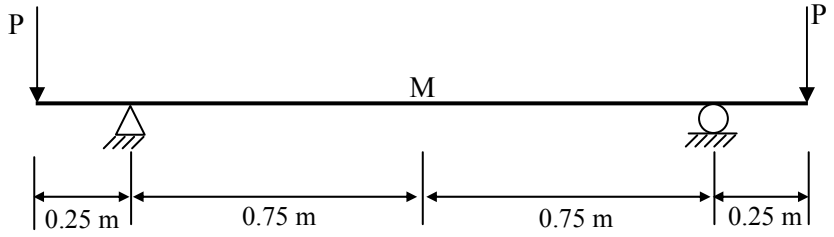
$$T = \text{No.OF HOURS/SHIFT} \times \text{NO.OF SHIFTS/WEEK} \times \text{NO.OF WEEK/YEAR} \times \eta_{line}(\text{UPTIME})$$

$T = 7.5 \times 5 \times 50 \times 0.99 \times 60$ minutes

$= 111375$ minutes

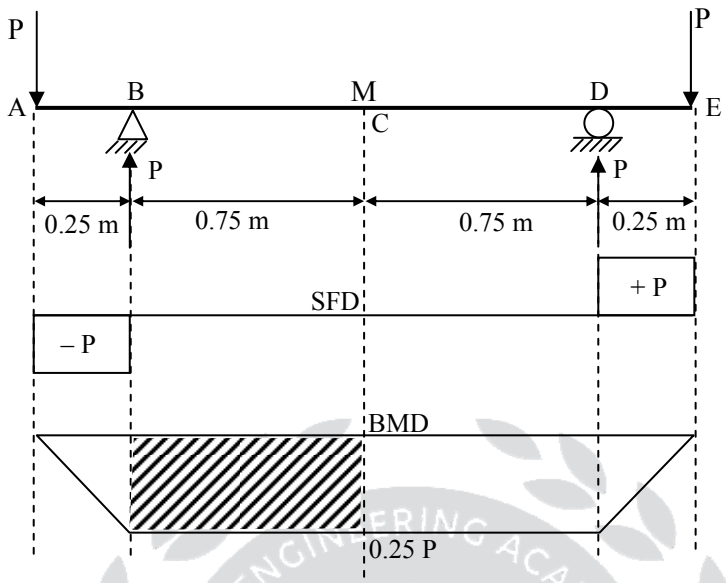
$$\text{Cycle Time} = C = \frac{T}{N} = \frac{111375}{103125} = 1.08 \text{ minutes}$$

41. The simply-supported beam shown in the Figure is loaded symmetrically using two equal point loads P. The radius of curvature of the deflection-curve is 15 m for the portion of the beam that is subjected to pure bending. The vertical deflection (in mm) at point M, equidistant from both the supports is _____ (up to *two* decimal places).



41. Ans: 18.75

Sol:



$$Y_c - Y_B = \frac{1}{EI}\left(A\overline{X}\right)$$

$$= \frac{1}{EI}\left(0.75 \times 0.25P \times \frac{0.75}{2}\right)$$

0.25 P = M (moment)

$$= \frac{1}{EI}\left(0.75 \times \frac{0.75}{2} \times M\right)$$

$$Y_c - Y_B = \frac{M}{EI}\left(0.75 \times \frac{0.75}{2}\right)$$

$$\frac{1}{R} = \frac{M}{EI}$$

R = 15 m (given)

$$\frac{1}{15} = \frac{M}{EI}$$

$$Y_c - Y_B = \frac{1}{15}\left(0.75 \times \frac{0.75}{2}\right)$$

$Y_B = 0$ [at support, no deflection]

$Y_c = 18.75$ mm

Y_c = deflection at c.

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42. An electrical appliances showroom sells 2,400 ceiling fans in one year (52 weeks). The holding cost is 10% of the cost of the ceiling fan. The most of one ceiling fan is Rs. 600. The cost incurred for placing an order is Rs. 201. There is a lead time of 5 weeks. The economic order quantity (EOQ) and the reorder level, respectively (rounded to the next higher integer) are

(A) 231, 127 (B) 38, 231 (C) 127, 231 (D) 127, 13

42. Ans: (C)

Sol: Annual Demand = A = 2400

No. Of weeks = t = 52

$$\text{Consumption rate} = r = \frac{A}{t} = \frac{2400}{52} = 46.1538 \text{ units/week}$$

Cost Per unit = C = Rs 600

Inventory Carrying cost, I = 0.1

Cost of Ordering = S = Rs. 201

Lead Time = 5 Weeks

$$EOQ = \sqrt{\frac{2AS}{CI}} = \sqrt{\frac{2\times 2400\times 201}{600\times 0.1}} = 126.8 \cong 127 \text{ UNITS}$$

Reorder Level = Consumption Rate × Lead Time

$$= 46.1538 \times 5 = 230.77 \cong 231$$

43. The improper integral $\int_0^\infty e^{-2t}\,dt$ converges to

(A) 0 (B) 1.0 (C) 0.5 (D) 2.0

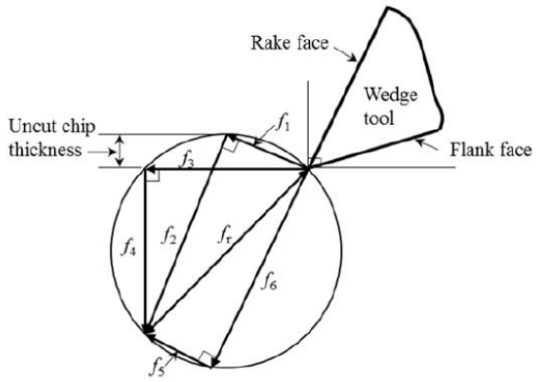
43. Ans: (C)

Sol: $$\int_0^\infty e^{-2t}dt = \left(\frac{-e^{-2t}}{2}\right)_0^\infty$$

$$= (0) - \left(\frac{-e^{-0}}{2}\right) = \frac{1}{2}$$

$\therefore$ The improper integral converges to 0.5.

44. The Merchant circle diagram showing various forces associated with a cutting process using a wedge shaped tool is given in the Figure



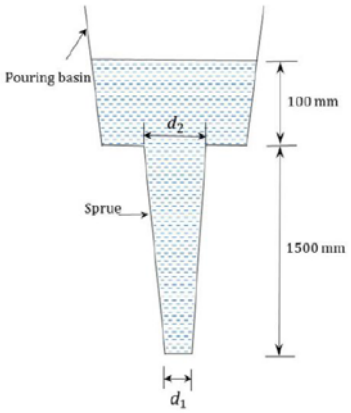
The coefficient of friction can be estimated from the ratio

(A) $\frac{f_1}{f_2}$ (B) $\frac{f_3}{f_4}$ (C) $\frac{f_5}{f_6}$ (D) $\frac{f_6}{f_5}$

44. Ans: (D)

Sol: μ = coefficient of friction = $F/N = f_6 / f_5$ (As the diagram)

45. Schematic diagram of pouring basin and sprue of a gating system is shown in the Figure. Depth of molten metal in the pouring basin is 100 mm and the height of the sprue is 1,500 mm.



Considering the cross-section of the sprue is circular, the ratio $d_1:d_2$ to avoid aspiration is

(A) 3:2 (B) 5:6 (C) 15:16 (D) 1:2

45. Ans: (D)

Sol: Given that $h_t = 1500 + 100 = 1600$mm, $h_2 = 1500$mm

To avoid aspiration effect

$A_1 / A_2 = [(h_t - h_2)/ h_t]^{0.5} = [(1600 - 1500) / 1600]^{0.5} = (d_1/d_2)^2$

$(d_1/d_2) = 1/2$

46. A hose coupling manufacturing company has production capacity of 2,500 units per year. The unit selling price of the item is Rs. 150. The fixed cost of production is Rs. 80,000 and variable cost of production per unit is Rs. 70. If the company wishes to achieve a profit of Rs. 20,000 during the calendar year, then the minimum quantity to be produced is _____

46. Ans: 1250

Sol: s = Rs 150/-

F = Rs 80,000

v = Rs 70/-

P = Rs 20,000

Marginal Costing Equation,

$q(s - v) = F + P$

$$q = \frac{F+P}{s-v} = \frac{80,000 + 20,000}{150 - 70} = \frac{1.00,000}{80} = 1250 \text{ units}$$

47. Two machines are defective in a lot of 10. A combination of four machines is to be picked at a time from the lot. The maximum number of combinations that can be obtained without any defective machine is _____

47. Ans: 70

Sol: Total number of machines = 10

Number of defective machines = 2

Number of non defective machines = 8

Number of combinations can be obtained with out any defective machine = $8C_4 = 70$

48. Quality control department of a company maintains 'c' chart to assess the quality of laptops. In this process, twenty laptops are examined randomly. The number of nonconformities observed per laptop is given in the Table.

Laptop number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Number of nonconformities	1	3	7	4	10	6	1	5	4	3	6	4	2	7	4	2	9	8	5	2

Based on the data, the upper control limit for the 'c' chart is _____ (up to *two* decimal places).

48. Ans: 11.11

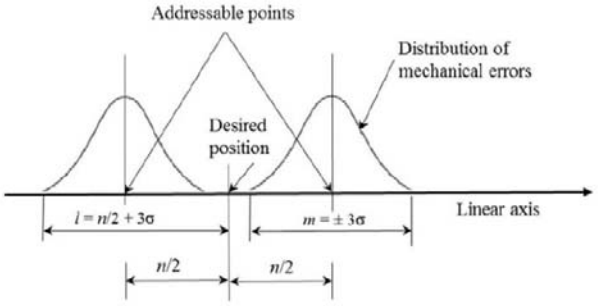
Sol: $\Sigma c = 93$, $n = 20$

$$\bar{c} = \frac{\Sigma c}{n} = \frac{93}{20} = 4.65$$

Control limit, CL = $\overline{C} = 4.65$

Upper Control Limit, $UCL = \overline{C} + 3\sqrt{\overline{C}} = 4.65 + 3\sqrt{4.65} = 11.11$

49. In a numerical control (NC) machine positioning system, the measures of precision are expressed by considering a single axis as shown in the Figure.



If σ is standard deviation of the error distribution, the *l*, *m* and *n* are

(A) *l* = Accuracy, *m* = Repeatability, *n* = Control resolution

(B) *l* = Repeatability, *m* = Accuracy, *n* = Control resolution

(C) *l* = Control resolution, *m* = Repeatability, *n* = Accuracy

(D) *l* = Accuracy, *m* = Control resolution, *n* = Repeatability

49. Ans: (A)

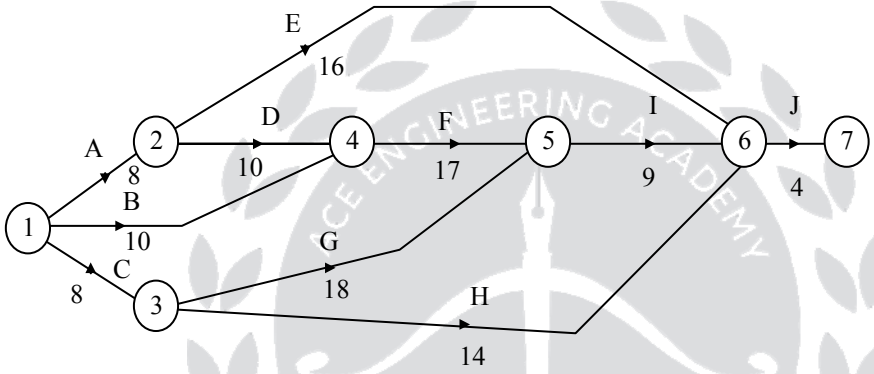
50. In a project, tasks A, B, C, D, E, F, G, H, I and J are to be performed. The precedence relationships and the time required (in days) to complete the tasks are given in the Table.

Tasks	A	B	C	D	E	F	G	H	I	J
Time (days)	8	10	8	10	16	17	18	14	9	4
Preceding tasks	-	-	-	A	A	B, D	C	C	F,G	E,I,H

The time required (in days) to complete the project along the critical path is _____

50. Ans: 48

Sol:



Paths	Duration
A-E-J	8+16+4=28
A-D-F-I-J	8+10+17+9+4 = 48
B-F-I-J	10+17+9+4=40
C-G-I-J	8+18+9+4 = 39
C-H-J	8+14+4 = 26

Critical path is ADFIJ = 48 days

51. A pair of spur gears with 20° full-depth involute teeth is used to transmit 3.5 kW of power. The pinion rotates at 700 rpm and has pitch circle diameter of 100 mm. Assuming a single pair of teeth in contact, the total force acting on a gear tooth (in kN) is

(A) 0.347 (B) 0.954 (C) 1.016 (D) 1.302

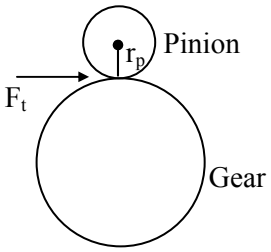
51. Ans: (C)

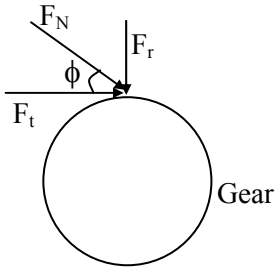
Sol: $\phi = 20°$,

Power = 3.5 kW

N_{pinion} = 700 rpm

r_{pinion} = 50 mm = 0.05 m





$$\text{Power} = \frac{2\pi \times N_p \times F_t \times r_p}{60}$$

$$3500 = \frac{2\pi \times 700 \times F_t \times 0.05}{60}$$

F_t = 954.92 N

Resultant force, $F_N = \frac{F_t}{\cos\phi} = \frac{954.92}{\cos 20} = 1016.21$ N

F_N = 1.016 kN

52. Runge-Kutta fourth order method is used to solve the differential equation $\frac{dy}{dx} = y - x$. If the initial value y(0) = 2 and step-size is 0.1, then the value of y(0.1) is _____ (up to *three* decimal places).

52. Ans: 2.20

Sol: Given $\frac{dy}{dx} = y - x$, y(0) = 2, h = 0.1

K_1= 0.1 f(0,2) = 0.1 (2) = 0.2

K_2 = 0.1 f(0.05,2.2) = 0.1 { 2.2 = 0.05} = 0.215

K_3= 0.1 f(0.05, 2.1075) = 0.1 {2.1075 – 0.05} = 0.2057

K_4 = 0.1 f(0.1, 2.2057) = 0.1 {2.2057 – 0.1} = 0.2105

$$K = \frac{1}{6}(K_1 + 2K_2 + 2K_3 + K_4)$$

$$= \frac{1}{6}\{0.2 + 0.43 + 0.4114 + 0.2105\} = 0.2086$$

$\therefore$ The value of *y* at x = 0.1 is $y_0 + K = 2 + 0.2086 = 2.2086$

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53. The potential production alternatives for manufacturing a product along with their unit cost and monthly capacity are given in the Table.

S.NO	Production Alternatives	Unit cost (Rs.)	Capacity/month
1	Regular time production	5	300
2	Overtime production	6	200
3	Subcontrating	10	500

The inventory at the end of July is 100 units. If the demand for the month of August is 620, then the minimum total cost (in Rs.) to meet the demand is _____

53. Ans: 2900

Sol: Demand in August = 620 units

Inventory at end of July = 100 units

Demand to be met = 620 – 100 = 520 units

RTP = 300 , OTP = 200 , SCP = 20

Total Cost = $300 \times 5 + 200 \times 6 + 210 \times 10 = 1500 + 1200 + 200 = 2900/-$

54. A firm manufactures capacitors using a specialized process. The desired specification for the capacitance is 40±10 picofarads (pF). The process used is in statistical control. If the process mean is 41 pF and the estimated standard deviation is 3 pF, then the process capability index C_{pk} is ____.

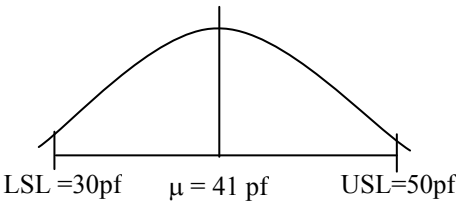
54. Ans: 1

Sol: USL = 50 pf , LSL = 30 pf, $\sigma = 3$ pf

$$\text{Process Capability} = \frac{\text{USL} - \text{LSL}}{6\sigma} = \frac{50-30}{6\times 3} = 1.11$$

$$(\text{CPU}) = \frac{\text{USL} - \mu}{3\sigma} = \frac{50-41}{3\times 3} = +1$$

$$(\text{CPL}) = \frac{\mu - \text{LSL}}{3\sigma} = \frac{41-30}{3\times 3} = 1.22$$



Process capability index, C_{pk} = min (CPU ; CPL) = 1

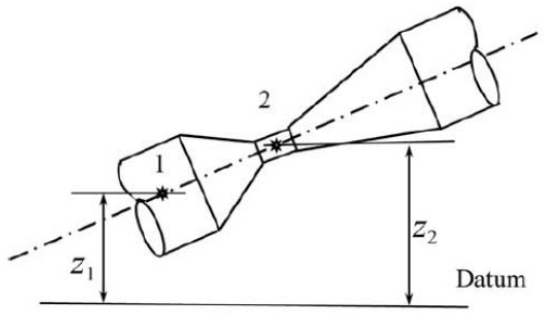
55. A pipeline with variable cross-section contains water with specific weight 10^4 N/m^3. The flow conditions at two points 1 and 2 on the axis of the pipe are:

$P_1 = 3$ bar, $V_1 = 10$ m/s

$P_2 = 1$ bar, $V_2 = 20$ m/s

Consider frictional losses to be negligible. For no-flow condition between points 1 and 2 (as shown in Figure), if the height z_1 from the datum is 1 m, then the height z_2 (in m) is _____

($g = 9.81$ m/s^2)



55. Ans: 21

Sol: For no flow condition

$$\vec{V}_1 = \vec{V}_2 = 0$$

Applying Bernoulli equation between (1) and (2)

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$\frac{P_1}{\rho g} + z_1 = \frac{P_2}{\rho g} + z_2$$

$\rho g = 10^4$ N/m^3 (given)

$$\frac{3\times10^5}{10^4} + 1 = \frac{1\times10^5}{10^4} + z_2$$

$$30 + 1 = 10 + z_2$$

$$z_2 = 21 \text{ m}$$

GENERAL APTITUDE

01. I _____ made arrangements had I _____ informed earlier.

(A) could have, been (B) would have, being

(C) had, have (D) had been, been

01. Ans: (A)

Sol: Conditional tense Type 3 – Past perfect (could have) + perfect conditional (had + V_3)

02. She has a sharp tongue and it can occasionally turn _____

(A) hurtful (B) left (C) methodical (D) vital

02. Ans: (A)

Sol: Hurtful → It is a supporting sentence. The word 'sharp tongue' strengthens the latter part of the sentence 'it can occasionally turn *hurtful*'

03. 40% of deaths on city roads may be attributed to drunken driving. The number of degrees needed to represent this as a slice of a pie chart is

(A) 120 (B) 144

(C) 160 (D) 212

03. Ans: (B)

Sol: Sum of angles in a pie chart = 360^o

The relation between angle and percentage is

$100\ \% = 360^o$

$\% = 3.6^o$

$\therefore\ 40\% = ?$

$40 \times 3.6 = 144^o$

04. Some tables are shelves. Some shelves are chairs. All chairs are benches. Which of the following conclusions can be deduced from the preceding sentences?

(i) At least one bench is a table

(ii) At least one shelf is a bench

(iii) At least one chair is a table

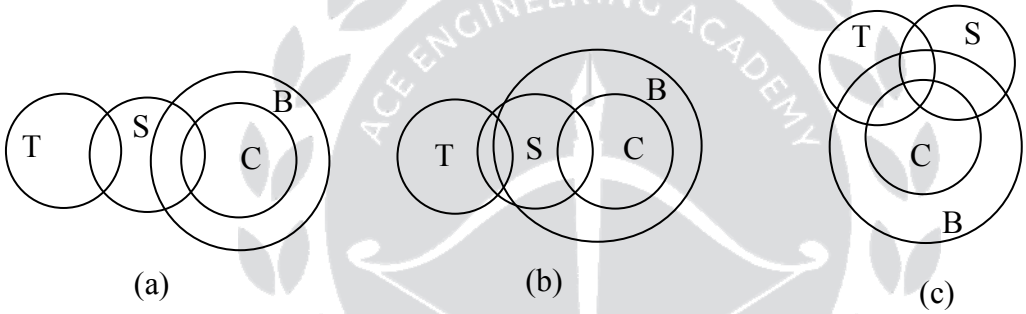
(iv) All benches are chairs

(A) Only i (B) Only ii (C) Only ii and iii (D) Only iv

04. Ans: (B)

Sol: From given statements the following venn diagrams are possible

T = tables, S = shelves, C = chairs and B = benches



From all of the above diagrams, conclusion (ii) only deduced from the statements.

05. In the summer, water consumption is known to decrease overall by 25%. A water Board official states that in the summer household consumption decreases by 20% while other consumption increases by 70%.

Which of the following statements is correct?

(A) The ratio of household to other consumption is $\frac{8}{17}$

(B) The ratio of household to other consumption is $\frac{1}{17}$

(C) The ratio of household to other consumption is $\frac{17}{8}$

(D) There are errors in the officials statement.

05. Ans: (D)

Sol: H = house hold consumption

P = other consumption

House hold consumption decreases by 20% $= \frac{80}{100}H$

Other consumption increases by 70% $= \frac{170}{100}P$

$$\frac{80H}{100} + \frac{170P}{100} = \frac{75}{100}(H + P)$$

$80\,H + 170\,P = 75\,H + 75P$

$80\,H - 75\,H = 75\,P - 170P$

$5\,H = -95\,P$

There is a negative ratio so, there are errors in the official's statement.

06. Trucks (10 m long) and cars (5 m long) go on a single lane bridge. There must be a gap of at least 20 m after each truck and a gap of at least 15 m after each car. Trucks and cars travel at a speed of 36km/h. If cars and trucks go alternately, what is the maximum number of vehicles that can use the bridge in one hour?

(A) 1440 (B) 1200 (C) 720 (D) 600

06. Ans: (A)

Sol: Length of truck + gap required = 10 + 20 = 30 m

Length of car + gap required = 5 + 15 = 20 m

Total distance is need for truck and car for passing alternatively = 30 + 20 = 50m

Given, speed = 36 kmph $= 36 \times \frac{5}{18} = 10\ \text{m/sec}$

Let 'x' be the number of repetitions of (Truck + car) in one hour

$$\frac{50 \times x}{60 \times 60} = 10\ \text{m/s}$$

$$\Rightarrow x = \frac{10 \times 60 \times 60}{50} = 720 \text{ numbers of (Trucks + cars)}$$

$\therefore$ The maximum number of vehicles = 720 + 720 = 1440

07. S, T, U, V, W, X, Y, and Z are seated around a circular table. T's neighbours are Y and V. Z is seated third to the left of T and second to the right of S. U's neighbours are S and Y; and T and W are not seated opposite each other. Who is third to the left of V?

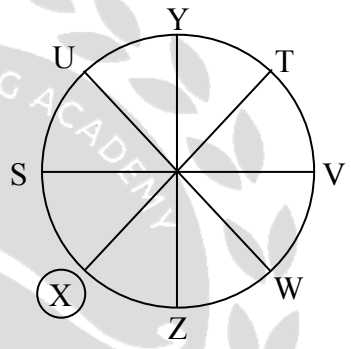
(A) X (B) W (C) U (D) T

07. Ans: (A)

Sol: From the given data, eight persons are seated around a circular table as follows

Y T V	S U Y
(or)	(or)
V T Y	Y U S

S — Z — — T



∴ X is third to the left of V

08. "If you are looking for a history of India, or for an account of the rise and fall of the British Raj, Or for the reason of the cleaving of the subcontinent into two mutually antagonistic parts and the effects this mutilation will have in the respective sections, and ultimately on Asia, you will not find it in these pages; for though I have spent a lifetime in the country, I lived too near the seat of events, and was too intimately associated with the actors, to get the perspective needed for the impartial recording of these matters".

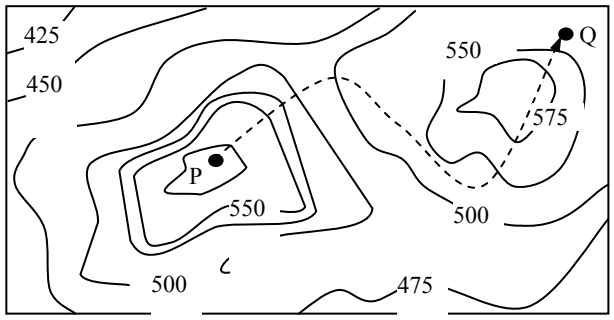
Here, the word 'antagonistic' is closest in meaning to

(A) impartial (B) argumentative (C) separated (D) hostile

08. Ans: (D)

Sol: 'Antagonistic' means showing dislike or opposition. So the word closest in meaning is 'hostile' (not friendly, having or showing unfriendly feelings, unpleasant or harsh)

09. A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25 m intervals in this plot.



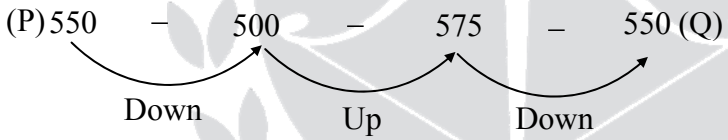
The path from P to Q is best described by

(A) Up-Down-Up-Down (B) Down-Up-Down-Up

(C) Down-Up-Down (D) Up-Down-Up

09. Ans: (C)

Sol: Contour lines can be observed to cross region with height from P to Q is as follows



∴ The path from P to Q is Down-Up-Down option (C) is satisfies this path

10. There are 3 Indians and 3 Chinese in a group of 6 people. How many subgroups of this group can we choose so that every subgroup has at least one Indian?

(A) 56 (B) 52 (C) 48 (D) 44

10. Ans: (A)

Sol: Sub group has at least one Indian means minimum one Indian and maximum three (or) more

Sub groups containing only Indians = $3C_1 + 3C_2 + 3C_3 = 3 + 3 + 1 = 7$

In the sub group one Indian and remaining are Chinese = $3C_1 [3C_1 + 3C_2 + 3C_3] = 3 [3 + 3 + 1]$
$= 3 \times 7 = 21$

In the sub group two Indians and remaining are Chinese
$= 3C_2 [3C_1 + 3C_2 + 3C_3] = 3 [3 + 3 + 1] = 3 \times 7 = 21$

In the sub group three Indians and remaining are Chinese = $3C_3[3C_1+3C_2+3C_3]$

$= 1\ [3 + 3 + 1\ ] = 7$

$\therefore$ Total number of sub groups = 7 + 21 + 21 + 7 = 56