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

Ans. (*b*)

Directions : The following *Six* (6) items consist of two statements, one labelled as '*Assertion (A)*' and the other as '*Reason (R)*'. You are to examine these two statements carefully and select the answers to these items using the codes given below :

Codes :

(*a*) Both A and R are individually true and R is the correct explanation of A

(*b*) Both A and R are individually true but R is NOT the correct explanation of A

(*c*) A is ture but R is false

(*d*) A is false but R is ture

Q. 13. *Assertion (A) :* All motor vehicles have differential gear mechanism at the back axle.
Reason (R) : This mechanism is fitted to enable the vehicles to run on bumpy roads.

Ans. (*c*)

Q. 14. *Assertion (A) :* A sound welded joint should not only be strong enough but should also exhibit a good amount of ductility.
Reason (R) : Welding process is used for fabricating mild steel components only.

Ans. (*c*)

Q. 15. *Assertion (A) :* Ductile materials generally absorb more impack loading than a brittle material.
Reason (R) : Ductile materials generally have higher ultimate strength than brittle materials.

Ans. (*a*)

Q. 16. *Assertion (A) :* Cold working of metals results in increase of strength and hardness.
Reason (R) : Cold working reduces the total number of dislocations per unit volume of the material.

Ans. (*a*)

Q. 17. *Assertion (A) :* In electron beam welding process, vacuum is an essential process parameter.
Reason (R) : Vacuum provides a highly efficient shield on weld zone.

Ans. (*c*)

Q. 18. *Assertion (A) :* The ratio of uncut chip thickness to actual chip thickness is always less than one and is termed as cutting ratio in orthogonal cutting.
Reason (R) : The frictional force is very high due to the occurrence of sticking friction rather than sliding friction.

Ans. (*b*)

Q. 19. A shaft is subjected to simultaneous action of a torque T, bending moment M and an axial thrust F. Which one of the following statements is correct for this situation ?

(*a*) One extreme end of the vertical diametral force is subjected to maximum compressive stress only

(*b*) The opposite extreme end of the vertical diametral fibre is subjected to tensile/compressive stress only

(*c*) Every point on the surface of the shaft is subjected to maximum shear stress only

(*d*) Axial longitudinal fibre of the shaft is subjected to compressive stress only

Ans. (*b*)

Q. 20. A member is subjected to the combined action of bending moment 400 Nm and torque 300 Nm. What, respectively are the equivalent bending moment and equivalent torque ?

(*a*) 450 Nm and 500 Nm (*b*) 900 Nm and 350 Nm

(*c*) 900 Nm and 500 Nm (*d*) 400 Nm and 500 Nm

Ans. (*a*) Equivalent twisting moment $= \sqrt{\mu^2 + \tau^2} = \sqrt{400^2 + 300^2} = 500$ Nm

Equivalent B.M. $= \frac{1}{2}(\mu + \sqrt{\mu^2 + \tau^2}) = \frac{1}{2}(400 + 500) = 450$ Nm

Q. 21. Match List I with List II and select the correct answer using the codes given below the Lists :

List I	*List II*
A. Wire winding	1. Hydrostatic stress
B. Lame's theory	2. Strengthening of thin cylindrical shell
C. Solid sphere subjected to uniform pressure on the surface	3. Strengthening of thick cylindrical shell
D. Autofrettage	4. Thick cylinders

Codes :

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

Ans. (*d*) A-2, B-4, C-1, D-3

Q. 22. A thin cylindrical shell of dimeter d, length l and thickness t is subjected to an internal pressure p. What is the ratio of longitudinal strain to hoop strain in terms of Poisson's ratio (1 / m) ?

(*a*) $\frac{m-2}{2m+1}$ (*b*) $\frac{m-2}{2m-1}$ (*c*) $\frac{2m-1}{m-2}$ (*d*) $\frac{2m+1}{m-2}$

Ans. (*b*) Ratio $= \frac{Pd}{2tE}\left(\frac{1}{2} - \frac{1}{m}\right) \Big/ \frac{Pd}{2tE}\left(1 - \frac{1}{2m}\right) = \frac{m-2}{2m-1}$

Q. 23. A thick cylinder of internal radius a and external radius b is subjected to internal pressure p as well as external pressure P. Which one of the following statements is correct ?
The magnitude of circumferential stress developed is

(*a*) maximum at radius $r = a$ (*b*) maximum at radius $r = b$

(*c*) maximum at radius $r = \sqrt{ab}$ (*d*) constant

Ans. (*a*)

Q. 24. Four columns of same material and same length are of rectangular cross-section of same breadth b. The depth of the cross-section and the end conditions are, however different are given as follows:

Column Depth	*End Conditions*
1. 0.6 b	Fixed-Fixed
2. 0.8 b	Fixed-Hinged
3. 1.0 b	Hinged-Hinged
4. 2.6 b	Fixed-Free

Which of the above columns has the maximum value of Euler buckling load ?

(*a*) Column 1 (*b*) Column 2

(*c*) Column 3 (*d*) Column 4

Ans. (*d*) Ratios in 4 cases are 4×0.6^3, 2×0.8^3, 1×1^3, $2.6^3/4$

Q. 25. A metal has FCC structure. Suppose its atomic weight and atomic radius are A and R respectively. Let N denotes Avogadtro's Number. What is the density of the material ?

(*a*) $\frac{A}{2\sqrt{2}\, r^3 N}$ (*b*) $\frac{A}{4\sqrt{2}\, r^3 N}$ (*c*) $\frac{A}{8\sqrt{2}\, r^3 N}$ (*d*) $\frac{A}{16\sqrt{2}\, r^3 N}$

Ans. (*a*)

Q. 26. Consider the following temperature ranges :

1. Room temperature
2. 0 to 910°C
3. 910°C to 1400°C
4. 1400°C to below melting point

In which of the above temperature ranges ferrite with body centered cubic structure is indicated in the $Fe - Fe_3$ C phase diagram ?

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

Ans. (*a*)

Q. 27. An iron-carbon binary alloy has 0.5 % C by weight. What is this alloy called ?

(*a*) Eutectoid alloy (*b*) Eutectic alloy
(*c*) Hypoeutectoid alloy (*d*) Hypereutectoid alloy

Ans. (*c*)

Q. 28. Match List I (*Name of alloy*) with List II (*Major alloying elements*) and select the correct answer using the codes given below the Lists :

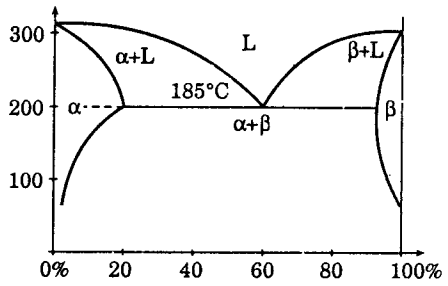
List I (*Name of alloy*)	*List II* (*Major alloying elements*)
A. Invar	1. Manganese
B. Hadfield steel	2. Chromium
C. Statellite	3. Nickel
D. Stainless steel	4. Tungsten
	5. Molybdenum

Codes :

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

Ans. (*d*)

Q. 29. Consider the following lead-tin phase diagram given below :



For which one of the following alloy compositions, the alloy will have the lowest melting point at 185°C ?

(*a*) 20% Sn and 80% Pb by weight

(*b*) 60% Sn and 40% Pb by weight

(*c*) 97% Sn and 3% Pb by weight

(*d*) 40% Sn and 60% Pb by weight

Ans. (*b*)

Q. 30. Match List I (*Name of treatment*) with List II (*Media used*) and select the correct answer using the codes given below the Lists :

List I (*Name of treatment*)	*List II* (*Media used*)
A. Pack carburising	1. Ammonia gas
B. Gas carburising	2. Sodium cyanide
C. Cyaniding	3. Carburising compound
D. Nitriding	4. Ethane

Codes :

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

Ans. (*a*)

Q. 31. Consider the following pairs :

Heat treatment	*Effects on medium carbon steel*
1. Normalising	: Grain refinement
2. Full annealing	: Uniform grain structure
3. Martempering	: Decreased ductility
4. Spheroidizing	: Maximum softness

Which of the pairs given above are correctly mathched ?

(*a*) 1 and 2 (*b*) 2 and 3

(*c*) 3 and 4 (*d*) 1, 2, 3 and 4

Ans. (*a*)

Q. 32. Match List I (*Material*) with List II (*Typical used*) and select the correct answer using the codes given below the Lists :

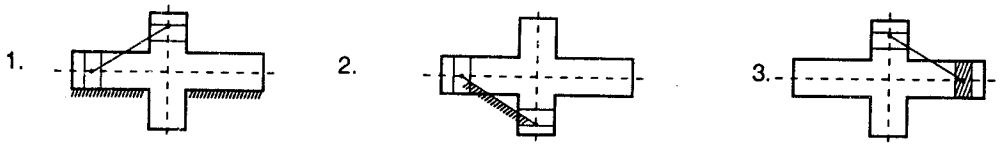
List I (*Material*)	*List II* (*Typical use*)
A. Branched polyethlene	1. Bottles
B. Polyester	2. Textile fibres
C. Polyvinylidene chloride	3. Films for packaging
D. Linear Polyethylene.	4. Transparent film

Codes :

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

Ans. (*b*)

Q. 33. The double slider - crank chain is shown below in the diagram in its three possible inversions. The link shown hatched is the fixed link :



Which one of the following statements is correct ?

(*a*) Inversion (1) is for ellipse trammel and inversion (2) is for Oldham coupling

(*b*) Inversion (1) is for ellipse trammel and inversion (3) is for Oldham coupling

(*c*) Inversion (2) is for ellipse trammel and inversion (3) is for Oldham coupling

(*d*) Inversion (3) is for ellipse trammel and inversion (2) is for Oldham coupling

Ans. (*a*)

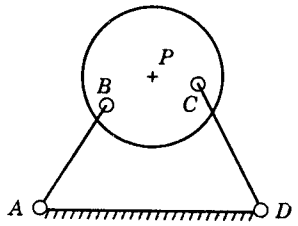
Q. 34. ABCD is a four bar mechanism, in which AD is the fixed link, and link BC, is in the form of a circular disc with centre P. In which one of the following cases P will be the instantaneous centre of the disc ?

(*a*) If it lies on the perpendicular bisector of line BC

(*b*) If it lies on the intersection of the perpendicular bisectors of BC & AD

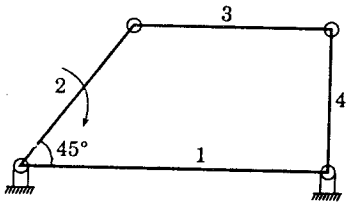
(*c*) If it lies on the intersection of the perpendicular bisector of AB & CD

(*d*) If it lies on the intersection of the extensions of AB and CD



Ans. (*d*)

Q. 35. In the diagram given below, the magnitude of absolute angular velocity of ling 2 is 10 radians per second while that of link 3 is 6 radians per second. What is the angular velocity of link 3 relative to 2 ?



(*a*) 6 radians per second (*b*) 16 radians per second

(*c*) 4 radians per second (*d*) 14 radians per second

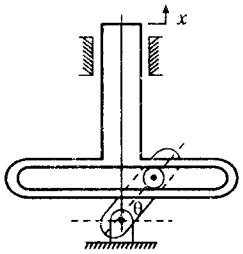
Ans. (*b*)

Q. 36. ABCD is a mechanism with link lengths AB = 200, BC = 300, CD = 400 and DA = 350. Which one of the following links should be fixed for the resulting mechanism to be a double crank mechanism? (All lengths are in mm)

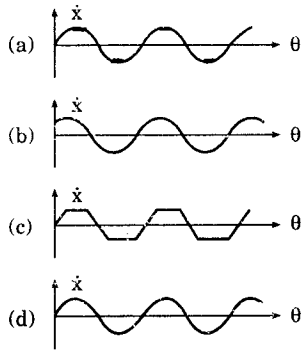
(*a*) AB (*b*) BC (*c*) CD (*d*) DA

Ans. (*a*)

Q. 37. The crank of the mechanism shown below in the diagram rotates at a uniform angular velocity θ :



Which one of the following diagrams shows the velocity of slider x with respect to the crank angle ?



Ans. (*c*)

Q. 38. In a plate cam mechanism with reciprocating roller follower, in which one of the following cases the follower has constant acceleration ?

(*a*) Cycloidal motion (*b*) Simple harmonic motion

(*c*) Parabolic motion (*d*) 3 - 4 - 5 polynomial motion

Ans. (*d*)

Q. 39. Which one of the following statements is correct ? In a petrol engine mechanism the velocity of the piston is maximum when the crank is

(*a*) at the dead centres (*b*) at right angles to the line of stroke

(*c*) slightly less than 90° to line stroke (*d*) slightly aboe 90° to line of stroke

Ans. (*b*)

Q. 40. In a differential machanism, two equal sized bevel wheels A and B are keyed to the two halves of the rear axle of a motor car. The car follows a curved path.
Which one of the following statements is correct ?

The wheels A and B will revolve at different speeds and the casing will revove at a speed which is equal to the

(*a*) difference of speeds of A and B

(*b*) atithmetic mean of the speeds of A and B

(*c*) geometric mean of the speeds of A and B

(*d*) harmonic mean of the speeds of A and B

Ans. (*a*)

Q. 41. Which one of the following conversions is used by a lawn-sprinkler which is a four bar mechanisms?

(*a*) Reciprocating motion to rotary motion

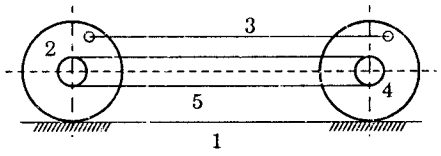
(*b*) Reciprocating motion to oscillatory motion

(*c*) Rotary motion to oscillatory motion

(*d*) Oscillatory motion to rotary motion

Ans. (*c*)

Q. 42.



In the mechanism shown above, link 3 has

(*a*) curvilinear translation and all points in it trace out identical cycloids

(*b*) curvilinear translation and all points in it trace out identical involutes

(*c*) linear translation and all points in it trace out identical helices

(*d*) linear translation and all points in it trace out identical ellipses

Ans. (*d*)

Q. 43. Consider the following statements :

1. C is an object - oriented programming like Java.
2. C + + uses the same set of programming concepts as those of C.

Which of the statements given above is / are correct ?

(*a*) 1 only (*b*) 2 only

(*c*) Both 1 and 2 (*d*) Neither 1 nor 2

Ans. (*a*)

Q. 44. Consider the following methods :

1. Trifiler suspension
2. Torsional oscillation
3. Fluctuation of energy of engine
4. Weight measurement and measurement of radius of flywheel

Which of the above methods are used to determine the polar mass moment of inertia of an engine flywheel with arms ?

(*a*) 1 and 4 (*b*) 2 and 3

(*c*) 1, 2 and 3 (*d*) 1, 2 and 4

Ans. (*b*)

Q. 45. A connecting rod has a mass of 0.5 kg. The radius of gyration through its centre of gravity is 5 cm and its acceleration is $2 \times 10^4 rad/s^2$. The equivalent two - mass system for the connecting rod has a radius of gyration 6 cm. What is the correction couple of the equivalent system ?

(*a*) 11 Nm (*b*) 9 Nm (*c*) 6 Nm (*d*) 2 Nm

Ans. (*a*) Correction couple $= I \propto = 0.5\left(\frac{5+6}{100}\right)^2 \times 2 \times 10^4 = 11$ Nm

Q. 46. Which one of the following statements is correct ? A governor will be stable if the radius of rotation of the balls

(*a*) increases as the equilibrium speed decreases

(*b*) decreases as the equilibrium speed increases

(*c*) increases as the equilibrium speed increases

(*d*) remains unaltered with the change in equilibrium speed

Ans. (*c*)

Q. 47. Which one of the following statements in the context of balancing in engines is correct ?

(*a*) Magnitude of the primary unbalancing force is less than the secondary unbalancing force

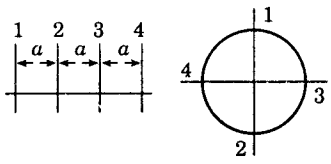
(*b*) The primary unbalancing force attains its maximum value twice in one revolution of the crank

(*c*) The hammer blow in the locomotive engines occurs due to unbalanced force along the line of stroke of the piston

(*d*) The unbalanced force due to reciprocating masses varies in magnitude and direction.

Ans. (*b*)

Q. 48. A four - cylinder in - line reciprocating engine is shown in the diagram given below. The cylinders are numbered 1 to 4 and the firing order is 1 - 4 - 2 - 3 :



Primary cranks

Which one of the following statements is correct ?

(*a*) Both primary and secondary forces are balanced

(*b*) Only primary force is balanced

(*c*) Only secondary force is balanced

(*d*) Both primary and secondary forces are unbalanced

Ans. (*b*)

Q. 49. Match List I with List II and select the correct answer using the codes given below the Lists :

List I	*List II*
A. Open loop system	1. Frequency domain analysis
B. Closed loop system	2. More stable
C. Step input	3. Less stable
D. Sinusoidal input	4. Time domain analysis

Codes :

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

Ans. (*b*)

Q. 50. Consider the following statements regarding improvement of efficiency of worm gear drive :

1. Efficiency can be improved by increasing the spiral angle of worm thread to 45° or more.
2. Efficiency can be improved by adopting proper lubrication.
3. Efficiency can be improved by adopting worm diamter as small as practicable to reduce sliding between worm - threads and wheel teeth.
4. Efficiency can be improved by adopting convex tooth profile both for worm and wheel.

Which of the statements given above are correct ?

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

Ans. (*a*)

Q. 51. Match List I (*Items in joints*) with list II (*Type of failure*) and select the correct answer using the codes given below the Lists :

List I

(*Items in joints*)

A. Bolts in bolted joints of engine cylinder cover plate
B. Cotters in cotter joint
C. Rivets in lap joints
D. Bolts holding two flanges in a flange coupling

List II

(*Type of failure*)

1. Double transverse shear
2. Torsional shear
3. Single transverse shear
4. Tension

Codes :

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

Ans. (*a*)

Q. 52. Match the List I with List II and select the correct answer using the codes given below the Lists :

List I	*List II*
A. Plan approach angle	1. Tool face
B. Rake angle	2. Tool flank

C. Clearance angle
D. Wedge angle

3. Tool face and flank
4. Cutting edge
5. Tool nose

Codes :

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

Ans. (*b*)

Q. 53. Match List I (*Cutting tool materials*) with List II (*Manufacturing methods*) and select the correct answer using the codes given below the Lists :

List I (*Cutting tool materials*)	*List II* (*Manufacturing methods*)
A. HSS	1. Casting
B. Stellite	2. Forging
C. Cemented carbide	3. Rolling
D. UCON	4. Extrusion
	5. Powder metallurgy

Codes :

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

Ans. (*d*)

Q. 54. The rake angle of a cutting tool is 15°, shear angle 45° and cutting velocity 35 m/min. What is the velocity of chip along the tool face ?

(*a*) 28.5 m/min. (*b*) 27.3 m/min
(*c*) 25.3 m/min. (*d*) 23.5 m/min.

Ans. (*a*) $V_c = \dfrac{\sin 45°}{\cos (45° - 15°)} \times 35 = 28.5$ m/min

Q. 55. A medium carbon steel workpiece is turned on a lathe at 50 m/min cutting speed, 0.8 mm/rev feed and 1.5 mm depth of cut. What is the rate of metal removal ?

(*a*) 1000 mm^3/min (*b*) 60,000 mm^3/min
(*c*) 20,000 mm^3/min (*d*) Can not be calculated with the given data

Ans. (*b*) $50 \times 1000 \times 0.8 \times 1.5 = 60{,}000$ mm^3/min.

Q. 56. Consider the following statements :

1. As the cutting speed increases, the cost of production initially reduces, then after an optimum cutting speed it increases.

2. As the cutting speed increases the cost of production also increases and after a critical value it reduces.
3. Higher feed rate for the same cutting speed reduces cost of production
4. Higher feed rate for same cutting speed increases the cost of production.

Which of the statements given above is/are correct ?

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

Ans. (*a*)

Q. 57. Match List I (*Machining process*) with List II (*Operating media*) and select the correct answer using the codes given below the Lists :

List I (*Machining processes*)	*List II* (*Operating media*)
A. Abrasive jet machining	1. Dielectric
B. Electron beam machining	2. Electrolyte
C. Electro-chemical machining	3. Abrasive slurry
D. Electro-discharge machining	4. Vacuum
	5. Air

Codes :

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

Ans. (*a*)

Q. 58. Consider the following fits :

1. I.C. engine cylinder and piston
2. Ball bearing outer race and housing
3. Ball bearing inner race and shaft

Which of the above fits are based on the shaft basis system ?

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

Ans. (*b*)

Q. 59. Consider the following alignment tests on machine tools :

1. Straightness
2. Flatness
3. Run out
4. Parallelism

Which of the above alignment tests on machine tools are common to both lathe and shaper ?

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

Ans. (*a*)

Q. 60. It is given that the actual demand is 59 units, a previous forecast 64 units and smoothing factor 0.3. What will be the forecast for next period, using exponential smoothing ?

(*a*) 36.9 units (*b*) 57.5 units (*c*) 60.5 units (*d*) 62.5 units

Ans. (*d*) $0.3 \times 59 + (1 - 0.3) \times 64 = 62.5$

Q. 61. The demand for a product in the month of March turned out to be 20 units against an earlier made forecast of 20 units. The actual demand for April and May turned to be 25 and 26 units respectively. What will be the forecast for the month of June, using exponential smoothing method and taking smoothing constant α as 0.2 ?

(*a*) 20 units (*b*) 22 units (*c*) 26 units (*d*) 28 units

Ans. (*d*)

Q. 62. Consider the following statements :

1. Preparation and master production schedule is an iterative process.
2. Schedule charts are made with respect to jobs while load charts are made with respect to machines.
3. MRP is done before master production scheduling

Which of the statements given above are correct ?

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

Ans. (*b*)

Q. 63. Match List I (*PPC function*) with II (*Activity*) and select the correct answer using the codes given below the Lists :

List I (*PPC functions*)	*List II* (*Activity*)
A. Capacity planning	1. Lasting products to be assembled and when to be delivered
B. Shop floor control	2. Rescheduling orders based on production priorities
C. Master production schedule	3. Closure tolerances
D. Material requirement planning	4. Monitor progress of orders and report their status
	5. Planning of labour and equipment

Codes :

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

Ans. (*b*)

Q. 64. Process X has fixed cost of Rs. 40.000 and variable cost of Rs. 9 per unit whereas process Y has fixed cost of Rs. 16,000 and variable cost of Rs. 24 per unit. At what production quantity, the total cost of X and Y are equal ?

(*a*) 1200 units (*b*) 1600 units (*c*) 2000 units (*d*) 2500 units

Ans. (*b*)

Q. 65. Which one of the following information combinations has lowest break - even point ?

(*Fixed cost (in Rs.)*)	(*Variable cost/unit (in Rs.)*)	(*Revenue/unit (in Rs.)*)
(*a*) 30,000	10	40
(*b*) 40,000	15	40
(*c*) 50,000	20	40
(*d*) 60,000	30	40

Ans. (*a*)

Q. 66. A company has four work centrers A, B, C and D, with per day capacities of 450 units, 390 units, 360 units 400 units respectively. The machines are laid down in order A,B,C and D and product has to be operated on all these machines for getting converted into finished product. The actual output turns out to be 306 unit per day. What is the system efficiency ?

(*a*) 68 % (*b*) 78 % (*c*) 80 % (*d*) 85 %

Ans. (*b*)

Q. 67. Consider the following statements with respect to PERT :

1. It consists of activities with uncertain time phases
2. This is evolved from Gantt chart.
3. Total slack along the critical path is not zero.
4. There can be more than one critical path in PERT network.
5. It is similar to electric network.

Which of the statements given above are correct ?

(*a*) 1, 2 and 5 (*b*) 1, 3 and 5 (*c*) 2, 4 and 5 (*d*) 1, 2 and 4

Ans. (*d*)

Q. 68. Match List I (*Study*) with List II (*Related factor*) and select the correct answer using the codes given below the Lists :

List I (*Study*)	*List II* (*Related factors*)
A. Job enrichment	1. Gilbreth's principles
B. Job evaluation	2. Movement of limbs by work factor system
C. Mathod study	3. Herzberg motivators
D. Time study	4. Jacques time - span of discretion

Codes :

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

Ans. (*b*)

Q. 69. Match List I (*Quantity contorl concepts*) with List II (*Quality contol techniques*) and select the correct answer using the codes given below the Lists :

List I (*Quantity contorl concepts*)	*List II* (*Quality control techniques*)
A. Tightened and reduced inspection	1. Dodge Romig tables
B. Lot tolerance per cent defective	2. Control chart for variables
C. Poisson distribution	3. MIL standards
D. Normal distribution	4. Control chart for number of non - conformities

Codes :

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

Ans. (*c*)

Q. 70. Quality control chart for averages was maintained for a dimension of the product. After the control was established, it was found that the standard deviation (σ) of the process was 1.00 mm. The dimension of the part is 70±2.5 mm. Parts above 72.5 mm can be reworked but parts below 67.5 mm have to be scrapped. What should be the setting of the process to ensure production of no scrap and to minimize the rework ?

(*a*) 68.5 mm (*b*) 70 mm (*c*) 70.5 mm (*d*) 72.5 mm

Ans. (*c*) Setlling should be at lower rejection limit + 3σ, *i.e.* 67.5 + 3 = 70.5 mm

Q. 71. Consider the following statements with respect to control charts for attributes :

1. The lower control limit is non - negative.
2. Normal distribution is the order for this data.
3. The lower control limit is not significant.
4. These charts give the average quality characteristics.

Which of the statements given above are correct ?

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

Ans. (*c*)

Q. 72. In case of solution of a two variable linear programming problem by graphical method one constraint line comes parallel to the objective function line. Which one of the following is correct ?

The problem will have

(*a*) infeasible solution (*b*) unbounded solution

(*c*) degenerat solution (*d*) infinite number of optimal solutions

Ans. (*a*)

Q. 73. Match List I (*Techniques/Methods*) with List II (*Models*) and select the correct answer using the codes given below the Lists :

List I (Techniques/Methods)	*List II (Models)*
A. Vogel's approximation method	1. Assignment model
B. Flood technique	2. Transportation model
C. Two phase method	3. PERT and CPM
D. Crashing	4. Linear programming

Codes :

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

Ans. (*b*)

Q. 74. The maximum distortion energy theory of failure is suitable to predict the failure of which one of the following types of materials ?

(*a*) Brittle materials (*b*) Ductile materials

(*c*) Plastics (*d*) Composite materials

Ans. (*b*)

Q. 75. Which one of the following conditons should be satisfied for the application of optimality test on an initial solution of transportation model ?

(*a*) Number of allocations should be less than m + n – 1.

(*b*) Number of allocations should be equal to m + n – 1.

(*c*) Number of allocations should be equal to m + n.

(*d*) Number of allocations should be more than m + n.

Ans. (*b*)

Q. 76. Customers arrive at a counter randomly at the rate of 6 customers per hour. The service is provided at the counter by a server. The mean time of the service is 4 minutes per customer. The services are exponentially distributed. What is the probability that a newly arrived customer has to wait ?

(*a*) 0.4 (*b*) 0.6 (*c*) 0.66 (*d*) 0.8

Ans. (*b*)

Q. 77. Which one of the following statements is correct ?
While designing a parallel sunk key it is assumed that the distribution of force along the length of the key

(*a*) varies linearly

(*b*) is uniform throughout

(*c*) varies exponentially, being more at the torque input end

(*d*) varies exponentially, being less at torque output end

Ans. (*b*)

Q. 78. Match List I (*Different systems*) with List II (*Associated terminology*) and select the correct ans wer using the codes given below the Lists :

List I (Different systems)	*List II (Associated terminology)*
A. Riveted joints	1. Nipping
B. Welded joints	2. Angular movement
C. Leaf springs	3. Fullering
D. Knuckle joints	4. Fusion

Codes :

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

Ans. (*d*)

Q. 79. In a cotter join, the width of the cotter at the centre is 50 mm and its thickness is 12 mm. The load acting on the cotter is 60 kN. What is the shearing stress developed in the cotter ?

(*a*) 120 N/mm^2 (*b*) 100 N/mm^2

(*c*) 75 N/mm^2 (*d*) 50 N/mm^2

Ans. (*d*) $50 \times 1000/(2 \times 50 \times 12) = 50$ N/mm^2

Q. 80. Match List I (*Coupling*) with List II (*Purpose*) and select the correct answer using the codes given below the Lists :

List I (Coupling)	*List II (Purpose)*
A. Muff coupling	1. To transmit power between two parallel shafts
B. Flange coupling	2. To transmit power between two intersecting shafts with flexibility
C. Oldham's coupling	3. For rigid connection between two aligned shafts for power transmission
D. Hooke's joint	4. For flexible connection between two shafts with some misalignment for transmitting power.

Codes :

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

Ans. (*b*)

Q. 81. Which one of the following is the correct expression for the torque transmitted by a conical clutch of outer radius R, inner radius r and semi - cone angle α assuming uniform pressure ? (Where W = total axial load and μ = coefficient of friction)

(*a*) $\dfrac{\mu W(R+r)}{2\sin\alpha}$ (*b*) $\dfrac{\mu W(R+r)}{3\sin\alpha}$

(*c*) $\dfrac{2\mu W(R^3-r^3)}{3\sin\alpha\,(R^2-r^2)}$ (*d*) $\dfrac{3\mu W(R^3-r^3)}{4\sin\alpha\,(R^2-r^2)}$

Ans. (*c*)

Q. 82. Which one of the following is the value of helix angle for maximum efficiency of a square threaded screw ? ($\phi = \tan^{-1}\mu$)

(*a*) $45° + \phi$ (*b*) $45° - \phi$ (*c*) $45° - \phi/2$ (*d*) $45° + \phi/2$

Ans. (*c*)

Q. 83. Which type of gears are used for shaft axes having an offiset ?

(*a*) Mitre gears (*b*) Spiral bevel gears

(*c*) Hypoid gears (*d*) Zerol gears

Ans. (*c*)

Q. 84. Which one of the following statements is correct ?
Certain minimum number of teeth on the involute pinion are necessary in order to

(*a*) provide an economical design

(*b*) avoid interference

(*c*) reduce noise in operation

(*d*) overcome fatigue failure of the teeth

Ans. (*b*)

Q. 85. Match List I (*Types of gear failure*) with List II (*Reasons*) and select the correct answer using the codes given below the Lists :

List I (Types of gear failure)	*List II (Reasons)*
A. Scoring	1. Oil film breakage
B. Pitting	2. Yielding of surface under heavy loads
C. Scuffing	3. Cyclic loads causing high surface stress
D. Plastic flow	4. Insufficient lubrication

Codes :

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

Ans. (*b*)

Q. 86. A helical gear has the active face width equal to b pitch p and helix angle α. What should be the minimum value of b in order that contact is maintained across the entire active face of the gear ?

(*a*) $p \cos \alpha$ (*b*) $p \sec \alpha$

(*c*) $p \tan \alpha$ (*d*) $p \cot \alpha$

Ans. (*d*)

Q. 87. Which one of the following statements is correct ? Shafts used in heavy duty speed reducers are generally subjected to

(*a*) bending stress only

(*b*) shearing stress only

(*c*) combined bending and shearing stresses

(*d*) bending, shearing and axial thrust simultaneously

Ans. (*c*)

Q.88. The diameter of a shaft is increased from 30 mm to 60 mm, all other conditions remaining unchanged. How many times is its torque carrying capacity increased ?

(*a*) 2 times (*b*) 4 times

(*c*) 8 times (*d*) 16 times

Ans. (*c*)

Q. 89. It is seen from the curve that there is minimum value of the coefficient of friction (μ) for a particular value of the Bearing Characteristic Number denoted by α. What is this value of the Bearing Characteristic Number called ?

(*a*) McKee Number (*b*) Reynolds Number

(*c*) Bearing Modulus (*d*) Sommerfeld Number

Ans. (*c*)

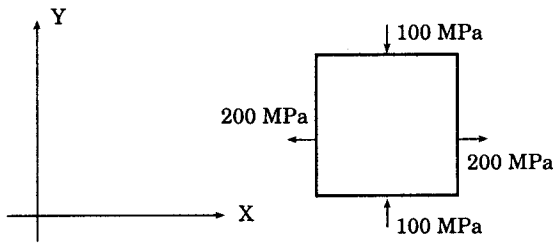
Q. 90. Which one of the following statements is correct ? Antifriction bearings are

(*a*) sleeve bearings (*b*) gas lubricated bearings

(*c*) ball and roller bearings (*d*) Journal bearings

Ans. (*c*)

Q. 91. Consider a two dimensional state of stress given for an element as shown in the diagram given below:



What are the coordinates of the centre of Mohr's circle

(*a*) (0, 0) (*b*) (100, 200) (*c*) (200, 100) (*d*) (50, 0)

Ans. (*d*)

Q. 92. The modulus of elasticity for a material is 200 GN/m^2 and Poisson's ratio is 0.25. What is the modulus of rigidity ?

(*a*) 80 GN/m^2 (*b*) 125 GN/m^2 (*c*) 250 GN/m^2 (*d*) 320 GN/m^2

Ans. (*a*) $E = 2G\left(1 + \frac{1}{m}\right)$, $G = \frac{200}{2 \times 125} = 80$

Q. 93. Which one of the following is correct in respect of Posson's ratio (ν) limits for an isotropic elastic solid ?

(*a*) $-\infty \leq \nu \leq \infty$ (*b*) $1/4 \leq \nu \leq 1/3$ (*c*) $-1 \leq \nu \leq 1/2$ (*d*) $-1/2 \leq \nu \leq 1/2$

Ans. (*b*)

Q. 94. A bar of length L tapers uniformly from diameter 1.1 D at one end to 0.9 D at the other end. The elongation due to axial pull is computed using mean diameter D. What is the approximate error in computed elongation ?

(*a*) 10 % (*b*) 5 % (*c*) 1 % (*d*) 0.5 %

Ans. (*c*) Elongation with tapered bar $\alpha \frac{0.1}{0.9 \times 1.1}$ *i.e.* $\frac{1}{0.99}$ $\therefore$ error = 1%

Q. 95. A bar of copper and steel form a composite system. They are heated to a temperature of 40°C. What type of stress is induced in the copper bar ?

(*a*) Tensile (*b*) Compressive

(*c*) Both tensile and compressive (*d*) Shear

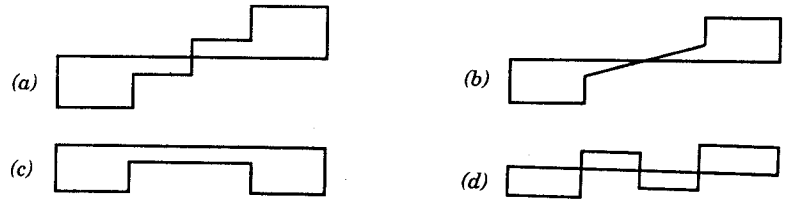
Ans. (*b*)

Q. 96. A cube with a side length of 1 cm is heated uniformly 1°C above the room temperature and all the sides are free to expand. What will be the increase in Volume of the cube ? (Given coefficient of thermal expansion is α per °C)

(*a*) 3 α cm^3 (*b*) 2 α cm^3 (*c*) α cm^3 (*d*) zero

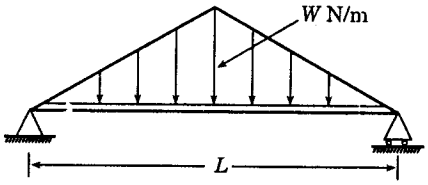
Ans. (*a*)

Q. 97. A beam of length 4 L is simply supported on two supports with equal overhangs of L on either sides and carries three equal loads, one each at free ends and the third at the mid - span. Which one of the following diagrams represents correct distribution of shearing force on the beam ?



Ans. (*d*)

Q. 98. A simply supported beam is subjected to a distributed loading as shown in the diagram given below:



What is the maximum shear force in the beam ?

(*a*) WL/4 (*b*) WL/2 (*c*) WL/3 (*d*) WL/6

Ans. (*a*)

Q. 99. A cantilever beam of length *l* is subjected to a concentrated load *P* at a distance of *l*/3 from the free end. What is the deflection of the free end of the beam ? (EI is the flexural rigidity)

(*a*) $\frac{2\,Pl^3}{81EI}$ (*b*) $\frac{3\,Pl^3}{81EI}$ (*c*) $\frac{14\,Pl^3}{81EI}$ (*d*) $\frac{15\,Pl^3}{81EI}$

Ans. (*c*)

Q. 100. What is the nature of distribution of shear stress in a rectangular beam ?

(*a*) Linear (*b*) Parabolic (*c*) Hyperbolic (*d*) Elliptic

Ans. (*b*)

Q. 101. A solid circular rod AB of diameter D and length L is fixed at both ends. A torqe T is applied at section X such that AX = L/4 and BX = 3 L/4. What is the maximum shear stress developed in the rod ?

(*a*) 16 $T/\pi D^3$ (*b*) 12 $T/\pi D^3$ (*c*) 8 $T/\pi D^3$ (*d*) 4 $T/\pi D^3$

Ans. (*a*)

Q. 102. A spring with 25 active coil cannot be accommodated within a given space. Hence 5 coils of the spring are cut. What is the stiffness of the new spring ?

(*a*) Same as the original spring (*b*) 1.25 times the original spring

(*c*) 0.8 times the original spring (*d*) 0.5 times the original spring

Ans. (*b*)

Q. 103. A closely coiled helical spring of 20 cm mean diameter is having 25 coils of 2 cm diameter rod. The modulus of rigidity of the materials is 10^7 N/cm^2. What is the stiffness for the spring in N/cm ?

(*a*) 50 (*b*) 100 (*c*) 250 (*d*) 500

Ans. (*a*)

Q. 104. Match List I (*Type of moulding*) with List II (*Mechanism involved*) and select the correct answer using the codes given below the Lists :

List I (*Type of moulding*)	*List II* (*Mechanism involved*)
A. Compression moulding	1. Mould cavity must be heated to curve the platic forced into it
B. Injected moulding	2. Similar to Hydraulic extrusion
C. Jet moulding	3. Analogous to hot-pressing of powdered metals
D. Extrusion moulding	4. Analogous to die casting of metals

Codes :

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

Ans. (*b*)

Q. 105. Match List I (*Steel type*) with List II (*Product*) and select the correct answer using the codes given below the Lists :

List I (*Steel type*)	*List II* (*Product*)
A. Mild steel	1. Screws
B. Tool steel	2. Commerial beams
C. Medium carbon steel	3. Crane hooks
D. High carbon steel	4. Blanking dies

Codes :

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

Ans. (*a*)

Q. 106. Match List I (*Alloy*) with List II (*Application*) and select the correct answer using the codes given below the Lists ;

List I (*Alloy*)	*List II* (*Application*)
A. Silicon steel	1. Marine bearings
B. High carbon steel	2. Cutting tools
C. High speed steel	3. Springs
D. Monel metal	4. Transformer laminations

Codes :

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

Ans. (*b*)

Q. 107. Conside following statements about cold working.

1. higher forces are required.
2. no heating is required.
3. less ductility is required.
4. better surface finish is obtained.

Which of the statements given above are correct ?

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

Ans. (*a*)

Q. 108. Consider the following factors :

1. Size and shape that can be produced economically.
2. Porosity of the parts produced
3. Available press capacity.
4. High density.

Which of the above are limitation of powder matallurgy ?

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

Ans. (*c*)

Q. 109. Match List I (*Welding problems*) with List II (*Causes*) and select the correct answer using the codes given below the Lists :

List I (Welding problem)	*List II (Causes)*
A. Cracking of weld metal	1. Excessive stresses
B. Cracking of base metal	2. High joint rigidity
C. Porosity	3. Failure to remove slag from previous deposit
D. Inclusions	4. Oxidation
	5. Excessive H_2, O_2, N_2, in the welding atmosphere

Codes :

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

Ans. (*d*)

Q. 110. Consider the following statements :

The size of the heat affected zone (HAZ) will increase with

1. increased starting temperature
2. increased welding speed.
3. increased thermal conductivity of the base metal.
4. increase in base metal thickness.

Which of the statements given above are correct ?

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

Ans. (*b*)

Q. 111. Consider the following statements :
The magnitude of residual stresses in welding depends upon
1. design of weldment.
2. support and clamping of components
3. welding process used
4. amount of metal melted/deposited.

Which of the statements given above are correct ?
(*a*) 1, 2 and 4 (*b*) 1, 2 and 3
(*c*) 1 and 3 (*d*) 2 and 3

Ans. (*a*)

Q. 112. The cutting speed of a milling cutter while cutting brass is :
(*a*) 45 to 60 m/min (*b*) 30 to 40 m/min
(*c*) 25 to 35 m/min (*d*) 15 to 20 m/min

Ans. (*b*)

Q. 113. In a machining operation chip thickness ratio is 0.3 and the back rake angle of the tool is 10°. What is the value of the shear strain ?
(*a*) 0.31 (*b*) 0.13
(*c*) 3.00 (*d*) 3.34

Ans. (*d*) Shear strain = $\cos \phi + \tan (\phi - \alpha)$, and $\tan \phi = \dfrac{r \cos \alpha}{1 - r \sin \alpha}$

Q. 114. Consider the following statements :
The helical flute in a twist drill provides the necessary
1. clearance angle for the cutting edge.
2. rake angle for the cutting edge.
3. space for the chip to come out during drilling.
4. guidance for the drill to enter into the workpiece.

Which of the statements given above are correct ?
(*a*) 1 and 2 (*b*) 2 and 3
(*c*) 3 and 4 (*d*) 1 and 4

Ans. (*b*)

Q. 115. One brand of milling machine has the followign two index plates supplied along with the indexing head :
Plate 1 : 15, 16, 17, 18, 19, 29 hole circles.
Plate 2 : 21, 23, 27, 29, 31, 33 hole circles.
It is proposed to mill a spur gear of 28 teeth using simple indexing method. Which one of the following combinations of index plate and number of revolutions is correct ?
(*a*) Plate 1 : 1 rovolution and 9 holes in 18 hole circles
(*b*) Plate 2 : 1 revolution and 9 holes in 21 hole circles
(*c*) Plate 2 : 1 revolution and 9 holes in 33 hole circles
(*d*) Plate 1 : 1 revolution and 9 holes in 15 hole circles

Ans. (*b*)

Q. 116. Match List I (*Cutting tools*) with List II (*Features*) and select the correct answer using the codes given below the Lists :

List I (*Cutting tools*)	*List II* (*Features*)
A. Turning tool	1. Chisel edge
B. Reamer	2. Flutes
C. Milling cutter	3. Axial relief
	4. Side relief

Codes :

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

Ans. (*c*)

Q. 117. Match List I (*Milling problem*) with List II (*Probable causes*) and select the correct answer using the codes given below the lists :

List I (*Milling problem*)	*List II* (*Probable causes*)
A. Chatter	1. Too high feed
B. Poor surface finish	2. Lack of righdity in machine, fixtures, bar or workpiece
C. Loss of accuracy	3. High cutting load
D. Cutter burrs	4. Radial ralief too great
	5. No enough lubricant

Codes :

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

Ans. (*a*)

Q. 118. Consider the following characteristics :

1. Single machine tool.
2. Manual materials handling system.
3. Computer control.
4. Random sequencing of parts to machines.

Which of the above characteristics are associated with flexible manufacturing system ?

(*a*) 1, 2 and 3 (*b*) 1 and 2

(*c*) 3 and 4 (*d*) 2, 3 and 4

Ans. (*c*)

Q. 119. Consider the following statements with respect to the relief angle of cutting tool :

1. This affects the direction of chip flow.
2. This reduces excessive friction between the tool and workpiece.
3. This affects tool life.
4. This allows better access of coolant to the tool - workpiece interface.

Which of the statements given above are correct ?

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

Ans. (*b*)

Q. 120. Consider the following statements :

During the third stage of tool-wear, rapid deterioration of tool edge takes place because

1. flank wear is only marginal.
2. flank wear is large.
3. temperature of the tool increases gradually.
4. temperature of the tool increases drastically.

Which of the statements given above are correct ?

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

Ans. (*b*)

PART—IV
INTERVIEWS

Interviews

What is interview?

The purpose of interview is to know about the capabilities of a person for a specific purpose. It is a method of assessing the suitability of job seekers for a given job. An interview refers to a meeting arranged with a purpose in which conversation takes place between interviewers and the interviewee in the form of questions and answers. The interviewer tries to evaluate the suitability of interviewee for a given job, whereas interviewee tries to convince the interviewers that he/she is the right choice for the job. Interviewers are good observers, patient listeners, have strong capability to gauge the candidate.

As the interviewers conduct the interview, they carefully observe the verbal and non-verbal responses, the personality attributes, expression power, attitude of candidate, his/her ability to conduct in difficult situations, logical reasoning capabilities.

In interviews, the basic aim is to judge the personality of a candidate, *i.e.* to assess the capacity of candidate for leadership, initiative and intellectual curiosity, tactfulness and other social qualities, mental alertness, grasp, practical application, integrity of character, approach to handle problems, motivation, endurance, communication skills, etc.

Interview — An art or science ?

Suitability of a person was earlier assessed by screening the information available in the application form, *i.e.* the academic record, work experience, etc. But as competition increased, the screening is being based on 2 or 3 or more stages. These may consist of conducting written tests, group discussions, personality tests, a few rounds of interviews (database interviews, situation interviews, stress interviews, teleconferencing interviews, etc.). A lot of scientific methods of evaluation have been developed. Techniques of conducting tests and screening have undergone drastic changes. Techniques of job analysis, job description, identifying duties and responsibilities for successful performance have been upgraded and help in facilitating selection of right candidate. Training courses are available both for interviewers (to conduct interviews in scientific way keeping objectives in mind), and interviewees (to face the interviews confidently and make clear and honest exhibition of their intelligence, attributes and capabilities). The candidates are subjected to several hours of perseverence not to harass them but to select the best possible candidate for a given job. A proper understanding of selection process is essential.

Why an Interview ?

Research reveals that effectiveness of interviewing, as a method of evaluating the suitability of a candidate for a job, measures around 12-20%, *i.e.* only 12 to 20 persons out of 100 are likely to be suitable candidates selected for a job. It is so because in many places, interviews are mere formalities and not conducted in scientific manner. In order that interviews are more effective in selection of suitable candidates, the interviewers should be given proper training for interviewing the candidates by objectives, taught the art of questioning and analysing the responses of the candidates. Interviewers have to clearly understand the job specifications/profiles, the qualities and attributes desirable for performance of the job, expectation from prospective candidates.

Interviews enable management to have feel of the type of person they are going to get, to gauge the depth of knowledge, judge the temperament and responses of candidate, his/her ability to react in difficult situations. Interviews provide an opportunity for both management and candidate to understand each other. Candidate can know about persons he/she has to deal with and the expectation of management, present himself/herself and try to cover up for any deficiency in grades or experience, and also impress management with his/her talent, initiative, drive, and other positive qualities.

Types of interviews

As already stated, interview continues to be an inescapable part of job securing process. In any selection process, substantial weightage is given to performance of a candidate in interview.

Various types of interviews, the candidates may have to face are :

(*i*) *One-to-one interview.* In such interview, the candidate is interviewed by a single individual, and it is usually the case in small sized private companies. Such an interview can be easily arranged and carried out. The candidate can feel more relaxed and express more openly. Usually the interviewer being a person with whom candidate has to work, such interview can yield fruitful outcome. However, the interviewer must know the art of interviewing and should not have any bias, to be able to select the most suitable candidate.

(*ii*) *Panel interview.* A panel interview is well suited for government organisation or autonomous body. This type of interview, also called board interview, enables selection of suitable candidate in just one interview. The board usually consists of four to six members headed by a chairman. The panelists may be nominees of the board of governors and finance committee, invited experts, senior executives of the company picked up from specialised areas of work, management, finance etc. Such interview process is fast and fair. The candidate is not subjected to strong likes and dislikes of one individual interviewer. Each interviewer acts as a check on the judgement of the other. The chairman plays a key role. He does the job of co-ordinating the interview and invites the experts one by one to examine the candidate. He makes the candidates get settled down by asking questions related to his background. Chairman may also ask some supplementary questions at the end of interview.

The instructions and suggestions given by chairman initially should be given full attention. While a candidate is being interviewed by a member, and if chairman interrupts, then candidate must pay immediate attention to chairman. The chairman takes decision after listening to the impression of all the board members, their comments about the candidate and finally on his own impression. The candidate gets interviewed on a variety of subjects related to his field, because each expert covers different areas.

Usually the interview panel is not aware of the scores of a candidate in written test. Accordingly the candidate, irrespective of performance in written test, can perform better in interview, if he/she has positive mental attitude, strong willpower, is active and ambitious.

(*iii*) *Screening Interviews.* Due to large scale unemployment, usually thousands of applications are received for one post. It thus becomes essential to scan the applicants and to reject those who do not meet the minimum prescribed criteria. Screening process could be conducted on telephone or by inviting candidates in person. In such interviews candidate should take it easy, need not be too formal, be polite and never express annoyance on any matter. The basic aim of such interviews is to screen out candidates on the basis of lack of qualification and experience, irrelevance to job, general behavior and nature, physique, expression, etc. The task before screening committee is to select ten candidates for a post, and all the ten should be worthy of being interviewed by the specialists and top executives.

Screening interview could be conducted sequentially, one following another by screening candidates every time. This is usually done when number of candidates are large so that only selected candidates after screening are to be interviewed by a panel of experts.

(*iv*) *Structured Interviews.* Same set of questions are asked to all the candidates with a view to compare the candidate more reliably and accurately. Sometimes same questions are repeated in different words to different candidates. Usually a large number of questions are posed to make the structured interviews more comprehensive. Usually computers are used to store, retrieve and compare the data of all the candidates. Such interviews are time consuming and dull.

(*v*) *Situational Interviews.* In such interviews the idea is to judge the responses of candidate under the real job conditions. Thus a situation of job is hypothetically created and relevant questions in form of 'if' and 'when' concerning the job environment are asked to judge the skills and traits of the can-

didate. Candidate need to react immediately, but can take time to think, analyse logically and then he can reply providing demonstration of his skills and resourcefulness in handling the situation. If situation is not clear, one may express his inability and request for another question instead of guessing about unknown area. Such frankness often pays as interviewers understand that no one is expert to handle all types of situations.

(*vi*) *Stress interviews.* Such interviews are conducted for jobs which are very demanding and the candidate is required to maintain his calm under difficult situations. A candidate is subjected to stress by a panelist by asking more than one question at a time, asking unrelated questions one after other without giving adequate time to respond to earlier question, using interrogatory tone and voice, provoking the feelings of the candidate, sometimes even using unpleasant words, etc. A candidate need not get worked up under such conditions, keep pitch of voice under control, need not retaliate. Instead he can pass smile, start answering various questions in a pleasant mood and tone. Candidate may like to answer last question first or in any sequence so as to maintain a logic and coherency.

(*vii*) *Walk-in-Interview.* Such interviews are conducted when companies are in immediate need of middle level managers/officers. Three to five days notice is given by inserting advertisements in leading newspapers and candidates are requested to contact the interviewee on particular days between specified hour. On reaching the office, candidate instead of peeping straight in the office of interviewee may contact the personal secretary first who would arrange interview at the earliest opportunity. Other way could be to fix up the time on telephone in advance. The candidate may reveal his name on telephone while fixing up the time. The prescribed time may be strictly adhered to. This itself will leave a good impression about the candidate.

(*viii*) *Group discussion.* It is a good method of screening unwanted candidates and picking up prospective candidates who can subsequently be interviewed. Group discussions are held with 5 to 8 candidates who are asked to interact on a given topic. The topic for discussions can be a problem stated inadequately. Alternately it could be based upon a set of data, graphs, facts and figures. The basic theme behind it is to judge the ability of candidates to formulate the problem, analyse their depth of understanding of a situation, to judge their ability to intercept given information. The performance of all the candidates is carefully observed by two or three judges. The initiative, problem solving skills, clarity of thought, presentation and communication skills, team skills of candidates are observed.

For success in group discussions it is important that candidates are able to rephrase the question in quantitative terms, make best use of basic laws, principles, rules and regulations, persuade others to follow his/her line of thought and action, think creatively and hit upon ideas and newer solution, liaise with others in getting information and exchange thoughts, display qualities of leadership, optimise the solutions, show patience in listening to others and hitting and pouncing on getting a chance, summarise the discussions. One can perform well in group discussions if he/she is attentive, has learnt well to express clearly and communicate freely, does not feel shy and is bold, tactful and confident, disciplined. All these qualities need to be developed and practiced. Before starting to speak out in group discussions, one should for a while concentrate on the problem, take brief notes and keep a record of events in mind. On getting a chance one should get started and demonstrate his/her abilities by expressing the viewpoints clearly and logically. To appear dumb is most harmful. One has to control his/her tone in communicating and never get emotional or excited. If one can remember the names of other candidates in groups, it is better to address them with their names to draw their attention towards you. In such discussions one should not interrupt others and should never mumble. In case discussions are deviating from the theme, you can remind speaker politely about the objectives of discussions. If one can take role of leader, that is excellent and should summarise the discussions highlighting the keypoints and the outcome. Every effort needs to be made to leave an impression of your qualities among the group members and the observers.

(*ix*) *Using Resume to Screen Applicants for Interviews.* Interviewers form some opinion about candidate on the basis of biodata like qualification, experience, achievements in previous career, personal interests, etc. A resume [or biodata, or (CV) Curriculum Vitae)] is very important document since it forms the starting point to judge a candidate. The CV should be concise, well written and professional looking. Presentation of CV matters a lot. A CV should be prepared in professional way to reflect the achievements, strength, attitudes and skills of the candidate. Presentation of information about education, experience and qualities deserves serious attention. Many times resume forms basis for interviewing and thus it should highlight the strong points so that questions are based on these points. In these days, writing CV is an art which every one should learn. CV should create an impression, be typed out neatly and legibly on white paper. There should be no grammar errors, and spelling mistakes, or typographical errors. Short and simple words should be used which make easier reading. It should be properly organised, covering all aspects in a professional way. Overwriting should be avoided. The accomplishments should be highlighted, avoiding irrelevant details. It should be prepared on a separate sheet with photo pasted on top right and attached with a well drafted covering letter. Remember your resume represents you before the screening authority. Neat, well presented, easy to read, to the point information about achievements without any irrelevant details would present an excellent visual aspect, reflect your personality on paper and help in being picked up.

Physical Preparation for Interviews

Well groomed corporate look of a candidate matters a lot in the interviews. The first impression created by his/her general appearance, personality, fresh looks, smile on face, the way of entering and greeting the board, etc. are of paramount importance. Interviewers carefully watch a candidate as he/she enters the room and walks to the chair to take his/her seat. They also critically observe the physical expression of a candidate when he/she is thinking, responding and reacting.

The general impression of a candidate is dependent on the good appearance for which it is essential that candidate takes good sleep on previous night, well dressed (shirt-right fit, comfortable collar and light colour ; jacket well tailored and dark in colour, tie matching with clothes, trousers without bulge and matching with the jacket, hair short and well cut, beard well trimmed, eye glasses framed to match skin tone and shape of face, slim brief-case and well organised inside, polished shoes and laced, long socks properly matching with trousers, etc. reaching before time, documents arranged properly, no tension or anxiety on face, appearing confident and alert. Preparation for dress, articles needed for grooming, documents (original and photocopies, CVs, blanksheets, pen and pencils, erasers, highlighters), fuel in the vehicle etc. be taken care of one day before the interview so that on the day of interview one need not get perplexed in arranging them. On the day of interview one should prepare to look fresh, clean, neat and well dressed so that he/she is more comfortable and appear more impressive.

In the interview, apart from general appearance, factors like smile of a person, the way of making eye contact, the way of speaking and expressing, the body language, appearance and alertness also have great influence on success of interview.

The candidate should identify his area of strength and plan so that on getting earliest chance, the candidate should create interest in the interviewers in the same area. By little efforts, it is possible to drag the interviewers to the subjects of your strength. Sometimes the panel can be known beforehand and also their pet areas which should be studied thoroughly before interview.

Knowledge of Company Before Interview

Before joining a company, one should try to have a good knowledge about the company since one has to make a career with them.

It always pays to know about the organisation in terms of nature of activities of the organisation, approximate employee strength, major activity centres, activity profile, major milestones, name of the head of the organisation, reputation of company, their future plans and developmental perspectives etc.

It is important not only because the organisation expects you to know all that but also because it would go a long way in boosting your confidence. In addition, it would help you to assess the level of seriousness that you have for the job in question. In fact, it is better if you take the pains to know a little about other similar organisations also. At the time of interview, the company would expect you to know a little about the activity profile of the organisation and its major achievements. And if you know about some things like the name of head of the organisation and so on, it will be a bonus. It would be even worthwhile to get hold of annual reports of these organisations which are brought out by almost all Governmental and Public sector organisations, as well as large sized private companies. This way one can get a glimpse of the performance of this company.

Another aspect that can probably be looked into is to visit the office where you are likely to be interviewed. A visit to the place of interview, may be a couple of days before the date of interview, would go a long way in familiarising you with the place and boosting your confidence.

Sometimes it pays to talk to someone who has already faced the board during those days. This is particularly applicable to very large organisations where the interviews may go on for more than one day. This could give you a lot of useful information on attitude of the board, the constitution of the board, the field of specialisation of different experts, the nature of questions being asked and so on. It is interesting to note that almost all experts have their own list of favourable questions which they don't miss to ask.

Knowing about the company before interview is essential because one should prepare application to suit the requirements of the company. The inside information about company can be obtained from study of rise or fall in profits, performance of share of company, reputation of promoters and other companies promoted by them. The desired information about company can also be obtained by writing to them directly. One should also try to know about product and processes, annual production, future expansion plans, organisational structure, the details of collaborators, if any, whether the company is diversifying into other areas. All such information about a company would create confidence in a candidate about his/her future prospects in the company, and enable him/her to face the interview board with greater confidence.

Types of Questions

The interviewers may ask any type of question depending on their first impression, their mood and requirements of the job. Generally the following types of questions in any order may be asked.

(*i*) *Introductory questions.* The aim is to initiate the dialogue and make the candidate start talking and establish the facts stated in biodata. Such questions have an expected response built in them and as such the answers may be in the form of 'Yes, Sir,' 'No, Sir', etc. Examples of such questions may be : You have done specialisation in instrumentation and controls. Answer will be Yes, Sir. You have mostly worked in power plants. Can you take care of requirements of chemical plants. Answer will be "Yes, Sir. The basic principles and techniques are by and large same in all types of industries". Private entrepreneurs are more demanding than state enterprise. Answer may be 'Yes, Sir, I understand it, Sir'.

(*ii*) *Open-ended questions.* These are asked to explore the background of the candidate and make him/her explain and demonstrate his/her knowledge and experience. Interviewers judge the attitude of the candidate while he/she is answering such questions. Such questions could be in the form of Tell us something about your .... ; What do you think about ..... ; Can you describe your .... ; Which computer languages you know ? How did you .... ; What is your opinion about .... ; Why did you leave earlier company etc. The candidate is expected to narrate his/her experience in details and show enthusiasm in his/her answering. He/she may make figures on a paper to clarify his/her viewpoint and clarify the explanation as much as possible.

(*iii*) *In-depth or probing questions.* Through these questions the interviewers try to probe the depth of understanding of candidate regarding his/her knowledge of the subject. The interviewers try to seek more and more and further information. They ask follow up questions on the statements made by the candidate. Such questions could be either real-life or hypothetical type. Their aim is to determine as to how the candidate would react to a situation in real field. All the qualities and attributes of the

candidate get judged. Such questions are in the inform of—. If this is ..., Why do you choose to...., What would you do if ..., But then ...., If .. then ..., How do you about ...., When .... how should ....., Where you see yourself five years from now ? Why you want to leave present job ? How many employees work under you ? Did management offer you freedom of action ? What is your position in the administrative hierarchy ? Describe your reaction on getting first promotion etc.

The candidate should think twice before jumping to answer. He/she must elaborate his view point. He/she may make use of paper for clear presentation.

(*vi*) *Close ended questions.* The aim of such questions is to ask specific and factual information on specific items and to test the knowledge base of the candidate on facts and figures. The questions may take the form of : What was your ... ; What is the .... ; Can you ..... ; Which one .... ; When do you .... ; How long were you ..... ; etc. The answers to such questions should be brief and to the point.

(*v*) *Impertinent or sarcastic questions.* Sometimes, such questions are asked to cause stress to a candidate if job requirements are such. The candidate has to maintain his calm and balance and respond to such questions with dexterity. There is no need to get excited and react violently showing signs of anger. If a candidate can show the restraint under such situations, he/she will be rated quite high.

(*vi*) *Compounded question.* Such questions are often confusing, there being several questions at a time. A candidate has to listen such questions carefully. An example of such question would be — Why pipe flow is determined from Mannings or Chezy's formula and not Benzin formula, if that be so what for Benzin formula is used. A candidate should answer such questions precisely.

(*vii*) *Hypothetical questions.* These are open questions, often meant to gauge the reach of imagination of a candidate and ability to tackle the hypothetical situations likely to be encountered.

Such questions may be in the form of

— What would you do if....
— What could have happened if ....
— Supposing your supervisor abused you, how you would react ?
— If you were fired one morning ....

(*viii*) *Reflective questions.* There are sensitive and tactful questions because these reflect back to the candidate some observations of the employer. Questions may take the form such as

— You seem to feel upset with ...
— If we understand you correctly, perhaps you ...
— In other words, you do not...

(*ix*) *General questions.* General questions are asked to know about qualification, experience and to discover the attributes of the candidate, *i.e.* know what candidate has done in past. Such questions could take the form. Could you describe yourself, about family background, place to which candidate belongs, father's profession, academic background, subjects studied at college, grades in studies, most favourite subject, least favourite subject, rank in the class, how do others describe you, ambitions and goals, how you take major decisions and who help in taking major decisions, about strength and weakness. Why candidate feels he/she is fit for the job, about interest in extra-curriculars ; details of previous job and reasons to leave the same ; about attitude of previous boss ; about key accomplishments of candidate ; candidate's own assessment where he/she can contribute best results ; liking to travel different places ; steps taken by candidate to overcome the weaknesses ; how important is carrier to candidate ; whether candidate likes his/her job to be assessed by others ; which books candidate reads for pleasure ; how candidate spends spare time ; details about practical training ; whether the candidate would like to pursue same course again if another chance is given ; where candidate would like to see him after five years ; whether a candidate would mix up well with colleagues — if yes — why and if it — why ; In which subject the candidate performed too well and why and in which subject the candidate faired badly and why ; out of money and power which is most important for candidate ?

The other set of general questions could be directed to find out the capabilities and resourcefulness of candidate in handling new areas of work. Such questions may be in the form of whether candidate is looking for comfortable or challenging job ; how the company would be benefited by the selection of the candidate ; what can the candidate do in the proposed position ; reaction of candidate if he/she finds job unsatisfactory ; the details of ambitions and goals of candidate in life and how the present job will help him/her ; how important is the career to the candidate ; whether candidate likes taking responsibilities and accepts challenges ; how his/her performance can be assessed by management ; the reaction of candidate for outside posting ; what does candidate look for after serving for sometime in proposed job ; why the company should select him/her ; whether candidate can manage time and whether he/she is an organised person and how ; reaction of candidate to a colleague who is not helpful; whether candidate wants to learn further and undergo training; whether candidate is interested in money, power, or satisfaction; how candidate will react if his/her boss asks to do a thing which he/she feels will not be in the interest of the company ; any evidence to show that targets were not missed ; methods to motivate others, what kind of people are difficult to get on, kind of people you get on best with, your reaction in case you are fired for mistake of others, what you have learnt from your failures, what you would do if not selected in this interview ; happiest moment of life ; most depressing moment of life ; whether the candidate is introvert or extrovert ; who has influenced the life of candidate the most; description of difficult situation handled successfully ; concept of ideal boss ; how candidate would handle woman subordinates ; concept of ideal subordinate ; how you judge your friends ; how do you overcome your weakness in performing the job, etc.

(*x*) *Frequently asked questions.* A candidate should be fully prepared for generally asked questions about background, ambition and goals, work experience, personality, hobbies and interests, etc. Since such questions have relevance for everyone, and these are frequently asked, the candidate should spend some time to review answers for them. Fumbling in answering such questions would leave poor impression. As information about these aspects is provided in the biodata, the answer should fall in line with information provided in the biodata. It is thus essential that the candidate reads his biodata carefully before interview to avoid any contradiction.

A classic opener in most interviews is — Tell us something about yourself. Although very easy question but one has to prepare for such simple questions with good care. The opening statement should be a summary of professional capabilities, achievements, background, strengths, professional objectives, relevant and interesting aspects about personality. A recital of what is stated in biodata may be boring and uninteresting. Same facts have to be put up in an interesting way. Take opportunity to lead interviewers in the direction of your strength, speciality and achievement. Irrelevant aspects of background may be ignored. Encouraging, positive and enthusiastic attitude can be stressed. Cover those aspects which are relevant and help in selection. Negative aspects of home background should be ignored. Avoid speaking for the sake of speaking.

Some generally asked questions are as follows. The analysis of various responses is also given to educate the candidate.

(*a*) Why do you want to leave present job ?

Four different candidates replied as under

(*i*) I did not get promotions.

(*ii*) I wish to leave present job because I can do better in new job due to my qualities.

(*iii*) I find my present job monotonous and I get meagre salary.

(*iv*) I am doing well in present job but I can do better in new job as it is to my liking and I have all the skills for new job.

Here first candidate ; though frank and candid but nobody would like to hear this reason. It also reflects on candidate that there might have been some shortcomings with the candidate. Second can-

didate gives no reason to leave the job but only uses general type of language and adjectives. This is also not satisfactory. Third candidate appears to be disgusted and complaining type which may not be liked by others. Response of fourth candidate is satisfactory because he has shown satisfaction with present job and given good reasons for seeking better prospects.

(*b*) How do you keep yourself uptodate ?

(*i*) I remain very busy in my work and learn new things there only.

(*ii*) I often revise my notes.

(*iii*) I read journals and attended a training course recently.

(*iv*) I look for good courses and often watch educative programmes on TV.

First candidate finds excuse in not keeping himself up-to-date . Remember that a person can always find time if he has will, howsoever busy he/she may be. Nobody likes to hear excuses. Second candidate does not realise that revising earlier notes alone will not help and has taken no steps for further advancement. Third candidate keeps himself uptodate by reading journals but has not planned for himself properly. Fourth candidate does right things for a progressive person and that is what is really required.

(*c*) How is your effectiveness measured in present job ?

(*i*) I am sincere worker. Why any body should measure my effectiveness.

(*ii*) My bosses keep a watch on me and see to it that I do my job well upto their expectation.

(*iii*) My company has a system of monthly appraisal vis-a-vis objectives and my boss reports regularly about my performance.

(*iv*) I monitor my performance on week to week basis and evaluate the same against weekly targets set.

Here first candidate appears to be totally ignorant about assessment. The response of second candidate is inadequate. Third candidate though aware of assessment by boss but makes no self appraisal. Fourth candidate has proper system of periodic self-evaluation and that is what people look for and like.

(*d*) How do you plan and manage your time ?

(*i*) I keep so busy there is no time to plan for time.

(*ii*) I spend most of my time in good activities and watch TV and relax in spare time.

(*iii*) I spend good time in office and rest of the time in social activities.

(*iv*) I prepare a list of activities to be performed next day, allot time for them and ensure adherence.

First candidate is not even aware of important concept of time management which is very vital for present day's executive. His feeling of busy will not help him achieve anything. Second and third candidates are also spending time like most of ordinary persons. This is not enough for success in life. A fourth candidate plans properly for his time, he finds time for everything and attends to all activities within a specified time slot. One has to allocate priorities to various activities and try to complete them within allocated time. Planning in advance is important so that none of important activities are overlooked. Also remember that spending more than necessary time for any activity is wastage of time and same is done at the cost of other important works to be attended.

(*xi*) *Innocent questions.* Sometimes interviewers ask innocent questions which may appear to be irrelevant but there is objective behind such questions to come to know important qualities and abilities. For instance question — How you spent your time in college vacations. The main purpose or motive is to know about how energetic/adventurous or sociable a person is. Question about hobbies is asked to know whether the candidate has intellectual pastimes or solitary interests, to understand taste and liking of the candidate. To gauge how much a person is attached with his family and whether he can take the risk of leaving family, the question instead of being put directly may be asked in the form of describe your domestic circumstances and your future plans. Question like — were you at any time let down by others, is asked to test the level of endurance of candidate. The decision making power

of a candidate is judged by asking who inspired him to pursue master degree. The verbal skills and clarity of expression can be judged by asking a candidate to describe an accident scene. It is important to understand that each of such questions has a bearing with the requirements of the job and thus they help in selecting the suitable candidate for the given job.

(*xii*) *Some questions not to be answered directly.* Many times interviewers ask such questions whose direct answer will only lead them to further trap. For instance, if asked — What is more important out of money, post, name, or family. The moment a candidate admits any one of these, the next trap question will be ready. Such questions have to be answered indirectly and tactfully.

The answer to such a question could be attempted as follows : Sir, while all the four are important, the preference could depend on so many factors and circumstances. In general, work is more important because one can contribute his best when job satisfaction is there. Depending on success in job, money will automatically flow. While family is also important, compromise needs to be made to satisfy their requirements by proper management of time. If three fronts are in order, name will automatically flourish.

Right Attitude

If a candidate adopts a negative attitude towards the interview and starts worrying about a possible failure in the interview, his/her deficiencies and limitations come to the fore. Candidate gets completely worked up, nervous and over-anxious. Some non-serious candidates feel that the competition is too fierce for them to succeed or that the job is not worth taking all that trouble with the result that they take the whole interview process very casually. Both these situations are not desirable. It is important that the candidate goes to the interview with the right attitude.

A right candidate should be confident and relaxed, but be a little anxious which enhances the performance rather than inhibits it. Being over-anxious harms the prospects of candidate. One should feel enthusiastic about the interview. One should sound and look not only keen in the job but also in the interview. The voice and face expressions of a candidate convey a lot to the board members about seriousness, interest and commitment. Enthusiasm coupled with a smiling face always scores over a casual looking attitude and a stony face.

Most interviewers expect the candidates to be polite and agreeable. So, if you have a different opinion and even if you are sure that you are correct, you should try to express your viewpoint in such a way that you don't offend the interviewer. A candidate should learn the art of acknowledging the opposing views of the interviewer without actually accepting them. Any issue can be debated in a more professional way. If interviewers try to provoke the candidate and attack his/her views in a more personal way, the candidate should remain cool under such circumstances and never lose temper. It is better to avoid firm expressions of disagreement with the interviewer except in cases where they want you to express your views on a certain topic. Sometimes, a little provocation from the interviewer is done purely from the viewpoint of knowing as to how the candidate reacts under stress.

Eye contact is other important component of having the right attitude in the interview. The candidate should have lot of eye contact with the interviewer but short of staring. In general, it is advised to look continuously towards the member when he is talking and look at him some of the time when you are talking to him.

It is advantageous to look for opportunities where you can voluntarily feed information on your strengths. You should frame your answers tactfully so that the information that you are trying to give does not look out of place. For instance, if the question was, "Have you studied instrumentation as a part of your degree course ?" The answer could be, "Yes sir, infact, microprocessor based instrumentation that has emerged very strongly in recent times has been one of the topics dear to me," You would notice here that how tactfully you have made the expert ask questions from a topic where you have strength.

While it pays to voluntarily disclose your strengths, the same does not apply to your shortcomings. Never volunteer any information like you never studied a particular topic in college or the professor who taught you such and such subject did not know much or you are scared of a certain topic. These statements can harm your prospects.

Another important factor is your speech, your accent, the time taken to give an answer once you have been asked a question and so on. As far your speech and accent are concerned, always be your nature self even if you have some regional touch to your accent. You should speak with clarity and a little louder so that every member of the board can hear. The aspect of time pause after the interviewer has finished his question and before you have started answering is very important. You should never rush your answer and should always give yourself a second or two before you start replying rather than blurting out the first thing that comes to your mind.

Success in Interview

If a candidate is satisfied that he meets the requirements specified by a company, he surely stands good chances for selection. To be sure that you are right candidate, you must ensure basic things that you have right age desired by them, you have sufficient experience desired, you are properly qualified etc.

After satisfying above basics, you must fill up the application form carefully. It must be neat and tidy, all questions being answered to the point-using additional sheets if need be, leaving no blanks. On the day of interview the candidate should look fresh, be well dressed and provide physical good look and be confident of impressing. In the interview, you should be a good listener and think twice before responding. Answers should be to the point, accurate and precise there being no beating about the bush or deviating from main content. If answer is not known, there is no harm in accepting and saying no with smiling face and confident look instead of showing dejection and defeated attitude. Whenever you answer to a question for which you are prepared, try to show the desired level of confidence and moderate level of assertion.

When a person is answering in an interview, his/her spoken image is being observed by experts. Remember spoken image basically in judged by physical and as well as stylistic features. Physical factors include voice (ensure throat not getting hoarse during interview), pace of speech (no excitement or nervousness and speaking clearly and normal way, no murmuring), gestures (sit comfortably, let your hands and head have free movements, use body language). Stylistic features include language and technique, (use simple language using your own accent, use past tense to narrate an incident, be concise and speak clearly and fluently, use direct and active style of speech — when a person talks, his personal qualities and excellence must come out of his talk), level of enthusiasm and energy (project your voice and do not shout, be in high spirits, be courteous and keep good humour).

In interview your personality must be impressive and you must appear enthusiastic to take the challenge, display your knowledge and managerial qualities, respond to the point, show your skills and the right attitudes and adaptability to job, show your capacity to grasp and learn and deliver goods, use flawless expression.

Leadership skills are rated high but same have to be demonstrated through character, commitment, and competence, and not merely by talking about it.

Lastly you must remember that some interviewers have strong likes and dislikes and they tend to perpetuate their ideas and beliefs. Factors like similarity of thought, attitudes, similarity of education, training and past experience increase chances of selection. A candidate can make use of such factors, if possible. Job reservation, personal preferences and prejudices, preference for female if she demonstrates her capacity to learn and grow are natural factors in interviews.

One has thus to take interviews little seriously and not in a casual way. Chances of success are very high if one takes care of all the points illustrated above.

Tackling Nervousness

Remember that nervousness is not a sign of inadequacy on part of candidate. Over-anxiousness often results in nervousness. Physical effects of nervousness are pounding heart, dry mouth, stiff face muscles, sweaty palms, tension in the back or shoulder.

If there is feeling of going to lavatory, this sensation should not be supressed. Deep breathing will calm down candidate and get into a more rythm. A candidate has to understand that being nervous will only harm and not allow the candidate to show his better self.

Important Do's and Don'ts

DO's

- Take care of physical appearance and look a little better than on a normal day.
- Take a deep breath, calm yourself and enter interview room with a cheerful face.
- Walk smartly and modestly from the entrance to the interview table.
- Carry a smart folder.
- Greet the members with a smile and look them in the eyes when you meet them first and when you leave.
- Maintain an upright posture, may be slightly leaning forward. Stay calm and composed and enthusiastic.
- Conduct yourself gracefully.
- Maintain lot of eye contact and use your body language.
- Can mention your views politely if you disagree.
- Portray what you wish to be observed. Play in areas of your strength.
- Take your time in answering questions. Concentrate on question before leaping.
- Listen to question carefully and respond accurately and precisely.
- Put forth information that is likely to get you job without sounding irrelevant.
- Be informed about latest developments.
- Defend your viewpoint in a friendly way.
- Demonstrate your abilities by your expression and communication.
- If in doubt, ask a question/clarification.
- Speak clearly and little loudly. Keep your pace of speech normal.
- Be polite and aggressive, show enough tact and prudence.
- Be brief and to the point in your response.
- Try to demonstrate that you are objective about your career.
- Communicate the technical information in simple language.
- Always sound positive about all aspects.
- For current affairs, state the facts with your opinions.
- Always act natural.
- Answer questions with little pause.

DON'Ts

- Don't rush answers. Don't feel nervous.
- Don't get excited. Don't speak fast. Don't talk too much.
- Don't argue with interviewers heatedly.
- Don't mislead yourself with overconfidence.
- Don't slouch in the chair.
- Don't speak ill about others.
- Don't be evasive about your answers and don't bluff.
- Don't try to be informal.
- Don't try to sell yourself directly.
- Don't mumble. Don't speak in a hushed tone or whisper.
- Don't succumb to undue pressure from an interviewer. Act with restraint and maintain your cool.
- Don't panic if there is silence in the board room for a few seconds. Don't talk for the sake of talking.
- Don't show over-emphasis on academics.
- Don't make over-ambitious remarks.

- Don't exhibit unambitious attitude.
- Don't open your brief case on the table to make a wall between you and chairperson.
- Don't scratch your nose or ears if answer is not known.
- Don't have chewing gum, chocolate, tobacco, betel or in your mouth.
- Don't touch things on interviewer's desk.
- Don't apply too much fragrance.
- Never argue with the interviewer.
- Never bluff or never wander completely off
- Don't sip tea/coffee till interviewers offer.
- Don't overstress your achievements.
- Don't try to be over-informal.
- Don't be arrogant and never show cleverness.
- Don't sound too timid and shy.
- Don't talk about politics and religion to avoid controversy.
- Do't give self-contradictory or conflicting or confusing answers.
- Never try to interrupt the interviewer.
- Never look back in your chair in an over relaxed way with your hands behind your head.
- Never get too close to the interviewer.
- Never put your hands in your pockets.
- Never cross your arms tightly in front of you.
- Never volunteer information about your weaknesses.
- Don't waste your time in last minute preparation.

Useful Quotations

Remember some useful quotations in regard to interviews.

These would enable one to realise how seriously the interview should be taken.

- You get only one chance to make mistake.
- An interview is not a conflict.
- Being number 2 or 3 one has to work hard, but work harder on being number 1.
- Nobody gets a second chance to make the first impression.
- No one is a perfect fit for any job.
- The error of a moment can become the sorrow of a lifetime.
- Interviewing is both an art and a science.
- Visual impressions linger longer than words.
- You do not have to be a superman to pass an interview.
- If you can't get what you want, them want what you can get.
- The only sure thing about luck is that it will change with time.
- It is only work that works.
- Career is a mission for life.
- Genious is one percent inspiration and ninety nine percent perspiration.
- Extreme ideas and values have no place in real life.
- Nobody likes people having craze for money and luxury.
- It is the spoken image of a person which is observed during interview.
- Facial expressions speak louder than words.
- There are no stumbling blocks in life, these are only stepping stones of progress.
- Know your strengths in order to base your career on your strengths.
- When you speak, your body language usually supports the spoken word.
- Thon shalt prepare thyself in order to fit the job description.
- A well drafted resume improves your chances of being picked.

SAMPLE INTERVIEWS

Background

The candidate, Mr. Sudhir Pandey, is a young man of fairly good height and around 22 years old. Based on his performance in the written examination of Indian Engineering Services he has been called for the interview. Sudhir Pandey dressed up in a formal outfit reaches the UPSC building about fifteen minutes before the scheduled time. He reports to the reception desk where he promptly fills in some papers and gets his certificates verified. He also inquires about his serial number. He is told that he is the second candidate to be interviewed and also that he should expect the call in another 45 minutes. He decides to go to the canteen for a cup of coffee. He comes back to the reception lounge in about thirty minutes time and then waits for his call. He is very calm and composed. He looks very confident and well prepared. He is not at all nervous. He takes a look on all the documents in the briefcase. On being called, he is escorted to the interview room. On reaching the designated room, the door is opened by the attendant. The candidate obtains permission to enter and then walks towards the chairman with his head high and face lit up with confidence and enthusiasm. The attendant closes the door behind him. Sudhir comes to a halt near the chair meant for the candidate. He greets the chairman and other members of the board and then stands to attention waiting for the next command.

The board comprises of chairman and six members, the chairman being in the center with three members each sitting on his left and right.

Sudhir : (*standing to attention near the chair*) Good morning to you all, sirs (*with smile on his face*).

Chairman : (*who is reading candidate's biodata, looks up*) Good morning Mr. Sudhir. Please take your seat. (*indicating to the candidate the chair meant for him*).

Sudhir sits in the chair meant for him. His head is high, his arms are resting on the table, his legs are close to the chair and his body posture is slightly leaning forward. He waits for the next command.

Chairman : You have done your B.Sc. (Engg) with Honours. Do you need to achieve something special to get your degree with honours ?

Sudhir : To get the engineering degree with honours, one needs to clear all the papers including practicals and viva-voce examinations in all eight semesters in the first attempt and secure at least 75% marks.

Chairman : Is it something difficult and how many students achieved it ?

Sudhir : Not really, sir All that one needs is sincerity, dedication and hard work. Three or four students are able to achieve this distinction, Sir.

Chairman : Then why you have decided to go for Government job and not join private sector and multinational company ?

Sudhir : I feel Government jobs would become more demanding since they have to regulate multinational companies. Right candidates will command lot of respect. Job being secured, one can use the energy in shaping the policies in the interest of common man. Further this has been a tradition in my family and we love and take it as honour in serving Government.

Chairman : Why you have given first preference of Central Power Engineering Services ?

Sudhir : Sir, Power Plant Engineering was my favourite subject in college though I feel comfortable in other subjects also.

The chairman smiles and looks towards the first member and asks him to proceed with the interview. The member acknowledges and makes an eye contact with the candidate.

First Member : Mr. Sudhir, on which the thermodynamic cycle a modern steam plant works?

Sudhir : A modern steam plant works on Rankine cycle, Sir,

First Member : Okay ! in what way Rankine cycle differs from Carnot cycle ?

Sudhir : In Rankine cycle the heat rejection process continues until the saturated liquid state is reached.

First Member : Tell us how the efficiency of Rankine cycle can be improved ?

Sudhir : The efficiency of Rankine cycle can be improved by superheating steam. It can be further improved by reheating and regeneration.

First Member : (*continuing the same question*) Okay ! Can you tell us why coal is pulverised in modern boilers ?

Sudhir : To burn a large quantity of coal in a given time, fuel is powdered to provide large area for burning.

First Member : What do you know about purging of boilers ?

Sudhir : Before fresh fuel is injected into boiler and ignition energy supplied, the furnace should be emptied of all unburnt fuel in the furnace. This is done by operating induced draft fan and forced draft fan for 10 minutes and only then fresh charge of full can be fed.

First Member : How you will ensure that combustion of fuel is complete in the boiler ?

Sudhir : The condition of complete combustion can be ensured by measuring oxygen content and carbon monoxide in flue gases. Even traces of carbon monoxide indicate unburnt particles, which represent fuel loss. Slight excess air with no traces of CO are indication of complete combustion.

First Member : That is correct. Tell me whether you have heard about 3Ts for combustion.

Sudhir : 3Ts stand for time, temperature and turbulence, the three essentials for combustion.

First Member : What all equipments are located in flue gas path ?

Sudhir : The flue gases from furnace leave at temperature of 1200-1400°C. Various equipments located in flue gas path to extract heat are super heater, reheater, economiser and air heater.

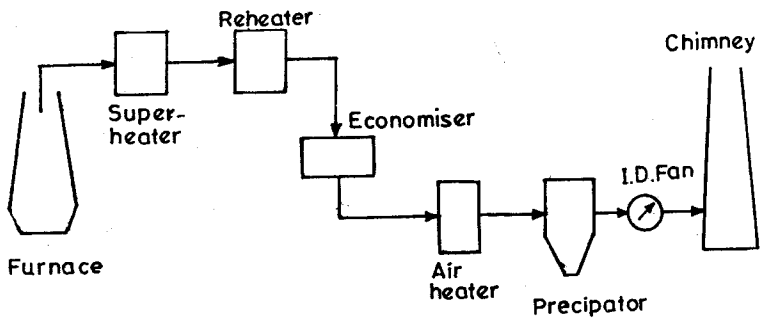


Fig. 1.1

First Member : (*interrupting the candidate*) Why don't you draw that on a piece of paper ?

Sudhir : Sure sir. He draws the flue gas path on a sheet of paper. It is reproduced above in Fig. 1.1.

First Member : Why tall chimneys are used in thermal plants ?

Sudhir : Tall chimneys spread the pollutants over a larger area, thus reducing concentration.

First Member : What is the height of chimney for 250 MW plant.

Sudhir : It is of the order of 275 metres.

First Member : What is the value of station heat rate of coal fired power plants ?

Sudhir : It is of the order of 2500 kcal/kWhr.

First Member : What is the difference between proximate analysis and ultimate analysis of coal ?

Sudhir : The proximate analysis gives information on behaviour of coal when it is heated. The ultimate analysis gives the elements of which the coal substance is composed.

First Member : One last question, Mr. Sudhir ! Explain the difference between gross and net caloric values of fuel.

Sudhir : For fuels containing hydrogen, gross or higher value is that obtained in a laboratory and based on the assumption that all the moisture formed during combustion is condensed to water. In actual practice the temperature of the gases and their moisture is above boiling point of water. Net calorific value is thus lower than gross calorific value.

The first member indicates to the chairman that he is through with the candidate. The chairman asks another member to proceed further with the interview.

Second Member : Can you identify the factors for selection of site for thermal power plant ?

Sudhir : Thermal plant has to be located close to coal mine or near load centre, or finding economics in transporting coal or electricity. In addition availability of water, ash dumping area have also to be ensured.

Second Member : What is the frequency of Indian Electricity Supply System ? How frequency is controlled ? Why tolerances have to be provided on frequency fluctuation and how much tolerance is permitted in Indian system ?

Sudhir : Sir, the frequency of Indian Grid System in 50 cycle/sec. The frequency is controlled by matching the generation with demand. If demand rises, the frequency will start falling and to bring it to value of 50 Hz, the additional generation is required. If generation is already at maximum limit, then load shedding has to be restored to. On the other hand if load reduces, frequency will rise and generation has to be reduced. It is thus essential that all the constituents connected to the grid follow the grid discipline to maintain desired frequency level. Tolerances for frequency are essential both for safety of power plant generating equipment and the consumer's appliances. The permitted variation on frequency on Indian System is ± 3%.

Second Member : Good ! Do you know something about spinning reserve ?

Sudhir : Yes Sir, Spinning reserve refers to additional generation capacity kept in readiness in system so that it can take on whenever any unit trips or load is suddenly increased and thus helps in maintaining frequency.

The second member indicates to chairman that he does not want to ask more questions. The chairman asks third member to examine the candidate.

Third Member : What is Reverse Osmosis and for what purpose it is used in thermal power plants ?

Sudhir : Sir, Reverse Osmosis is the newest of the two membrane processes and is used to convert saline water (such as sea water) to fresh water.

Third Member : Why deaerator is used in thermal power plants and how the oxygen in feed water is removed ?

Sudhir : Sir, deaerator acts as a heater in the feed heating cycle and removes all non-condensable and dissolved gases mechanically from condensate by deaeration process. The oxygen escaping mechanical deaeration process is removed or neutralised by adding hydrazine (N_2H_4) which on reaching with O_2 forms N_2 gas and water.

Third Member : Is this the only function of deaerator ?

Sudhir : Sir, while this is the major function, deaerator also provides net positive suction head (NPSH) for boiler feed pump, and also acts as a reservoir to provide for losses in the system in the form of leaks and blowdowns.

Third Member : Can you tell us the role of steam jet air ejectors in thermal plants ?

Sudhir : Steam jet air ejectors remove air from the condenser so that desired vacuum can be maintained.

Third Member : From which part of the condenser the air is removed ?

Sudhir : The air is extracted from the under-cooling zone, *i.e.* beneath the air extraction baffles where cooling tubes cool air.

The third member looks at chairman and indicates that he is through. The chairman asks fourth member to cover areas other than thermal power plants.

Fourth Member : Mr. Sudhir, can you explain the difference between isotopes, isobars and isotones ?

Sudhir : Sir, isotopes are nuclides having the same number of protons but a different number of neutrons and consequently, a different mass. Isobars are nuclides having equal mass but different combinations of protons and neutrons. Isotones are nuclides having the same number of neutrons but different number of protons, and therefore different mass.

Fourth Member : Which nuclear reactor use ordinary water as moderator, coolant and working fluid ?

Sudhir : Boiling water reactor, Sir

Fourth Member : What are fuel cells ?

Sudhir : Sir, I am not conversant with this term.

Fourth Member : One of the direct energy conversion system in MHD generator. What does MHD stand for and on which law it works?

Sudhir : Sir, MHD stands for magneto hydro-dynamic. It works on Faraday's law of electromagnetism.

The fourth member indicates to the chairman that he has finished. Chairman looks towards fifth member.

Fifth member : Only one question Mr. Sudhir. What is the difference between objective career and subjective career ? How career planning helps an individual ?

Sudhir : When career is viewed as a sequence of positions occupied by a person during the course of his lifetime, it is called objective career. If career is viewed as an amalgam of changes in values, altitudes and motivation that occur as a person grows older is referred to as subjective career. An individual can make a difference to influence his destiny over time, and can adjust in ways that

would help him to enhance and optimise the potential for his own career development. Thus career planning helps the individual to explore, choose and strive to derive satisfaction with one's career objectives.

The member indicates to the chairman that he has finished with the candidate. The chairman asks the last member if he would like to examine the candidate.

Sixth Member : Mr. Sudhir ! nowadays, we talk about quality assurance and total quality management in our products and services. Are you aware of any standards which if adhered to would serve the purpose of quality assurance ?

Sudhir : ISO-9000 standards are a step in this direction, Sir.

Sixth Member : What are ISO-9000 standards ?

Sudhir : ISO-9000 standards are made up of five parts namely ISO-9000, ISO-9001, ISO-9002, ISO-9003 and ISO-9004. ISO-9000 and ISO-9004 are advisory documents. For instance, ISO-9000 contains guidelines for using the standards. The standards are contained in ISO-9001, 9002 and 9003.

Sixth Member : (*continuing further*) Which ISO standard would be applicable if the product or the service involved design and development ?

Sudhir : It would involve ISO-9001 which is the model for quality assurance in design, development, production, installation and servicing.

Sixth Member : Can you tell us about ISO-9002 and 90003 also ?

Sudhir : ISO-9002 is for quality assurance in production, installation and servicing and ISO-9003 is for quality assurance in final inspection and test.

The member indicates to the chairman that he is through with the candidate. The chairman looks at his watch and then looks at candidate with feeling of satisfaction.

Chairman : Well ! Mr. Sudhir, you have been with us for more than thirty minutes and we will not trouble you more ...

Sudhir : Sir, it has been a truly wonderful experience interacting with the members of this esteemed board and answering to their questions.

Chairman : (*smilingly*) What do you think are your chances of making it to the final list ?

Sudhir : Sir, I think I did very well in the written examination and I also think that I have tried to do fairly well today. In fact, I feel that I have done my part to the best of my ability, sincerity and commitment.

Chairman : All the best Mr. Sudhir. Thank you !

The candidate gets up smartly, gathers his belongings, bows before the board as a mark of respect and proceeds towards the door. He gently opens the door, makes an exit and closes the door behind him.

Concluding Comments

The candidate has come for the interview fully prepared. He is sound in fundamentals. He has successful in twisting members to question mostly on his pet subject of power plant engineering. The response of the candidate to questions has been quick and crisp. This shows his strength. Not even once has he fumbled. He has been examined on a large variety of fields. He was also asked a couple of unexpected questions. He has handled them with confidence and a positive attitude. He has also paid adequate attention to his personal hygiene and dress and has succeeded in creating a favourable first impression. He knows the importance of being relaxed and cool before the interview. That is why, he has started from his residence a little early and reached the venue ahead of scheduled time. An excellent performance.

SECOND INTERVIEW SAMPLE

Background

The board comprised 4 members including the chairman. Chairman was sitting in the middle with two members on right side and one on left side.

On entering the chamber, Mr. Sunil greeted the members present there.

Chairman : Please take your seat.

Sunil : Thank you, Sirs.

Chairman : (On seeing the place of birth in the biodata) You belong to Bhagalpur.

Sunil : No Sir ! My father being in a transferable job was posted at Bhagalpur at the time of my birth. Now, we have permanently settled at Patna.

Chairman : Well, you have been "I" Divisioner through out your college time. How much time you devoted to studies after college hours ?

Sunil : Yes Sir ! I used to study six to eight hours after college.

Chairman : Tell me something about your hobbies and day to day interests.

Sunil : Basically Sir, I am interested in collecting variety of materials from paper cuttings, sketches and proverbs.

Chairman : What sort of paper cuttings ? How do you classify and store them ? And whether you are able to retrieve them whenever required ?

Sunil : Anythings that's different and attractive to my eyes. I have more than 12 classifications and same number of files. Storage and retrieval is thus very systematic.

Chairman : Tell me subjects of your choice.

Sunil : Environmental Engineering, Sir.

The chairman directs Ist technical person to proceed.

Ist Member : Tell me something about global warming and its causes.

Sunil : Global warming can be explained with green house effect. The increasing concentration of automobile exhausts and green house gases like CO_2 prevent the earth to radiate heat back and thus cause unsystematic warming conditions.

First Member : What are its effects ?

Sunil : It leads to greater melting of ice, rise in sea level leading to inundation of low lying area near sea. Also it causes uncomfortable conditions.

Chairman looks at second member and asks him to continue.

Second Member : How you can define fuel ?

Sunil : A fuel can be considered as a finite resource of chemical potential energy in which energy stored in the molecular structure of particular compounds is released via complex chemical reactions.

Second Member : What are the basic requirements of a fuel ?

Sunil : A fuel should have high energy content, it should release high heat of combustion, should have good thermal stability to enable long storage, should have low vapour pressure or volatility, and should possess nontoxicity to take care of environmental impact.

Second Member : Can you tell us what advances are essential in engine technology ?

Sunil : Modern day engines should be designed to minimise pollution emissions, maximise engine efficiency, and optimise tolerance to a wider variety of fuels.

Second Member : What do you understand by stoichiometric conditions ? Can it produce complete combustion ?

Sunil : Stoichiometric conditions are referred to as 100% theoretical air required for combustion of a fuel-air mixture. Actual reaction having stoichiometric fuel air proportions will not actually produce complete combustion.

Second Member : How do the specific heats (C_p and C_v), and specific heat ratio vary with increase in temperature ?

Sunil : Specific heats C_p and C_v increase with increasing temperature but specific heat ratio decreases with increasing temperature.

Second Member : Define the term heat of combustion and explain the difference between lower and higher heating value of the fuel ?

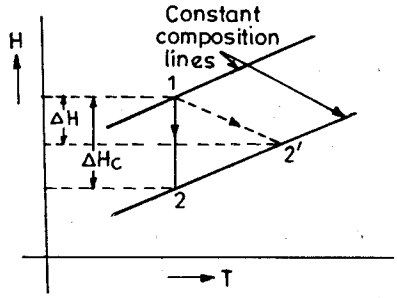
Sunil : The heat of combustion is the energy liberated when a compound reacts with an oxidant to form the most oxidised form of the reactants, and is brought back to the initial reactant temperature. If the water formed exists in the vapour state, the heat of combustion is referred to as lower heating value ; and if the water in the product state exists as a liquid, the heat of combustion is termed higher heating value of the fuel.

Second Member : Under what conditions the peak flame temperature is obtained in oxidiation reactions ? Why the peak temperature in actual combustion is lower ?

Sunil : In practice the maximum adiabatic flame temperature occurs just on the rich side of the stoichiometric proportions. In actual flame systems, the peak temperature is reduced due to incomplete combustion and heat loss to surroundings.

Second Member : How you can define combustion efficiency ? Explain with a diagram.

Sunil : Combustion efficiency is the ratio of actual heat released to the ideal heat released. In the Fig. 1.2, vertical part 1-2 represents the heat of combustion in going from reactants to products. But some amount of energy is needed to heat the product mixture from STP (Standard Temperature and Pressure) condition to the final state 2′. Thus combustion efficiency is $\Delta H/\Delta H_C$.



1 — Initial (reactant) state
2′ — Final (product) state
Fig. 1.2

Chairman directs 3rd member to continue.

Third Member : How you define turbomachines.

Sunil : Turbomachine is a power or head generating machine which employs the dynamic action of a rotating element (rotor). The action of the rotor changes the energy level of the continuously flowing fluid through the turbomachine.

Third Member : Draw a table listing the major points of difference between positive displacement machines and turbomachines.

Sunil : He prepares the table as shown below

Characteristic	*Positive Displacement Machine*	*Turbo Machine*
Speed	Low speed	Higher speed
Vvolumetric efficiency	80-90%	close to 100%
Type of compression	Near isothermal	Adiabatic
Flow rate	smaller	larger
Status of gas on stopping of machine	Gas trapped inside cylinder stays in same state	The gas experiences change as dictated by the surroundings.

Third Member : Explain the difference between fan, blower, and compressor,

Sunil : A fan continuously moves a mass of air without appreciable increase in pressure.
A blower develops an appreciable rise in pressure of gas flowing through it so as to overcome resistance in the gas flow path.
Compressors develop high pressure and thus pressure rise through compressor is expressed in terms of pressure ratio.

Third Member : Tabulate characteristics of axial and radial stages of turbomachines.

Sunil : He again prepares table as below.

Characteristic	*Axial stage*	*Radial stage*
Direction of flow	axial	perpendicular to axis of rotation
Change in radius of inlet and outlet	small	finite
Ideally suited for	high flow rate	high pressure ratio
Frontal area	low	large
Length of blade passages	small	large
Aerodynamic losses	lower	higher
Efficiency	higher	lower
Peripheral speed of rotor	lower	higher
No. of stage that can be employed	large	three or four.
Strength of rotor	poor due to separate blades	higher due to integral blades in rotor

Third Member : What is the difference between impulse stage and reaction stage in turbomachines ?

Sunil : In impulse stage there is no change of static or pressure head of the fluid in the rotor. The rotor blades only cause energy transfer without any energy transformation. Energy transformation occurs in fixed blade only. In reaction stage, changes in static or pressure head occur both in the rotor and stator blade passages. The degree of reaction of a turbomachine stage is defined as the ratio of the static or pressure head change occurring in the rotor to the total change across the stage.

Third Member : What is the special characteristic of 50% or half degree reaction machine ?

Sunil : It has symmetrical blades in their rotors and stators.

Third Member : What problems are experienced in operating turbomachines at off-design conditions?

Sunil : Off-design condition may arise due to changes in rotational speed, flow rate, load or boundary conditions. At off-design conditions performance becomes poor due to changed velocity triangles of the stages, flow deviates from optimum conditions giving low efficiency.
Some off-design conditions are prohibitive, which may lead to break down of the stable flow conditions. The surge line determines the range of stable operation in these machines.

Third Member : What is stagnation state ?

Sunil : The stagnation state of a gas is often used as a reference state. It is obtained by decelerating a gas isentropically to zero velocity.

Third Member : How much turbine output is required in case it is used as (*i*) Aircraft engine and (*ii*) in turbojet engine ?

Sunil : In case a turbine is used as an aircraft engine, the net output at the turbine shaft is used to drive a propeller in a turboprop engine.
If turbine is used in a turbojet engine, the turbine output equals the power required to drive the compressor.

Third Member : Plot the curves of overall efficiency of various types of propulsion methods.

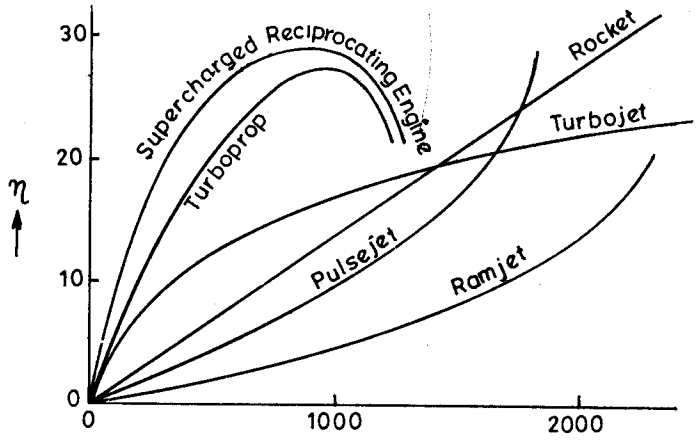


Fig. 1.3

Sunil : He quickly draws the curves as above and shows to member.

Third Member : Arrange various propulsion methods in increasing order in respect of relative frontal area (drag).

Sunil : The increasing order is Rocket, Ramjet, Pulsejet, Turbojet, Turboprop, Supercharged Reciprocating Engine.

Chairman interrupts and says we had enough questions now and directs fourth member for final round.

Fourth Member : What are the common profiles used for splines in machine elements ?

Sunil : The profiles used for splines in machine elements are straight sided splines, triangular splines and involute splines.

Fourth Member : What type of threads are used for pressure tight joints and for power transmission?

Sunil : Pipe threads are used for pressure tight joints and square threads for power transmission.

Fourth Member : What do you understand by cogeneration ?

Sunil : In cogeneration, two or more forms of useful energy are produced simultaneously. Usually, one power is electric power and other may be steam or shaft power.

Fourth Member : What is the advantage of cogeneration ?

Sunil : Cogeneration processes use significantly less fuel input to produce outputs than would be needed to produce them separately. Thus due to higher efficiency, cogeneration results in energy conservation.

Fourth Member : Could you elaborate how you get higher efficiency in cogeneration ?

Sunil : In producing electricity, a substantial amount of heat energy is lost in condenser to condense steam and same goes as waste in the water used for cooling in the condenser. If part of steam energy can be used as such for process requirements, to that extent wastage in condenser is avoided and efficiency improves and less fuel is required.

Fourth Member : What is the difference between topping cycle and bottoming cycle used in cogeneration plants ?

Sunil : The topping cycle uses the fuel energy to produce electricity and steam for process requirement or the energy of flue gases as useful heat for other industrial activities.
The bottoming cycle uses waste industrial heat for power generation by supplementing heat from any fossil fuel.

Fourth Member : What do you know about fuel cell ? Explain its working with a diagram.

Sunil : A fuel cell is a device to convert chemical potential energy stored in a fuel directly into electricity, thus providing an efficient energy conversion process because the reactants are into converted into products isothermally and power is produced without producing heat.

The candidate quickly produces schematic diagram of fuel cell and draws attention of member to it.

An easily ionised fuel such as H_2 is fed continuously and bubbled through a porous electrode to an electrolytic solution (phosphoric acid) where it is reduced at an anode surface. The anode (platinum) catalytically causes hydrogen to give up electrons forming hydrogen ions via an anode reaction. ($2H_2 \rightarrow 4H^+ + 4e^-$). Oxygen is fed towards porous cathode and bubbled through it. Hydrogen ions produced at the anode pass through the electrolyte and combine with O_2 and electrons at the cathode to produce water via an anode reaction ($4H^+ + 4e^- + O_2 \rightarrow 2H_2O$). The electrons produced at anode travel to cathode via an external load. The ideal efficiency with H_2 is 83%. It can be as high as 99.4% if hydrogen is replaced with hydrazine. The cell output is dependent upon the mixture composition cell temperature and reaction pressure.

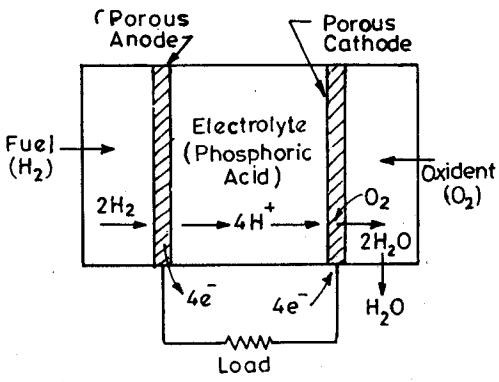


Fig. 1.4

At the stage Chairman take one.

Chairman : O.K. Sunil. The interview is over. We had lot of coverage with you. Have a good day.

Sunil : Thank you very much, Sir.

The candidate smiles and gets up. After moving out of chair, he puts chair back in position and makes a smart exit.

THIRD SAMPLE INTERVIEW

Ajay : May I come in Sirs.

Chairman : Yes, you can.

Ajay : Good morning Sirs (*After reaching near the vacant chair*).

Chairman : (*Indicates towards the vacant chair*) Sit down.

Ajay : Thank you Sir (After sitting)

Chairman : Mr. Ajay, tell us about yourself.

Ajay : I am an Indian citizen from the state of Haryana. My father worked with Ministry of Defence. I am a young man with sound health. I am endowed with commanding voice, normal eye sight and analytical power. I enjoy with open-minded people. I spend leisure time in gardening and love natural environment. I enjoy reading about great people. I am a determined professional with knowledge of engineering and computers. I consider myself committed to achieving optimum results from given resources, without degrading the environment and without grudging about deficiencies and lack of resources.

Chairman : Your hobby is gardening and enjoying nature. How you get time for these ?

Ajay : Sir, with proper time planning and management, one can find time for any activity. Everybody has to fix priorities properly.

Chairman : *Points towards the first member to proceed with the interview.*

First Member : What is your subject of interest in Mechanical Engineering.

Ajay : Machine Design, Sir.

First Member : How computer helps in designing ?

Ajay : Computer is able to store lot of information and same can be retrieved fast. It performs calculations very fast. The design can be visualised on screen and any alterations made and its effects clearly seen. Thus optimum designs can be achieved much faster and these are thoroughly tested from all angles.

First Member : How would you design a riveted joint in steel structure?

Ajay : Rivet value and strength of the plate are found out. For the strength of plate gross area is considered in the case of compression member and net area in the case of tension member. Net area is equal to gross area minus the area of holes for riveted connections. Rivet value is calculated as minimum of the bearing strength and shear strength. Shear strength should be considered to be in single or double shear depending upon type of connection.

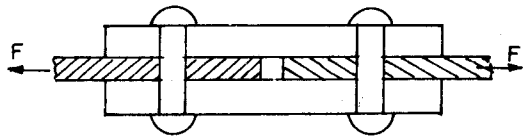


Fig. 1.5

First Member : Show a double shear situation.

Ajay : He draws a rivet joint subjected to double shear (Refer for Fig. 1.5)

First Member : Can you tell something about Hazop study ?

Ajay : In Hazop (Hazards and operatibility) study each and every conceivable process deviation from normal operating condition of a system having identical design intention, is thoroughly analysed for causes and consequence and required action plan to mitigate hazard/operability problems are suggested on the basis of available protective system.

First Member : Why slenderness ratio is considered in design of members ?

Ajay : When length of the member is increased, the member may fail due to buckling even though the member is symmetrical in all respects and the load is concentric.

First Member : This is true for compression member but why it is considered for the design of tension member ?

Ajay : I do not know, Sir.

Chairman interrupts and says —

: *Please recall your accomplishments and the satisfaction you derived out of them and tell us what are your strengths ?*

Ajay : (*After a little pause*). My strengths are visualisation, analysis and finding optimum solutions for a given situation. My favourite subject has been instrumentation. I won a special award for my project concerned with measurement of level of water in drum subjected to a pressure of 200 kg/cm^2.

Chairman : How is level measured in closed vessels ?

Ajay : One tap off is taken from steam side and steam is allowed to condense in a chamber. One tap off is taken from water side. A differential pressure transmitter is used to sense differential pressure at bottom of chamber and the other tap off.

Chairman : Why same method can not be used at high pressure ?

Ajay : At high pressure, density of steam becomes comparable to density of water and differential pressure instruments require density correction.

Chairman : What is the principle of instrument developed by you ?

Ajay : My instrument is based on conductivity probes which sense presence of water or steam. A number of such probes are installed in an outside chamber connected to drum. Probes immersed in water make green lights to glow and those in steam make red lights to glow. Thus a stepped indication of level is available.

Chairman directs 2nd member to interview.

Second Member : The major component in crude oil or petroleum on mass basis is carbon. What is its percentage and what are other elements and their composition?

Ajay : Carbon in crude oil on mass basis is 84-87%, hydrogen 11-14%, sulphur 0-2%, and nitrogen 0-0.2%.

Second Member : Cracking is a technique often used for producing more specific fuel shifts of hydrocarbons by breaking larger molecules into smaller species. Explain briefly the thermal cracking, catalytic cracking, and hydrogenation.

Ajay : Thermal cracking is a high-temperature and high pressure conversion process. Catalytic cracking is a lower temperature and lower-pressure conversion process. Hydrogenation is a thermal cracking done in a hydrogen gas atmosphere to allow unsaturated hydrocarbon compounds to pick up additional hydrogen atoms to become saturated.

Second Member : What do you understand by liquid biomass fuels ?

Ajay : Liquid biomass fuels are produced from feedstocks by drying the plants to remove water, reduced in size by grinding, and then boiled in a solvent such as heptane to extract liquid biocrude. This is further processed to produce useful fuels.

Second Member : What is the major constituent of natural gas ? What is its colour and odour ? At what temperature the liquefied natural gas stored ?

Ajay : The major constituent of natural gas is methane (75 to 99% by volume). It is a colourless and odourless gas. It requires a cryogenic refrigeration for storage and handling at –102°C.

Second Member : What do you understand by coal pyrolysis ?

Ajay : It is a destructive thermal distillation process in which coal or coke is placed in a closed vessel (retort) and heated by external coal combustion (at 530-1000°C). Thus volatile combustible fractions like hydrogen, methane, ethylene, and carbon monoxide are driven off.

Second Member : An important operational parameter for a particular burner is its trun down ratio. Define it and the factors that govern it.

Ajay : Turn down ratio of a burner is the ratio of maximum fuel input rate to minimum fuel input that it can burn safely. The upper range is governed by incomplete combustion, blow off, or inability to supply sufficient primary air. The lower limit is governed by the extinction of the flame or flashback tendency of the reaction zone.

(*Chairman asks fourth member to take over.*)

Fourth Member : Liquid fuels with lower specific gravities have higher heating values per unit mass. Why ?

Ajay : Liquid fuels with lower specific gravities have greater percentage of hydrogen. Since the heating value of hydrogen per unit mass is approximately four times that for carbon, liquid fuels with more hydrogen (lower specific gravity) will have higher heating value.

Fourth Member : What is volatility of liquid fuel and how does it influence the suitability of fuel in particular combustion system ?

Ajay : The vaporising characteristic of liquid fuels, expressed as a percent of volume distilled for a fixed total pressure and variable distillation temperature, is referred to as its volatility.

Volatility will influence combustion in following ways. It represents potential evaporative fuel loss during storage. Highly volatile fuels can be source of potential fire hazard. It influences proper fuel air preparation requirements prior to combustion, *i.e.* carburation, atomisation, and distillation. Since ambient conditions influence volatility, thus volatility of fuel needs consideration for cold start limitation, potential vapour lock.

Fourth Member : On what factors volumetric efficiency of engines depends ? Volumetric efficiency of an engine falls off at high and low engine speeds. Why ?

Ajay : The volumetric efficiency is strongly influenced by heat transfer, fuel parameters, thermodynamic state of both intake charge and residual gases, intake and exhaust valve manifolds and valve design.

At low engine speed, the incoming charge has little kinetic energy influence on the intake process. At higher speeds, inertial ramming increases the charge input to a maximum value but frictional effects tend to reduce the volumetric efficiency from mid-speed optimum value.

Fourth Member : How the fuel ratings of S.I. and C.I. engine measured ?

Ajay : Fuel rating of S.I. engine is measured in terms of octane rating, and fuel ratings of CI engine are specified by a cetane scale.

Fourth Member : How the octane and cetane numbers related ?

Ajay : High octane fuel has a low cetane rating and a low octane fuel has a high cetane index.

Fourth Member : Supercharging and turbocharging are the techniques used for power boosting a given engine design. What is the difference between the two ?

Ajay : Supercharging uses an engine driven compressor and turbocharging uses exhause gas driven turbine for this purpose.

Fourth Member : In general what factors play important role for reducing knock in spark ignition engines ?

Ajay : Lower-reaction thermal conditions and shorter periods of time for reaction will reduce the tendency for spark knock. Thus thermodynamic factors that can reduce the potential for knock are — reducing the charge by throttling, raising the combustion chamber wall temperature, operating with excessively rich or lean mixture, lowering the inlet air temperature, increasing the air inlet humidity, raising the octane number of the fuel.
Following time factors will also help increasing cylinder turbulence — increasing engine speed, decreasing flame travel distance, retarding spark timing.
Indirect methods to help control knock are : promotion of combustion chamber swirl (turbulence), exhaust gas recirculation, manifold and/or cylinder-injected combustion, nonhomogeneous combustion.

Fourth Member : Whether the gas turbine output increases or decreases with increase in ambient temperature, altitute, relative humidity, and system frequency and why ?

Ajay : The gas turbine output with increase in ambient temperature decreases because air at higher temperature is less dense and as such mass flow entering the gas turbine compressor would reduce.
Similarly air at higher altitutes is less dense and turbine output would reduce in case station is located at a higher altitute.
Humid air being less dense than dry air, the mass flow reduces and gas turbine output decreases with increase in relative humidity.
If system frequency increases the output will increase because the compressor output increases at higher speed.

Fourth Member : What is green house effect ?

Ajay : Gases like CO_2 and water vapour absorb high temperature thermal radiation in the infrared region of the electromagnetic spectrum but these are opaque to low temperature radiation in the infrared region. This ability of CO_2 and H_2O in the atmosphere to pass solar energy to the earth but block environmental radiation back into space is known as green house effect.

Fourth Member : Burning of coal releases fly ash and particulates. What harm is produced from them?

Ajay : The fine particles consist of inert materials and traces of toxic metals like arsenic and cadmium. These are thus principal carriers of toxic and carcinogenic trace metals. Since these can be easily inhaled, are very harmful. Their greater surface area also increases reactive or absorptive capacity. Particles in the size range of 0.1 to 1 μ scatter or absorb sunlight, thus lowering visibility.

(At this stage Chairman signals that the interview is over. The candidate gets up, thanks, smiles and leaves the room).

SHORT QUESTIONS AND ANSWERS IN MECHANICAL ENGINEERING

Q. 1. What is the difference between isotropic and anisotropic materials ?

Ans. If a material exhibits same mechanical properties regardless of loading direction, it is isotropic, *e.g.* homogeneous cast materials. Materials lacking this property are anisotropic.

Q. 2. What are orthotropic materials ?

Ans. It is a special class of anisotropic materials which can be described by giving their properties in three perpendicular directions *e.g.* wood; composites.

Q. 3. A plain carbon steel has BHN of 180. What are values of R_C, VHN and ultimate strength ?

Ans. $$R_C \simeq \frac{BHN}{10} \simeq 18$$

$$VHN \simeq BHN \simeq 180$$

Ultimate Strength $\simeq 3.45 \times BHN$ MPa $\simeq 620$ MPa.

Q. 4. What properties need to be considered for applications calling for following requirements :

(*i*) rigidity

(*ii*) strength for no plastic deformation under static load

(*iii*) strength to withstand overload without fracture

(*iv*) wear resistance,

(*v*) reliability and safety.

Ans. (*i*) Rigidity — Elastic modulus and yield strength

(*ii*) Strength (no plastic deformation under static loading) — yield point

(*iii*) Strength (overload) — Toughness and impact resistance

(*iv*) Wear resistance — Hardness

(*v*) Reliability and safety — Endurance limit and yield point.

Q. 5. Explain the effects of alloying chromium and nickel in stainless steel. *(UPSC CES 1999)*

Ans. Addition of nickel and chromium increases the tensile strength and increase in resistance to corrosion takes place.

Q. 6. Mention two types of dislocations. *(UPSC CES 1999)*

Ans. Dislocation refers to a break in the continuity of the lattice. In edge dislocation, one plane of atoms gets squeezed out. In screw dislocation the lattice atoms move from their regular ideal positions.

Q. 7. What are the principal constituents of brass ? *(UPSC CES 1999)*

Ans. Principal constituents of brass are copper and zinc.

Q. 8. What is Curie point ?

Ans. Curie point is the temperature at which ferromagnetic materials can no longer be magnetised by outside forces.

Q. 9. Specific strength of materials is very high when they are in fibre size but lower when they are in bar form — Why ? *(UPSC CES 1998)*

Ans. Crystal structure has ordered, repeating arrangement of atoms. Fibres are liable to maintain this and thus have high specific strength. As size increases, the condition of ordered and repeating arrangements can't be guaranteed because of several types of defects and dislocations and thus the specific strength gets lower.

Q. 10. What is the percentage of carbon in cast iron ?

Ans. 2.5%.

Q. 11. Which element is added in steel to increase resistance to corrosion ?

Ans. Chromium.

Q. 12. Whether individual components in composite materials retain their characteristics or not ? **Ans.** Yes.

Q. 13. An elastomer is a polymer when its percentage elongation rate is ..... ?

Ans. Greater than 100%.

Q. 14. If Percentage elongation of a material is more than 200%, it is classed as ..... ?

Ans. Rubber.

Q. 15. Why is it that the maximum value which the residual stress can reach is the elastic limit of the material ?

Ans. A stress in excess of elastic limit, with no external force to oppose it, will relieve itself by plastic deformation until it reaches the value of the yield stress.

Q. 16. Why fatigue strength decreases as size of a part increases beyond around 10 mm ?

Ans. Perfection of material conditions is possible at lower sizes and as size increases, it is not possible to attain uniform structure of the material.

Q. 17. Distinguish between creep and fatigue. *(UPSC CES 1999)*

Ans. Creep is low and progressive deformation of a material with time under a constant stress at high temperature applications. Fatigue is the reduced tendency of material to offer resistance to applied stress under repeated or fluctuating loading condition.

Q. 18. While normal carburising and nitriding surface treatments increase fatigue strength, excessive treatment may decrease the fatigue strength. Why ?

Ans. Normal carburising/nitriding treatments increase volume due to phase transformation at surface and introduce residual compressive surface stress and thus increase the fatigue strength. By excessive treatment the high compressive stresses are introduced but these are balanced by high internal tensile stresses of equal value and the subsurface fatigue cracks may develop in the regions of high tensile stress and lead to early fatigue failure.

Q. 19. List at least two factors that promote transition from ductile to brittle fracture. *(UPSC CES 1999)*

Ans. Manner of loading, and the rate of loading promote transition from ductile to brittle fracture. A machine member may have ductile failure under static loading but may fail in a brittle fashion when the load is fluctuating. Similarly a material may evidence ductile failure under tensile loading at ordinary testing speed but if load is applied at a high velocity then failure may be brittle.

Q. 20. Which theories of failure are used for (*a*) ductile materials, and (*b*) brittle materials ?

Ans. For ductile materials, theories of failure used are maximum shear stress theory, and maximum energy of distortion theory ; while for brittle materials, theory of maximum principal stress, and maximum strain are used.

Q. 21. The principal stresses at a point are tensile $\sigma_1 = 250$ MPa and compressive $\sigma_2 = 150$ MPa. What is the maximum shear stress ? What is the factor of safety based on maximum shear stress theory, if yield stress of material is 600 MPa ?

Ans. Maximum shear stress $= \dfrac{\sigma_1 + \sigma_2}{2} = 200$ MPa

Factor of safety based on maximum shear stress theory is $\dfrac{600}{2 \times 200} = 1.5$

Q. 22. Which factor influence the type of fracture in failure of a material ?

Ans. Seven factors influencing type of failure are :

(*i*) Type of material (inherent structure properties), (*ii*) Manner of loading (Static versus dynamic), (*iii*) Range of imposed stress, (*iv*) Strain rate (static, dynamic, impact), (*v*) Stress distribution (discontinuity in material/shape), (*vi*) temperature, and (*vii*) surface treatment.

Q. 23. Group the following into thermosets and thermoplastics :

Acrylic, Alkyds, Polyamide, Nylon, Epoxy, Phenolic, Silicone and PVC. (*UPSC CES 2001*)

Ans.

Thermosets	**Thermoplastics**
Alkyds	Acrylic
Epoxy	Polyamide
Phenolic	Nylone
Silicone	PVC

Q. 24. List two effects of manganese in plain carbon steels. (*UPSC CES 2000*)

Ans. Manganese increases tensile strength and hardness. It decreases weldability.

Q. 25. Name the strongest and weakest type of atomic bonds. (*UPSC CES 2000*)

Ans. Metallic bond is strongest and molecular bond also known as Vander Waals bond is weakest.

Q. 26. Calculate the number of atoms, from first principles, per unit cell of FCC and BCC structure. (*UPSC CES 2000*)

Ans. In FCC lattice, there are 8 corner atoms with each one of these atoms having 8 cells enclosing the corner. There are 6 face centered atoms, each of them being a member of 2 cells, one on either side.

$\therefore N = \frac{8}{8} + \frac{6}{2} = 4$ atoms per unit cell. In bcc lattice, there are 8 atoms at 8 corners in each unit cell, and each forming a member of 8 cells circumscribing it. Further there is one atom per unit cell.

$\therefore$ Total no. of atoms per unit cell $= \frac{8}{8} + \frac{1}{1} = 2.$

Q. 27. What is temper embrittlement in alloy steels and what are its effects ? (*UPSC CES 2001*)

Ans. Embrittlement attack is usually intergranular in metals, *i.e.* cracks progress between the grains of the polycrystalline material. It imparts a tendency to fail under a static load after a given period of time in those alloy steels which are susceptible to embrittlement.

Q. 28. What are whiskers ?

Ans. Whiskers are very small crystals which are virtually free from imperfections and dislocations.

Q. 29. What is Bauschinger effect ?

Ans. According to Bauschinger, the limit of proportionality of material does not remain constant but varies according to the direction of stress under cyclic stresses.

Q. 30. What is the difference between heat capacity and specific heat of a material ?

Ans. The heat capacity of a material is the amount of heat transformed to raise unit mass of a material 1 degree in temperature.

The specific heat of a material is the ratio of the amount of heat transferred to raise unit mass of a material 1 degree in temperature to that required to raise unit mass of water 1 degree of temperature at some specified temperature.

For most engineering purposes, heat capacities may be assumed numerically equal to specific heats.

Q. 31. Explain the rule to find specific heat of aqueous solutions.

Ans. For aqueous solutions of salts, the specific heat can be estimated by assuming the specific heat of the solution equal to that of the water alone. Thus, for a 15% by weight solution of sodium chloride in water, the specific heat would be approximately 0.85.

Q. 32. What do you understand by latent heat ? Give four examples of latent heats.

Ans. For pure substances, the heat effects accompanying changes in state at constant pressure (no temperature change being evident) are known as latent heats. Examples of latent heats are ; - heat of fusion, vaporisation, sublimation, and change in crystal form.

Q. 33. Define the terms free energy and free enthalpy. What is their significance and importance ?

Ans. Free energy (or Helmholtz function) is defined as $f = u - T s$.

It is equal to the work during a constant-volume isothermal reversible nonflow process.

Free enthalpy (or Gibbs function) is defined as $g = h - Ts$

(where u = internal energy, h = enthalpy, T = temperature, s = entropy)

Gibbs function is of particular importance in processes where chemical changes occur. For reversible isothermal steady-flow processes or for reversible constant-pressure isothermal nonflow processes, change in free energy is equal to net work.

Q. 34. What do you understand by equation of state ? Write two thermodynamic equations of state.

Ans. An equation of state is an equation in p, v, and T for the properties of a substance. Thermodynamic equations of state give equations in terms of p, v, and T the necessary relations that must hold for any system, however complex.

Two such equations are :

$$\left(\frac{\partial h}{\partial p}\right)_T = \frac{1}{J}\left[v - T\left(\frac{\partial u}{\partial T}\right)_p \right]$$

and

$$\left(\frac{\partial u}{\partial v}\right)_T = -\frac{1}{J}\left[p - T\left(\frac{\partial p}{\partial T}\right)_v \right]$$

J = mechanical equivalent of heat = 4186 J/cal.

Q. 35. What is polytropic process ? Under what conditions it approaches isobaric, isothermal, and isometric process ? In which reversible process no work is done ?

Ans. A polytropic process is one that follows the equation pv^n = constant (index n may have values from $-\infty$ to $+\infty$. This process approaches isobaric when $n = 0$, isothermal when $n = 1$, and isometric when $n = \infty$. No work is done in isometric process.

Q. 36. According to second law of thermodynamics what is the limitation for conversion of heat to work ? What all conclusions are drawn for efficiency of conversion of heat to work ?

Ans. According to second law of thermodynamics, conversion of heat to work is limited by the temperature at which conversion occurs.

According to it, no cycle can be more efficient than a reversible cycle operating between given temperature limits T_1 and T_2. Also the efficiency of all reversible cycles absorbing heat only at a single constant higher temperature T_1 and rejecting heat only at a single constant lower temperature T_2 must be the same. Efficiency $= \frac{W}{Q_1} = \frac{T_1 - T_2}{T_1}$, and $Q_1/T_1 + Q_2/T_2 = 0$.

Q. 37. What is Clapeyron equation and when it is useful ?

Ans. According to Clapeyron equation

$$\frac{dp}{dT} = \frac{JQ}{TV_{12}}$$

where p = pressure (absolute) J = mechanical equivalent of heat

T = absolute temperature V = linear velocity

Q = quality of heat

This relation is useful in calculations relating to constant pressure evaporation of pure substances. In that case, equation may be written as $v_{fg} = \frac{Jh_{fg}}{T}\left(\frac{1}{dp/dT}\right)$

(v = volume, h = enthalpy)

Q. 38. In a cycle, air is compressed to a high pressure. Fuel is then injected into air, which is at a temperature above ignition point, and it burns at nearly constant pressure. Isentropic expansion of the products of combustion is followed by exhaust and suction of fresh air. Which is this cycle ?

Ans. It is Diesel cycle.

Q. 39. For conduction of heat, the instantaneous rate of heat flow is product of three factors. What are these ?

Ans. (*i*) Area of the section of the heat flow path, perpendicular to the direction of heat flow.

(*ii*) temperature gradient, *i.e.* change of temperature w.r.t length of path

(*iii*) thermal conductivity of material.

Q. 40. Under what condition the extended surface effectively increases the heat transfer to or from a gas ?

Ans. When $h < Pk/4A$

h = convective heat transfer film coefficient (surface to fluid)

P = Perimeter of extended surface (on plane of fluid flow)

k = thermal conductivity of extended surface material

A = cross sectional area of extended surface (normal to heat flow)

Q. 41. An engine is visualised as a cylinder with a piston at each end. Between the pistons is a regenerator. The cylinder is assumed to be insulated except for a contact with a hot reservoir at one end and a contact with a cold reservoir at the other end. Which is this engine ?

Ans. Stirling engine.

Q. 42. In most cases of heat transfer, heat is transmitted from one fluid to another through a wall separating the two. A thin film of fluid adjacent to the wall offers considerable resistance, having film coefficients h_i and h_o (i and o standing for in and out). If k is thermal conductivity of wall and l its length, t_i and t_o the temperatures at inlet and outlet, A_i, A_m and A_o being areas at inlet, mean, and outlet, then what is the total thermal resistance offered ?

Ans. Total thermal resistance $= \frac{1}{h_i A_i} + \frac{l}{k A_m} + \frac{1}{h_o A_o}$

Q. 43. How convective heat transfer is effected and on what factors it depends ?

Ans. Convective heat transfer is effected between a solid and fluid by a combination of molecular conduction within the fluid in combination with energy transport resulting from the motion of fluid particles. It depends on boundary layer configuration, fluid properties and temperature difference.

Q. 44. For determination of heat transfer coefficient for convective heat flow for any set of conditions use is made of experimental data and dimensionless numbers are developed. What are these numbers and how they can be interpreted physically ?

Ans. Nusselt number, Prandtl number, Grashof number, and Reynolds number

Nusselt number is ratio of temperature gradient in the fluid immediately in contact with the surface to a reference temperature gradient.

Prandtl number is a ratio of the physical properties of the fluid.

Grashof number is ratio of buoyant to viscous forces in convective system.

Reynolds number is ratio of the fluid flow inertia forces to viscous forces.

Q. 45. What does thermal diffusivity of metals signify ?

Ans. Thermal diffusivity is associated with the speed of propagation of heat into solids during changes in temperature with time.

Q. 46. What is critical radius for small wires etc. ?

Ans. The outside radius that yields maximum heat flow is called critical radius. It is a function of the outside convective coefficient and the thermal conductivity of insulation. Critical radius $= \frac{\text{thermal conductivity}}{\text{heat transfer coefficient}}$

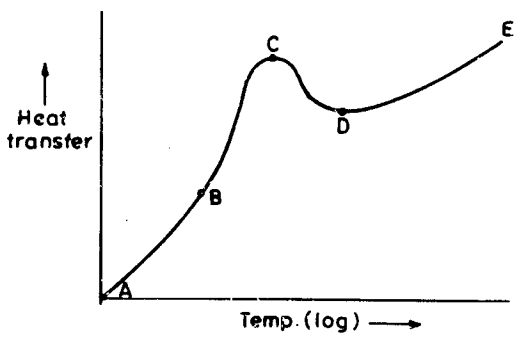
Q. 47. Which physical properties affect the film coefficient ? How film coefficients are correlated ?

Ans. Thermal conductivity, viscosity, density, and specific heat affect the film coefficient.

For a given velocity and fluid, the film coefficient depends upon the direction of flow of fluid relative to the heating surface. With free or natural convection, for a given arrangement of surface, the film coefficient also depends on the coefficient of thermal expansion, temperature difference surface and fluid, and on the local gravitational acceleration. With forced convection at low rates of flow, particularly with viscous fluids such as oil, laminar motion may prevail and the film coefficient depends on thermal conductivity, specific heat, mass rate of flow per tube, and length and diameter of the tube. The film coefficients are correlated in terms of dimensionless groups of the controlling factors.

Q. 48. Demonstrate with sketch how heat transfer takes place in boiling water, clearly explaining the natural convection heat transfer zone, nucleate boiling, transitional boiling, point of minimum heat flux.

Ans. Figure on right shows the transfer of heat from a submerged heater to a pool of boiling water. In the range *AB*, heat transfer takes place by natural convection, the evaporation occurring at the free surface of the pool. Nucleate boiling occurs in the range *BC*, *i.e.*, bubbles form at active nuclei on the heating surface, detach, and rise to the pool surface. At point *C*, the heat flux passes through a maximum. Transitional boiling occurs in the range *CD*, the transition being complete at point *D* and heating surface gets completely blanketed by a vapour film. *D* is the point of minimum heat flux. The heating surface continues to be blanketed by a vapour film in the range *DE*.



Q. 49. What relationships are provided by Stefan-Boltzmann law, Planck's law, and Kirchhoff's law in radiant-heat transfer ?

Ans. Stefan Boltzmann law provides relationship between total radiative flux throughout a hemisphere Q from a black surface of area A and at absolute temperature T, *i.e.* $Q = A \sigma T^4$ (σ = Stefan-Boltzmann constant = 5.67×10^{-8} $W/m^2 (K)^4$)

Planck's law provides relationship for spectral distribution of energy flux from a black body.

Kirchhoff's law states that the emissivity and absorptivity of a surface in surroundings at its own temperature are the same, for both monochromatic and total radiation.

Q. 50. Arrange the following substances, in order of increasing thermal conductivity. Stainless steel, air, silver, wood, water, lead, mild steel.

Ans. Air, water, wood, stainless steel, lead, mild steel, silver.

Q. 51. How the gray nature of real surfaces accounted for relating radiation between gray and black bodies ?

Ans. Emissivity of a gray body takes care of radiation from such bodies compared to black body.

Q. 52. What is view factor ?

Ans. View factor is dependent upon geometry of the two surfaces exchanging radiation.

Q. 53. What do you understand by the term 'ablation'.

Ans. During the re-entry of a space vehicle into the earth's atmosphere, a large quantity of heat is generated at the surface due to air friction, which is very rapidly removed by a process called ablation, in which a part of the solid body is allowed to melt away.

Q. 54. Define the terms (*i*) heat exchange effectiveness and (*ii*) number of transfer units (NTU), for heat transfer equipment.

Ans. Heat exchanger effectiveness is the ratio of actual rate of heat transfer to the maximum rate of heat transfer permitted by the second law of thermodynamics. NTU is measure of the size of a heat exchange from the point of view of heat transfer

$$NTU = \frac{UA}{(\text{heat capacity})_{\min}}$$

U = overall heat transfer coefficient referred to area A

A = heat transfer surface area required in heat exchanger

For parallel flow heat exchanger, effectiveness $= \frac{1 - \exp(-2\,NTU)}{2}$

and for counter-current flow heat exchanger, effectiveness $= \frac{NTU}{1 + NTU}$

It may be seen that effectiveness may have maximum value of unity for counter flow and 0.5 for parallel flow.

Q. 55. What is mass transfer and state Fick's law ?

Ans. Transport of one constituent from a region of higher concentration to that of lower concentration is known as mass transfer. Mass transfer by molecular diffusion is analogous to conduction of heat in solids, and is stated by Fick's law, according to which, rate of mass flux of the diffusing component in mole/sec/unit area is equal to diffusivity (coefficient of molecular diffusion) and the local concentration gradient of the diffusing component.

Q. 56. What do you understand by the term thermal diffusivity ?

Ans. Thermal diffusivity of a material indicates how fast heat is propagated or diffused through a material during changes of temperature with time. It has units of m^2/s.

Q. 57. What is the basic equation developed from dimennsional analysis for use in determining value of heat transfer coefficient ?

Ans. $Nu = C\,(Gr)^a\,(Pr)^b$

Q. 58. What is free convection modules ?

Ans. $Gr \times Pr = \frac{g\beta \rho^2 C_p}{\mu k} \cdot (L^3 \Delta T)$

The group $\frac{g\beta\rho^2 C_p}{\mu k}$ contains only fluid properties and has dimensions of $L^{-3} T^{-1}$ and is commonly known as free convection modulus (α).

Q. 59. What do you understand by free convection boundary layer and how does it affect heat transfer ?

Ans. When a fluid flows across a solid surface, a disturbed flow region extends out from the solid surface/liquid interface, called the boundary layer. Characteristics of fluid flow in boundary layer adjacent to the solid surface have a dominant effect upon the convective heat transfer. The motion of the fluid in free convective boundary layer is caused by buoyance effects resulting from fluid density variations associated with the boundary layer temperature gradients.

Q. 60. What is meant by critical radius of insulation ?

Ans. Addition of insulation increases the heat loss upto a certain thickness only. Its value is the ratio of thermal conductivity and the heat transfer coefficient.

Q. 61. What is Biot number ?

Ans. Biot number is $\frac{h L}{k}$. This dimensionless number compares the heat transfer coefficient with the internal conductance of a slab. It is the ratio of the conductive to convective resistance of a slab.

Q. 62. What do you understand by extendent surfaces ?

Ans. In order to increase heat transfer by convection between a surface and the fluid surrounding it, thin strips of metals (fins) or extended surface are attached to the surface. These increase the effective area of surface thereby increasing the heat transfer by convection.

Q. 63. What is the efficiency of a fin ?

Ans. The efficiency of a fin is the ratio of the actual heat transferred by fin to the maximum heat transferable by fin, if the entire fin area were at base temperature.

Q. 64. Why parabolic fins are preferred ?

Ans. A fin of parabolic profile dissipates the maximum amount of heat at minimum material cost.

Q. 65. What do you understand by shape factor in multi-dimensional steady state conduction ?

Ans. Conduction shape factor is inversely proportional to thermal resistance. Its value can be determined by plotting temperature distribution and heat flow lines. Shape factor is ratio of heat flow channels and number of temperature increments.

Q. 66. Define boundary layer concept.

Ans. The flow field over a body is divided into two regions. (*i*) a thin region near the body called boundary layer, where velocity and temperature gradients are large, and (*ii*) the region outside the boundary layer where velocity and temperature gradients are very nearly equal to their free stream values. The thickness of boundary layer is defined as distance where local velocity (temperature) reaches 99% of the external velocity (temperature).

Q. 67. What happens to static pressure, temperature, density and velocity across shock wave ?

Ans. Static pressure, temperature and density increase across shock wave and velocity decreases.

Q. 68. How boundary layer thickness (x) determined ?

Ans. $x = \dfrac{R_e \cdot \mu}{\rho v_\infty}$ (Re = cirtical Reynold number = 5 × 105, v_∞ = free stream velocity)

Q. 69. What is Couette flow ?

Ans. Couette flow provides simple model for flow between two parallel plates.

Q. 70. What do Prandtl number and Nusselt number represent ? How Nusselt number is related in forced convection heat transfer ?

Ans. Prandtl number $(Pr) = \dfrac{\mu c\, p}{k}$ and it a measure of relative effectiveness of momentum and energy diffusion in the velocity and thermal boundary layer.

Nusselt number $(Nu) = \dfrac{k\, L}{k_f}$.

It is the dimensionless tempeature gradient at the surface and is a measure of the convection energy transfer occurring at the surface.

$$Nu = f(Re, Pr).$$

Q. 71. What is Stanton number in forced convection heat transfer and how it is related ?

Ans. In forced convection heat transfer, the heat transfer coefficient is designated by Stanton number

$$St = \frac{h}{\rho\, \mu C_p} = \frac{N_u}{R_e \cdot Pr}$$

Q. 72. What is significance of Grashof number in free convection ?

Ans. In natural convection the flow is produced by buoyant effects resulting from a temperature difference. These effects are included in Grashof number (Gr). Grashof number is the ratio of buoyancy force to the viscous force in fluid.

$$Gr = \frac{\rho^2\, \beta\, g\, L^2\, \Delta T}{\mu^2}, \quad Nu = (Gr, Pr).$$

Q. 73. What is boundary layer thickness in free convection case ?

Ans. Velocity of fluid flow at solid surface is zero and it increases rapidly as distance from solid surface becomes greater, reaches a maximum value and then decreases to that of undisturbed fluid. The distance between the solid surface and point where boundary layer velocity equals undisturbed flow (edge) is called boundary layer thickness.

Q. 74. What do you understand by forced convection ?

Ans. When convective heat transfer occurs between a solid body and a fluid and where circulation of fluid is caused and controlled by some mechanical means.

Q. 75. What is boundary layer thickness in turbulent boundary layer ?

Ans. In case of turbulent boundary layer, boundary layer thickness is defined as the distance from solid surface at which the fluid velocity is 90% of the undisturbed free stream velocity. Near the surface of solid, there is laminar flow which changes to buffer zone and finally turbulent region.

Q. 76. Whether the boundary layer in case of turbulent boundary layer is uniform in character along the entire length of surface ?

Ans. No. The boundary layer develops as the fluid flows along the solid surface. At the initial point of contact with the solid surface the boundary layer is thin, building up along the surface until a fully developed boundary layer is reached.

Q. 77. What would be the order of boundary layer in pipe flow — (*i*) laminar (*ii*) transition, and (*iii*) fully turbulent ?

Ans. In laminar flow, boundary layer extends right from surface upto centre. In fully turbulent it may extend 5-10% of radius only whereas in transition flow, boundary layer may be from 50-60% of radius of pipe.

Q. 78. In general how the boundary layer and local film coefficient of heat transfer are related ?

Ans. In general, the thinner the boundary layer, the higher the value of local heat transfer film coefficient.

Q. 79. When the compressibility effects become significant in heat transfer problems in high speed flow ?

Ans. Compressibility effects usually become significant at gas flow velocities greater than 0.5 times the velocity of sound.

Q. 80. What is stagnation temperature and when it is encountered ?

Ans. The temperature of the gas at the point of zero velocity w.r.t. solid body is called stagnation temperature (T_s) and it is the sum of the free stream gas temperature (T) and the adiabatic compression temperature rise

$$T_s = T\left(1 + \frac{C_p/C_v - 1}{2} M^2\right)$$

M = free stream mach number

Q. 81. In high speed flow, two numbers (Mach and Knudsen) are also considered in addition to Reylond number. What is Knudsen number ?

Ans. Knudsen number is a measure of the degree of relative coarseness of the molecular structure.

K_n is the ratio of molecular mean free path length and a significant length of the solid body

$$K_n = 1.26\sqrt{C_p/C_v \cdot \frac{M}{Re}}$$

Q. 82. The gas flow, with respect to molecular mean free path length, could be divided into 4 regions. What are these and describe them briefly ?

Ans. Continuum, slip flow, transition, and free molecular flow.

In continuum region, the mean free path of the gas molecules is small with respect to boundary layer. It is limited to $R_e \geq 1.0$ and $M/R_e < 0.1$

In slip flow region, mean free path is of the order of 1 to 10% of the boundary layer thickness. Molecules immediately adjacent to the solid surface do not stick to it, as in the continuum region, but slide along it with a definite tangential velocity.

In the transition region, the collisions between molecules and molecules and the solid surface are of equal importance.

In the free molecular flow region no boundary layer exists.

Molecule to molecule collisions are negligible in comparison with the molecule to solid surface collisions. The region is defined as $M/Re > 3$.

Q. 83. What is the relationship between equivalent diameter and cross-section area of noncircular duct for the purposes of heat transfer calculations ?

Ans. Equivalent Diameter $= \dfrac{4 \times \text{Area of noncircular duct}}{\text{Perimeter of noncircular duct}}$

Q. 84. How you define the emissivity of a body ?

Ans. Emissivity of a body is the ratio of the emitted radiant energy flux density to the emitted radiant energy flux density of a blackbody at the same temperature.

Q. 85. What is gray body ?

Ans. When the emissivity of material does not change with temperature, it is called gray body.

Q. 86. Rayleigh number is sometimes used in place of Grashof number in free convection heat transfer. How it is defined ?

Ans. Rayleigh Number $Ra = \frac{g \beta L^3 (T_S - T_\infty)}{\nu \alpha} = Gr \cdot Pr.$

Q. 87. Define Fin efficiency for extended heat transfer surfaces.

Ans. Fin efficiency is defined as the ratio of the mean temperature difference from surface to fluid divided by the temperature difference from fin to fluid at the base or root of the fin.

Q. 88. What are the harmful effects of sulphur in coal used for power generation ?

Ans. Sulphur in coal gives rise to number of ecological problems ranging from acid mine drainage to ash waste problems and air pollution due to SO_2 emission. Emission of SO_2 is the cause of acid rain and is responsible for severe environmental damage.

Q. 89. What do you understand by microbial desulphurisation ?

Ans. Sulphur from coal can be removed by physical, chemical and microbial means. Microbial means has a number of advantages over other methods. Thiobalillus ferroxidans is the most widely used micro organism studied for coal desulphurisation. This bacteria can remove 90-98% of pyritic sulphur from coal. The reaction, of course, is slow and may take several days to several weeks to complete the reaction.

Q. 90. Under what conditions $\int p\,dv$ represents the work ?

Ans. $\int pdv$ represents work, when the system is closed and process takes place in non-flow system; the process is quasi-static, and the boundary of the system moves in order that work may be transferred.

Q. 91. What are the similarities between heat and work ?

Ans. Both heat and work are transient phenomenon, *i.e.* these cross the boundaries of system whenever system undergoes a change of state.

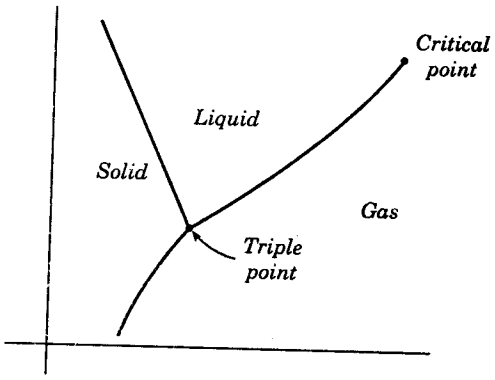
Both of them are observed at boundaries of the system.

Both are path functions and are in-exact differentials.

Q. 92. What is the difference between triple point and critical point of a substance ?

Ans. At triple point of a substance, all three phases—solid, liquid and vapour—can coexist simultaneously in equilibrium in varying proportions.

At pressures above critical point pressure, there is no clear demarcation between the liquid and vapour phases. Figure on right shows these points.



Q. 93. (*a*) **Define property of a system**

(*b*) **How one can determine whether a given quantity is property or not ?**

(*c*) **Explain the difference between intensive and extensive properties.**

Ans. (*a*) Property represents any observable characteristic of the system. Property of a system depends only on its state, irrespective of how that state was attained.

(*b*) If a given quantity dependent on two parameters is connected such that these parameters are connected by a line path, then the quantity is not a property. If a given quantity is an exact differential, it is a property, otherwise not. For instance, the quantity $\int (p\,dv + v\,dp) = \int d\,(pv) = pv$.

This quantity being exact differential, is a property.

If a quantity is of the form $A\,dx + B\,dy$, then it is a property if $\left(\frac{\partial A}{\partial y}\right)_x = \left(\frac{\partial B}{\partial x}\right)_y$

(*c*) If a property of a system does not depend upon its mass, it is intensive property, for example, pressure, temperature, density, etc.

On the other hand if the property is dependent upon its mass, then it is extensive property; for example, volume, enthalpy, etc.

Q. 94. What is the definition of 1K as per the internationally accepted temperature scale ?

Ans. $1K = \frac{1}{273.16}\,th$ of the triple point of water.

Q. 95. Out of superheated cycle, reheat cycle, and ideal regenerative cycles which has maximum efficiency ?

Ans. η of ideal regenerative cycle approaches the η of Carnot cycle and thus it is highest.

Q. 96. For a single stage impulse turbine with a rotor diameter of 2m and a speed of 3000 rpm with nozzle angle of 20°, what is the optimum velocity of steam ?

Ans. For optimum conditions, blade speed $= \frac{1}{2} \times$ jet velocity in direction of blade

or $$\frac{\pi DN}{60} = \frac{V \cos 20°}{2} \text{ or } V = \frac{\pi \times 2 \times 3000}{60} \times \frac{2}{\cos 20°} = 668 \text{ m/s}$$

Q. 97. What causes rotation of steam turbine rotor ?

Ans. Rotation of turbine rotor is caused by centrifugal force created due to change of direction of fast flowing jet of steam.

Q. 98. What do you understand by the term coagulation ?

Ans. Impurities in water are usually in finely divided state which takes long time to settle and these usually pass through the filtering media. By adding certain chemicals (coagulants), gelatinous substances are formed which cause small particles to coalesce into groups large enough to be checked during filtering.

Q. 99. What is equivalent evaporation in a boiler plant ?

Ans. It is the amount of water that would be evaporated from water at 100°C to steam at 100°C by the same amount of heat which was actually absorbed by water and steam under operating conditions.

Q. 100. What is meant by balanced draft in boiler ?

Ans. Balanced draft refers to combination of forced and induced draft fans controlled to keep the furnace under slightly vacuum condition.

Q. 101. What is pitting ? How it is caused ?

Ans. Non uniform corrosion over the entire metal surface, but occurring only in small pits is called pitting. It is caused by lack of uniformity in metal.

Q. 102. What is caustic embrittlement ?

Ans. It is the actual physical change in metal that makes it extremely brittle and filled with minute cracks. It occurs particularly in the seams of rivetted joints and around the rivet holes.

Q. 103. Which impurities form hard scale and which impurities soft scale ?

Ans. Sulphates and chlorides of lime and magnesium form hard scale, and carbonates of lime and magnesium form soft scale.

Q. 104. What is the difference between hard water and soft water ?

Ans. Hard water contains excess of scale forming impurities and soft water contains very little or no scale forming substances.

Q. 105. Which two elements in feed water can cause corrosion of tubes and plates in boiler ?

Ans. Acid and oxygen in feed water lead to corrosion.

Q. 106. What should be done to prevent a safety valve to stick to its seat ?

Ans. Safety valve should be blown off periodically so that no corrosion can take place on valve and valve seat.

Q. 107. Why large boilers are water tube type ?

Ans. Water tube boilers raise steam fast because of large heat transfer area and positive water circulation. Thus they respond faster to fluctuations in demand. Further single tube failure does not lead to catastrophy.

Q. 108. What type of boiler does not need a steam drum ?

Ans. Super-critical pressure boiler.

Q. 109. Why manholes in vessels are usually elliptical in shape ?

Ans. Elliptical shape has minimum area of opening and thus plate is weakened the least. Further it is very convenient to insert and take out the cover plate from elliptical opening.

Q. 110. Low water in boiler drum is unsafe because it may result in overheating of water tubes in furnace. Why it is unsafe to have high water condition in boiler drum ?

Ans. High drum level does not allow steam separation to be effective and some water can be carried over with steam which is not desirable for steam turbine.

Q. 111. Why boiler is purged everytime before starting firing of fuel ?

Ans. Purging ensures that any unburnt fuel in furnace is removed, otherwise it may lead to explosion.

Q. 112. What is the principle of mechanical refrigeration ?

Ans. A volatile liquid will boil under the proper conditions and in so doing will absorb heat from surrounding objects.

Q. 113. Why high latent heat of vaporisation is desirable in a refrigerant ?

Ans. A high latent heat of vaporisation of refrigerant results in small amount of refrigerant and thus lesser circulation system of refrigerant for same tonnage.

Q. 114. What is the critical temperature of a refrigerant ?

Ans. Critical temperature is the maximum temperature of a refrigerant at which it can be condensed into liquid and beyond this it remains gas irrespective of pressure applied.

Q. 115. Maximum combustion temperature in gas turbines is of the order of 800°C whereas same is around 2000°C in I.C. engine ? Why ?

Ans. High temperature in I.C. engine can be tolerated because it lasts for a fraction of second but gas turbines have to face it continuously which metals can't withstand.

Q. 116. Why efficiency of gas turbines is lower compared to I.C. engines ?

Ans. In gas turbines, 70% of the output of gas turbine is consumed by compressor. I.C. engines have much less auxiliary consumption. Further combustion temperature of I.C. engines is much higher compared to gas turbine.

Q. 117. What do you understand by timed cylinder lubrication ?

Ans. For effective lubrication, lub oil needs to be injected between two piston rings when piston is at bottom of stroke so that piston rides in oil during upward movement. This way lot of lub oil can be saved and used properly.

Q. 118. What is HUCR in relation to petrol engine ?

Ans. HUCR is highest useful compression ratio at which the fuel can be used in a specific test engine, under specified operating conditions, without knocking.

Q. 119. In some engines glycerine is used in place of water for cooling of engine. Why ?

Ans. Glycerine has boiling point of 290°C which increases its heat carrying capacity. Thus weight of coolant gets reduced and smaller radiator can be used.

Q. 120. Why consumption of lubricating oil is more in two-stroke cycle petrol engine than four-stroke cycle petrol engine ?

Ans. In two-stroke engine lub oil is mixed with petrol and thus some lub oil is blown out through the exhaust valves by scavenging and charging air. There is no such wastage in four stroke petrol engine.

Q. 121. As compression ratio increases, thermal η increases. How is thermal η affected by weak and rich mixture strength ?

Ans. Thermal η is high for weak mixture and it decreases as mixture strength becomes rich.

Q. 122. How engine design needs to be changed to burn lean mixture ?

Ans. Engine to burn lean mixture uses high compression ratio and the highly turbulent movement of the charge is produced by the geometry of the combustion chamber.

Q. 123. Horse power of I.C. engines can be expressed as RAC Rating, SAE rating, or DIN rating. To which countries these standards belong ?

Ans. U. K., USA and Germany respectively.

Q. 124. What is the use of flash chamber in a vapour compression refrigeration cycle to improve the COP of refrigeration cycle ?

Ans. When liquid refrigerant as obtained from condenser is throttled, there are some vapours. These vapours if carried through the evaporator will not contribute to refrigerating effect. Using a flash chamber at some intermediate pressure, the flash vapour at this pressure can be bled off and fed back to the compression process. The throttling process is then carried out in 2 stages. Similarly compression process is also done in two separate compressor stages.

Q. 125. Why pistons are usually dished at top ?

Ans. Pistons are usually hollowed at top to (*i*) provide greater space for combustion, (*ii*) increase surface for flue gases to act upon, and (*iii*) better distribution of stresses.

Q. 126. What is the function of thermostat in cooling system of an engine ?

Ans. Thermostat ensures optimum cooling because excessive cooling decreases the overall efficiency. It allows cooling water to go to radiator beyond a predetermined temperature.

Q. 127. What is the value of cyclic integral of dQ/T for a reversible cycle ?

Ans. zero.

Q. 128. What is the name given to a system in which mass remains constant but transfer of energy takes place across its boundaries ?

Ans. Closed system.

Q. 129. Quantities like pressure, temperature, density, viscosity, etc. are independent of mass. What are these called ?

Ans. Intensive properties.

Q. 130. The amount of radiation emitted per sq. cm per sec is called ..... ?

Ans. Emissive power.

Q. 131. In convection heat transfer, if heat flux intensity is doubled then temperature difference between solid surface and fluid will ..... ?

Ans. get doubled.

Q. 132. How you can define coal ?

Ans. Coal is a naturally occurring hydrocarbon that consists of the fossilised remains of buried plant debris and have undergone progressive physical and chemical alteration, called coalification, in the course of geologic time.

Q. 133. Which pollutant is major greenhouse gas and what is its effect ?

Ans. CO_2 is major greenhouse gas and it traps the radiation of heat from the sun within earth's atmosphere.

Q. 134. In order to increase efficiency and reduce CO_2 emissions and other emissions, clear coal technologies are receiving major attention. What are these ?

Ans. (*i*) Advanced pulverised and pressurised pulverised fuel combustion.

(*ii*) Atmospheric fluidised bed combustion and pressurised fluidised bed combustion.

(*iii*) Integrated gasification combined cycle systems.

(*iv*) Advanced integrated gasification, including fuel cell systems.

(*v*) Magneto hydrodynamic electricity generation.

Q. 135. What are the important operational performance parameters in design of fuel firing equipment ?

Ans. Fuel flexibility, electrical load following capability, reliability, availability, and maintenance ease.

Q. 136. What is the difference between total moisture and inherent moisture in coal ?

Ans. The moisture content of the bulk as sampled is referred to as total moisture, and that of the air dried sample is called inherent moisture.

Q. 137. Proximity analysis of coal provides data for a first, general assessment of a coal's quality and type. What elements it reports ?

Ans. Moisture, volatile matter ash and fixed carbon.

Q. 138. Ultimate analysis of coal is elementary analysis. What it is concerned with ?

Ans. Carbon, hydrogen, nitrogen, and sulphur in coal on a weight percentage basis.

Q. 139. Explain the difference between AFBC, BFBC, PFBC and PCFB in regard for fluidised bed technologies.

Ans. AFBC (Atmospheric fluidised bed combustion) process consists of forming a bed of inert materials like finely sized ash or ash mixed with sand, limestone (for sulphur removal), and solid fuel particles in a combustor and fluidising it by forcing combustion air up through the bed mixture. The gas flows through bed without disturbing particles significantly but gas velocity is high enough to support the total weight of bed (fluidisation). At slightly higher velocity excess gas passes through the bed as bubbles (fluidised bed) and gives the bed the appearance of a boiling liquid.

Bubbling fluidised bed combustion (BFBC) has a defined height of bed material and operates at or near atmospheric pressure in the furnace.

Pressurised fluidised bed combustion (PFBC) system operates the bed at elevated pressure. Exhaust gases have sufficient energy to power a gas turbine, of course, gases need to be cleaned.

In fluidised combustion, as ash is removed some unburned carbon is also removed resulting in lower efficiency. In circulating fluidised bed combustion (CFBC) system, bed is operated at higher pressure leading to high heat transfer, higher combustion efficiency, and better fuel feed. Circulating fluidised beds operate with relatively high gas velocities and fine particle sizes. The maintenance of steady state conditions in a fast fluidised bed requires the continuous recycle of particles removed by the gas stream (circulating bed). The term circulating bed is often used to include fluidised bed systems containing multiple conventional bubbling beds between which bed material is exchanged.

Q. 140. What for Schmidt plot used in heat transfer problems ?

Ans. Schmidt plot is a graphical method for determining the temperature at any point in a body at a specified time during the transient heating or cooling period.

Q. 141. In which reactor the coolant and moderator are the same ?

Ans. Pressurised water reactor.

Q. 142. Which reactor has no moderator ?

Ans. Fast breeder reactor.

Q. 143. What are thermal neutrons ?

Ans. Thermal neutrons are slow neutrons (having energy below 1 ev) which are in thermal equilibrium with their surroundings.

Q. 144. What is the purpose of biological shield in nuclear plants ?

Ans. Biological shield of heavy concrete prevents exposure to neutrons, beta rays and gamma rays which kill living things.

Q. 145. Which two elements have same percentage in proximate and ultimate analysis of coal ?

Ans. Moisture and ash.

Q. 146. On which analysis is based the Dulong's formula for the heating value of fuel ?

Ans. On ultimate analysis.

Q. 147. Which element causes difference in higher and lower heating values of fuel ?

Ans. Hydrogen.

Q. 148. Which heating value is indicated by a calorimeter and why ?

Ans. Gross heating value because steam is condensed and heat of vapour formed is recovered.

Q. 149. State the difference between ultimate and proximate analysis of coal ?

Ans. In ultimate analysis, chemical determination of following elements is made by weight : Fixed and combined carbon, H_2, O_2, N_2, S, water and ash. Heating value is due to C, H_2 and S.

In proximate analysis following constituents are mechanically determined by weight. Moisture, volatile matter, fixed carbon and ash. Heating value is due to fixed carbon and volatile matter.

Q. 150. What is fuel ratio ?

Ans. Fuel ratio is the ratio of its % age of fixed carbon to volatile matter.

Q. 151. How the analyses and caloriific values of fuels can be reported ?

Ans. It may be reported as

(*a*) as received or fired (wet) basis

(*b*) dry or moisture free basis

(*c*) combustible or ash and mositure free basis.

Q. 152. Why an increase in area is required to produce an increase of velocity in case of supersonic flow ?

Ans. Increase in area for increase in velocity for supersonic flow is required because the density decreases faster than velocity increases at supersonic speeds and to maintain continuity of mass area must increase.

Q. 153. Under what circumstances would there be an increase in pressure in a divergent nozzle ?

Ans. For subsonic flow at inlet section of a diffuser a lower velocity and higher pressure will exist at the exit section. For supersonic isentropic flow at the inlet section a higher velocity and lower pressure will exist at the exit but if a shock wave occurs in the diffuser then a higher pressure will exist at the exit.

Q. 154. Why water can't be used as refrigerant for small refrigerating equipment ?

Ans. The refrigerant should be such that vapour volume is low so that pumping work will be low. Water vapour volume is around 4000 times compared to R-22 for a given mass.

Q. 155. Which parameter remains constant in a throttling process ?

Ans. Enthalpy.

Q. 156. How does the velocity of sound in gas varies with change in ratio of specific heats, absolute temperature, and specific gravity ?

Ans. Velocity of sound in a gas varies directly as $\sqrt{\text{ratio of specific heats}}$, directly as $\sqrt{\text{absolute temperature}}$, and inversely as $\sqrt{\text{specific gravity}}$.

Q. 157. Why excess air is required to burn a fuel completely ?

Ans. Excess air is required to ensure adequate mixing of fuel and air, avoid smoke, minimise slagging in coal burning, and to ensure maximum steam output.

Q. 158. What is factor of evaporation ?

Ans. It is the ratio of heat change from feed water to steam and the heat of vaporisation of steam at atmospheric pressure.

Q. 159. Materials which absorb neutrons and produce fissionable material are called ___?

Ans. Fertile materials, such as U^{238} and Th^{232}.

Q. 160. What is the process which produces fissionable material from a fertile material ?

Ans. Breeding.

Q. 161. What is burn up in connection with fissionable material ?

Ans. Burn up corresponds to destruction of fissionable material when it undergoes nuclear fission.

Q. 162. What kind of nuclear fuel is used in Narora, Kalapakkam and Rana Pratap Sagar nuclear plants ?

Ans. Natural uranium.

Q. 163. Which type of plant will you recommend for remote location if power is required in six to twelve months time ?

Ans. Diesel engine power plant.

Q. 164. Under what condition a nuclear reaction is said to be critical ?

Ans. For critical condition, the reaction should continue at a steady rate which is possible when rate of production of neutrons is same as the combined rate of absorption of neutrons and the rate of leakage of neutrons.

Q. 165. If a nuclear reactor generates more fuel that it consumes, it is called ..... ?

Ans. Fast breeder reactor.

Q. 166. Natural uranium contains only 0.7% U^{235} which is capable of switching chain nuclear reaction. How this percentage is increased ?

Ans. Percentage of U^{235} in natural uranium is increased by a process called uranium enrichment.

Q. 167. Why the vane passages are gradually increased in size in successive wheels in steam turbine ?

Ans. The velocity of steam decreases in successive stages and to accommodate same flow per unit time, the area of flow must increase.

Q. 168. At what pressure and temperature the density of water and steam is same ?

Ans. At 225 kg/cm^2 and 374.6° C.

Q. 169. What is the latent heat of evaporation at critical point ?

Ans. Zero.

Q. 170. How much space steam will occupy at atmospheric pressure corresponding to 1 kg of water ?

Ans. 3100 times the space occupied by 1 kg of water.

Q. 171. What is meant by quality of steam ?

Ans. It refers to amount of unevaporated moisture in steam. If steam is perfectly dry, it's quality is 100%.

Q. 172. What is diagram efficiency in steam turbine ?

Ans. Diagram efficiency $= \dfrac{\text{change in K.E./kg}}{\text{Energy supplied/kg}}$.

Q. 173. What do you understand by effectiveness of heat exchanger ?

Ans. Effectiveness of heat exchanger $= \dfrac{\text{actual heat transfer}}{\text{maximum possible heat transfer}}$.

Q. 174. If superheat and condenser temperatures are same and if pressure of steam is increased, then what happens to dryness fraction of steam after isentropic expansion ?

Ans. It will decrease.

Q. 175. As pressure of steam is increased, why reheating is necessary ?

Ans. As pressure is increased, the dryness fraction of steam lowers on isentropic expansion. Therefore, steam has to be reheated after partial expansion so that dryness fraction remains within limits after expansion.

Q. 176. What is the optimum velocity of steam for a single stage impulse turbine of diameter D and speed of N rpm if nozzle angle = α.

Ans. Blade speed $= \dfrac{\pi DN}{60}$

For optimum condition, blade speed $= \dfrac{\text{Jet velocity in direction of blade}}{2} = \dfrac{V \cos \alpha}{2}$

$$\therefore \quad V = \frac{2\pi DN}{60 \cos \alpha}.$$

Q. 177. A Carnot cycle refrigerator operates between 250°K and 300° K. What is the value of COP.

Ans. $COP = \dfrac{T_2}{T_1 - T_2} = \dfrac{250}{300 - 250} = 5.$

Q. 178. In radiative heat transfer, a gray surface is one whose emissivity is ..... ?

Ans. independent of wavelength.

Q. 179. Why the efficiency of superheat Rankine cycle is higher than that of simple Rankine cycle ?

Ans. Because the mean temperature of heat addition is higher for superheat cycle.

Q. 180. A Carnot cycle is to be designed to attain efficiency of 0.75. If temperature of high temperature reservoir is 727° C, then low temperature reservoir will have to be maintained at ..... ° C.

Ans. – 23° C.

Q. 181. A gas having a negative joule-Thompson coefficient, when throttled, will become ..... ?

Ans. hotter.

Q. 182. A cyclic heat engine does 50kJ of work per cycle. If η of engine is 75%, the heat rejected per cycle will be ..... ?

Ans. $\eta = 0.75 = \frac{W}{Q_1} = \frac{50}{Q_1}$, $\therefore Q_1 = \frac{200}{3}$

Since $W = Q_1 - Q_2$, $\therefore Q_2 = Q_1 - W = \frac{200}{3} - 50 = \frac{50}{3}$ kJ.

Q. 183. Stirling cycle with regenerative arrangement and Carnot cycle operate within same temperature limits. What can be said about thermal efficiencies of these two ?

Ans. Thermal η of both will be same.

Q. 184. How does the stagnation temperature behave along a streamline in adiabatic flow with friction ?

Ans. It remains constant.

Q. 185. What is the frequency of secondary imbalance in four-stroke engine ?

Ans. Two times the engine speed.

Q. 186. A single-acting two-stage reciprocating compressor with perfect intercooling delivers air at 16 bar. If air intake is at 1 bar and 15° C, pressure ratio per stage is ..... ?

Ans. $\sqrt{16 \times 1} = 4$ bar.

Q. 187. In a spark engine working on Otto cycle, the compression ratio is 5.5. Work output per cycle (area on PV diagram) is $W \times V_c$ J. (V_c = clearance volume) - What is indicated m.e.p. = ?

Ans. Compression ratio = $5.5 = \frac{V}{V_C}$, or $V = 5.5\ V_c$

Now m.e.p. $\times (V - V_c) = W \times V_c$, $\therefore m.e.p. = \frac{W}{4.5}$.

Q. 188. Out of constant volume and constant pressure line, which line on T-S diagram has higher slope ?

Ans. Constant volume.

Q. 189. A heat engine and a refrigeration cycle operate between two temperature limits T_1 and T_2 ($T_1 > T_2$). The product of efficiency of heat engine and COP of refrigeration cycle will be ..... ?

Ans. T_2/T_1.

Q. 190. A refrigerator and a heat pump are working on the reversed Carnot cycle between the same temperature limits. How COP of refrigerator and heat pump related ?

Ans. COP of refrigerator = COP of heat pump - 1.

Q. 191. For a given set of operating pressure limits of a Rankine cycle, for which cycle the efficiency will be highest ?

Ans. For regenerative cycle which approaches Carnot cycle.

Q. 192. Which cycle is approached by a gas turbine with infinitely large number of stages during compression and expansion.

Ans. Ericssion cycle.

Q. 193. A steam pipe is to be insulated by two different insulating materials of same thickness. What arrangement is preferred ?

Ans. Material with lower thermal conductivity should be used for inner layer and material with higher thermal conductivity for the outer layer.

Q. 194. Why steam is in open space and water inside tube in condensers used in power plants ?

Ans. Overall heat transfer coefficient can be increased by increasing velocity of water in tube. Further steam needs more space due to higher specific volume.

Q. 195. A condenser of a refrigeration system rejects heat at a rate of 60 kW, while its compressor consumes a power of 15 kW. What will be the coefficient of performance of this system ?

Ans. 3.

Q. 196. Why a refrigeration compressor designed to operate with R22 refrigerant can't be operated with R12 ?

Ans. Condensing pressure of R22 at any given temperature is higher than that of R12.

Q. 197. What is the name given to process of removing non condensables in steam and other vapour cycles ?

Ans. Deaeration process.

Q. 198. We often come across use of jet pumps in process industry ? What is the reason for this ?

Ans. Jet pumps are easy to maintain and can be used to transport gases, liquids and mixtures of both.

Q. 199. When it can be said that a fluid is Newtonian ?

Ans. When the shear stress is directly proportional to velocity gradient.

Q. 200. Why alcohol can't be used in diesel engine ?

Ans. Alcohol has low cetane number and thus its ignition is prevented by compression.

Q. 201. Out of 2 stroke SI engine, 4 stroke SI engine, and 4 stroke CI engine, how the brake thermal efficiency behaves if these are to be used in road vehicles ?

Ans. 4 stroke CI engine has highest brake thermal efficiency followed by 4 stroke SI engine and the 2 stroke SI has lowest brake thermal efficiency.

Q. 202. A jet engine is used to drive a vehicle. When its mechanical efficiency will be maximum ?

Ans. It will be maximum when vehicle speed approaches the relative velocity of gases at nozzle exit.

Q. 203. The knocking tendency in a S.I. engine can be reduced by increasing ..... ?

Ans. speed.

Q. 204. Two balls are projected with identical velocities, from same point at 60° and 30° respectively. First ball will attain ..... times the height of second ball.

Ans. 3.

Q. 205. A test specimen is stressed slightly beyond the yield point and then unloaded. What happens to its yield strength ?

Ans. It will increase.

Q. 206. Out of circular, square, channel, I sections, which is most economical for a component subjected to bending ?

Ans. I section.

Q. 207. What does the area under the stress-strain curve represent ?

Ans. Energy required to cause failure.

Q. 208. A tension member of certain diameter is to be replaced by a square bar of the same material. Side of square compared to diameter will be _____ ?

Ans. Smaller.

Q. 209. A circular bar subjected to tension is designed for a particular safety factor. If both load and diameter are doubled, then factor of safety will be _____ ?

Ans. doubled.

Q. 210. Which section is economical for the parts such as frame of the C clamp ?

Ans. T section.

Q. 211. A free bar of length L is heated by 100°C. How much stress will be induced in the bar.

Ans. Zero because of free expansion.

Q. 212. What type of joint would you recommend for two cases, (*i*) when no relative motion is permitted between two rods, and only axial tensile/compressive load is to be transmitted and (*ii*) when relative angular motion is permitted between two rods ?

Ans. (*i*) cotter joint, (*ii*) knuckle joint

Q. 213. How much taper is provided on cotter and why it can't be more or less ?

Ans. Taper on cotter should be of the order of 1:24 (vary within 1:20 to 1:30). Higher taper would result in removal of cotter due to applied force. Very less taper could render taper effect negligible due to wear and tear.

Q. 214. Define a lever. To what type of load lever is subjected to ?

Ans. A lever could be considered as a straight or bent rod capable of turning about a fixed point and doing some useful work after the application of an effort. Lever is subjected to bending moment.

Q. 215. What is the function of rubber bush and brass bush in bushed pin type of flexible coupling ?

Ans. Rubber bush provides flexibility to allow small misalignment of shaft and brass bush takes care of wear.

Q. 216. What is the shape of bending moment diagram for a cantilever beam carrying a uniformly distributed load over its length ?

Ans. A parabola.

Q. 217. Whether the size of the flywheel for an inline multicylinder engine of a particular h.p. can be reduced by increasing the number of cylinders ? If so, why ?

(UPSC CES 2001)

Ans. Yes, because the number of effective working strokes increase and the fluctuation of energy per cycle decreases.

Q. 218. What is the difference between whirling and critical speed of a shaft ? Mention two physical parameters of the shaft-bearing system, which can increase the critical speed of the shaft. *(UPSC CES 2001)*

Ans. Whirling of shaft refers to its running (or rotor mounted on it) eccentrically i.e. centre line of shaft and bearing do not coincide. Critical speed of shaft refers to its operation near natural frequency at which shaft develops lateral displacements of relatively high amplitudes.

Critical speed of shaft can be increased by increasing its diameter and increasing the flexibility of mounting.

Q. 219. Which equation is used for testing short time fatigue life of a component ?

Ans. Miner's equation

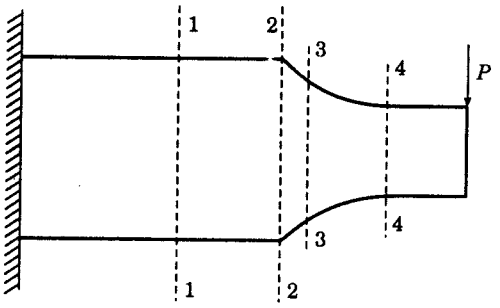
Q. 220. At how many cycles of reversals, the endurance strength of a component is determined ?

Ans. 10^6

Q. 221. For which situation Goodman' diagram is used ?

Ans. To get the complete picture of variable stresses.

Q. 222. At which section in the figure on right, the stress induced in maximum ?



Ans. 3-3

Q. 223. What are stress raisers ?

Ans. In a machine element with abrupt change in cross section, at sharp corners or extremities of the hole, the stress is found to be higher than the nominal value. Sharp corners, hole, small cracks, tool marks act as stress raisers.

Q. 224. Why the effect of stress concentration is more predominant for variable type of loading ?

Ans. For variable loading the stress concentration gives rise to a crack which propagates to cause the final fracture.

Q. 225. What are the various methods to increase fatigue strength ?

Ans. Fatigue strength is increased by improving surface finish, hardening surface, inducing compressive stress layer on surface by cold working, prestressing or heat treatment.

Q. 226. What is the difference between endurance curve and endurance limit ? On what factors endurance limit depends ?

Ans. Endurance curve gives the relationship between reversible stress and number of cycles of reversals for failure. The value of stress at which the material completes 10^6 number of cycles of reversal before failure is termed as endurance limit. Endurance limit depends on surface finish, size of component, type of loading and reliability factor.

Q. 227. Which equation defines the relationship between static stress (s_m), variable stress (s_v), ultimate stress (s_u), endurance stress (s_e) and stress factor FS ? What is this relationship ?

Ans. Goodman line defines relationship between s_m, s_v, s_u, s_e and FS This relationship is

$$\frac{s_m}{s_u} + \frac{s_v}{s_e} = \frac{1}{FS}$$

Q. 228. For same type and size of discontinuity, actual stress concentration factor may be different for different materials. How theoretical and actual stress concentration factors are related ?

Ans. Theoretical stress concentration factor (K_t) and form stress concentration factor (K_f) are related by notch sensitivity factor q as under

$$q = \frac{K_f - 1}{K_t - 1}$$

Q. 229. Distinguish between stress concentration factor and stress-intensity factor. *(UPSC CES 2001)*

Ans. Stress concentration refers to the localisation of maximum stress in sections where abrupt change in shape occurs. Stress concentration factor is ratio of maximum to nominal stress.

Stress intensity factor refers to a factor to allow for increase in nominal stress on account of factors like curvature shear stress in helical springs and other similar causes.

Q. 230. What is meant by 6 × 7 Lang lay-right lay wire rope ? *(UPSC CES 2001)*

Ans. 6 × 7 refers to rope having six strands, and each strand having seven wires. Lang lay means, that the directions of twist of the wires and the strands are the same. Right lay implies that the strands coil in the same direction as the right hand screw thread.

Q. 231. Two gears having an angular velocity ratio of 3 : 1 are mounted on shafts whose centres are 136 mm apart. If the module of gears is 4 mm, how many teeth are there on each gear ? *(UPSC CES 2001)*

Ans. PCR of gear $= 136 \times \frac{3}{4} = 102$ mm, $PCD_G = 204$ mm

and PCR of pinion $= 136 \times \frac{1}{4} = 34$ mm, $PCD_P = 68$ mm

no. of teeth on gear $= \frac{PCD}{m} = \frac{204}{4} = 51$; no. of teeth on pinion $= \frac{68}{4} = 17$.

Q. 232. Differentiate between strut and column. What is the general expression used for determination of their critical load ? *(UPSC CES 2001)*

Ans. Column is a vertical structural member subjected to compression. Strut is an inclined member subjected to compression. Critical load is determined by Euler's equation, according to which $P_{cr} = \frac{\pi^2 EI}{l^2}$.

Q. 233. A tension member with a cross-sectional area of 3 mm^2 resists a load of 80 kN. Calculate the normal and shear stresses on the plane of maximum shear stress. *(UPSC CES 2001)*

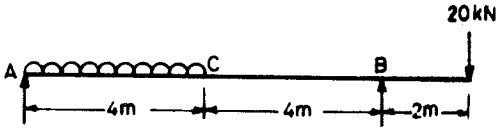
Ans. $$s_x = \frac{80 \times 1000}{30} \text{ MN/m}^2 = 2667 \text{ MN/m}^2 \; ; \quad s_y = 0$$

$$\therefore \quad s_{n_1} = \frac{s_x + s_y}{2} \pm \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + s_s^2} = 2667 \text{ MN/m}^2 \; ; \quad s_{n_2} = 0$$

$$\therefore \text{ Maximum shear stress} = \frac{s_{n_1} - s_{n_2}}{2} = 1333 \text{ MN/m}^2$$

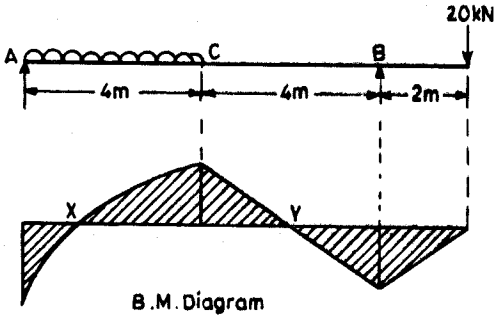
Normal stress on plane of maximum shear = 0.

Q. 234. What is meant by point of contraflexure or point of inflexion in a beam ? Show the same for the beam given below ?



(UPSC CES 2001)

Ans. In fixed beam the restraint moments act at the ends of the beam, and the beam bends convex upwards at the two ends and convex downwards in the middle position. The point of contraflexure is one where the beam changes its curvature in bending from convex upwards to convex downwards. At these points the bending moment is zero.



Points of inflexion occur at X and Y.

Q. 235. What is elastic line ?

Ans. The line to which the longitudinal axis of a beam bends or deflects under a given load is known as elastic line.

Q. 236. How are stiffness and deflection of beam related ?

Ans. Stiffness of a beam is inversely proportional to the deflection.

Q. 237. What is the difference between strength criterion and stiffness criterion ?

Ans. As per strength criterion the stresses induced should be within the allowable limits and as per stiffness criterion the deflection of beam should not be greater than predetermined value.

Q. 238. What is statically indeterminate beam ?

Ans. A beam in which the number of unknown reaction components exceeds the number of statical equilibrium equations available for the system.

Q. 239. What is the difference between fixed beam and continuous beam ?

Ans. A fixed beam is one in which the ends are rigidly fixed in a horizontal position.

A continuous beam is one which is supported on more than two supports.

Q. 240. If the angle of repose is 30°, then what will be the maximum efficiency of inclined plane for motion up the plane ?

Ans. $33\frac{1}{3}\%$.

Q. 241. If load to be raised on screw jack is doubled, then efficiency of screw jack will ..... ?

Ans. Remain same, because efficiency of screw jack does not depend on load.

Q. 242. What is the ratio of frictional torque produced for uniform wear to frictional torque produced for uniform pressure ?

Ans. 0.75.

Q. 243. From safety consideration which criterion is adopted (uniform pressure or uniform wear) for designing friction clutch ?

Ans. Uniform wear.

Q. 244. What is friction axis of a link ?

Ans. When friction in turning pair of link is also considered then resultant force does not pass through link but acts at tangent to friction circle at turning pair. The displaced position of resultant force of a link so as to be tangential to friction circle is referred to as friction axis of a link.

Q. 245. A helical spring is compressed axially. How does the spring wire get shear strain ? *(UPSC CES 1985)*

Ans. Spring is made by winding wire into a helix. When spring is compressed the wire is twisted further and thus subjected to shearing action. The maximum shear strain occurs on the inside surface of spring coil.

Q. 246. For increasing the stiffness of a helical spring one should —

(*a*) increase/decrease diameter of spring

(*b*) increase/decrease diameter of spring wire.

(*c*) increase/decrease length of spring or length of spring has no effect.

(UPSC CES 1985)

Ans. Stiffness of spring $\alpha\ d^4/D^3$

$\therefore$ answer for (*a*) is decrease, (*b*) increase, (*c*) length of spring has no effect.

Q. 247. The deflection of a spring with 20 active turns under a load of 1000 N is 10 mm. The spring is made into two pieces each of 10 active coils and placed in parallel under the same load. Deflection of this system = ... ?

Ans. Stiffness of original spring $= \dfrac{1000}{10} = 100$ N/mm

Stiffness after spring is cut into $2 = 100 \times 2 = 200$ N/mm

$\therefore$ Deflection of new set up $= \dfrac{\text{load}}{\text{stiffness}} = \dfrac{1000/2}{200} = 2.5$ mm.

Q. 248. If the ratio of diameter of rivet hole to the pitch of rivet is 0.25, the tearing η of joint is ..... ?

Ans. $\dfrac{d}{p} = 0.25$, $\eta = \dfrac{p-d}{p} \times 100 = 75\%$.

Q. 249. Distinguish between

(*i*) Yield stress and proof stress

(*ii*) Fatigue strength and creep strength. *(UPSC CES 1990)*

Ans. (*i*) Yield stress is the lowest stress at which strain increases without increase in stress. Proof stress is used where yield point does not exist and it is the stress at which the non-proportional elongation amounts to a specified percentage of the original gauge length.

(*ii*) Fatigue strength is the maximum stress below which a material can presumably withstand an infinite number of cycles of stress. Creep strength is the highest stress that a material can withstand for a specified length of time without excessive deformation.

Q. 250. State the limitations of Euler's formula for calculating critical load on columns. *(UPSC CES 1999)*

Ans. The limitation of Euler's formula are :

(*i*) It invalid only if proportional limit of the material is not exceeded.

(*ii*) This does not hold good for small values of slenderness ratio.

(*iii*) It is applicable only if the column is initially straight and is axially loaded and the column section is uniform.

Q. 251. What conditions must be specified for a pair of helical gears to mesh properly ? *(UPSC CES 1989)*

Ans. Following conditions must be fulfilled for two helical gears to mesh

(*i*) same pitch, (*ii*) same pressure angle

(*iii*) same helix angle and of opposite hands.

Q. 252. Mention the factors necessary for the design of spur gears. *(UPSC CES 1989)*

Ans. Factors necessary for design of spur gears are power, rpm, velocity ratio, and centre distance.

Q. 253. What is the difference between a bolt and a screw. Mention their applications in practice. *(UPSC CES 1989)*

Ans. A bolt is a threaded fastener designed to be used with a nut. Screw is also a threaded fastener but intended to be mated with either a preformed or self-made internal threads. Bolts are used for steel structures, foundation, machine tools etc. Screws are used where bolts are inconvenient to use. These are used for precision, semi-precision applications and as tapping screws.

Q. 254. Why V-threads are not preferred in power screws ? *(UPSC CES 1988)*

Ans. V-threads are not used in power screws because friction is high and lot of power is required to lift load. Efficiency is also very low with V-threads in power screws.

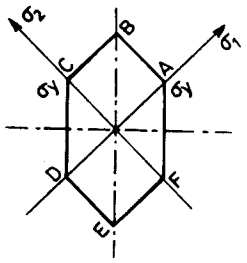
Q. 255. Why does torque transmitted by a belt decreases at high speeds ? *(UPSC CES 1988)*

Ans. At high speeds, centrifugal tension of belt increases and effective tension of belt and its transmission capability decrease.

Q. 256. In a three dimensional stress field, state the relationships between the principal stresses according to the criteria :

(*i*) maximum shear stress theory

(*ii*) maximum distortion energy theory and represent graphically the safe working zone for two dimensional cases. *(UPSC CES 1988)*



Ans. According to maximum shear stress theory, a material subjected to three dimensional stress will fail whenever the maximum shear stress exceeds the yield or ultimate shear strength

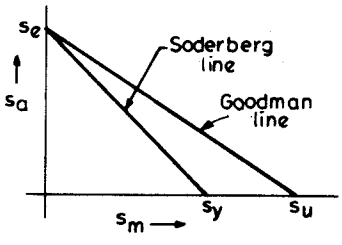
i.e. $$\sigma_y = \sigma_1 - \sigma_3$$

According to maximum distortion energy theory

$$2\,\sigma_y^2 = (\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2$$

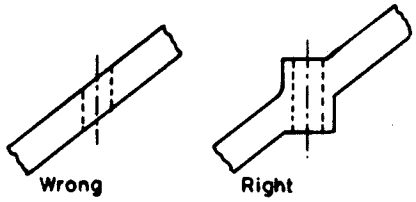
Q. 257. Draw the Goodman straight line and the Soderberg straight line for designing under fatigue loads. *(UPSC CES 1987)*

Ans. Soderberg line is a straight line joining endurance stress and yield stress whereas Goodman line is straight line joining endurance stress and ultimate stress on graph between mean stress and fluctuating stress amplitude.

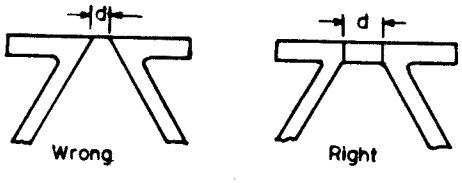


Q. 258. Give two examples involving change in the shape of a component due to manufacturing requirement. *(UPSC CES 1987)*

Ans. Fig. (*a*) shows change in shape of part to allow drilling.



(*a*)



(*b*)

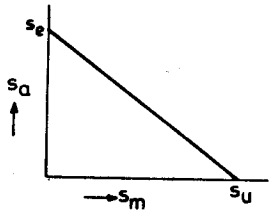
Fig. (*b*) shows change in shape so that walls of a casting do not run obliquely into working surface so that dimension 'd' can be achieved in machining.

Q. 259. What is endurance limit ? *(UPSC CES 1986)*

Ans. It is the maximum stress below which a material can withstand an infinite number of cycles of stress.

Q. 260. Draw Goodman diagram for fatigue loading. *(UPSC CES 1986)*

Ans. Goodman line is a straight line on a graph plotted between mean or steady stress *vs.* stress amplitude of fluctuating stress for axial and bending loading for ductile materials. Goodman line joints points of endurance limit s_e and ultimate stress s_u.



Q. 261. Define reliability as applied to engineering component. *(UPSC CES 1986)*

Ans. Reliability is defined as the probability of a device to perform its purpose adequately for the period of time intended under the operating conditions encountered.

Q. 262. Why is a spring washer used in some bolted joints ? *(UPSC CES 1986)*

Ans. Spring washer acts as take up device to compensate for developed looseness and the loss of tension between parts of an assembly. When spring washer is compressed by nut, it exerts an upward force which increases the friction between the threads of the bolt and nut.

Q. 263. For spur gears, state the relationship between module and circular pitch. *(UPSC CES 1985)*

Ans. Module $= \dfrac{\text{Circular pitch}}{\pi}$.

Q. 264. What is the role of hunting tooth or hunting cog in gear transmission ? *(UPSC CES 1985)*

Ans. It distributes wear uniformly on all gear teeth.

Q. 265. A piece of sheet metal can be easily bent, while the same strip when formed into a channel shape becomes stiffer. Explain. *(UPSC CES 1989)*

Ans. Ease/difficulty in bending depends on its section of modulus. When sheet is formed into channel its section of modulus increases considerably and thus it can take up lot of bending force.

Q. 266. Why is involute curve universally used as gear tooth profile ? *(UPSC CES 1988)*

Ans. Involute curve satisfies the law of gearing.

Q. 267. A rubber band is elongated to double its initial length. Calculate its true strain. *(UPSC CES 1985)*

Ans. True strain $= \dfrac{\Delta l}{l} = \dfrac{l}{l} = 100\%$.

Q. 268. Distinguish between 'fail safe' and 'safe fail' concepts in machine design. *(UPSC CES 1985)*

Ans. In fail safe design no risk of failure can be taken. The reliability of product to continue in service should be 100%. In such system standby arrangements are provided so that failure of one product will not lead to catastrophy.

Most of the machine design components are normally designed as safe fail, *i.e.* suitable safety factor is adopted to ensure that parts will continue to operate for a definite period of time.

Q. 269. For which application Petroff's equation is used ?

Ans. Petroff's equation is used to find coefficient of friction for journal and bearing.

Q. 270. What is the difference between bearing characteristic number and bearing modulus ?

Ans. Bearing characteristic number in Petroff's equation is $\frac{ZN}{p}$.

Coefficient of friction is $\alpha \frac{ZN}{p}$

Value of $\frac{ZN}{\rho}$ corresponding to minimum coefficient of friction is called bearing modulus.

Q. 271. What is attitude in hydrodynamic bearings ?

Ans. Attitude is ratio of eccentricity and radial clearance.

Q. 272. What is the difference between hydrostatic and hydrodynamic bearings ?

Ans. Pump is needed to pressurise lubricating oil in hydrostatic bearings. In hydrodynamic bearings the fluid film is formed due to rotation of journal.

Q. 273. What is critical pressure in hydrodynamic bearings ?

Ans. When metal to metal contact begins.

Q. 274. On which theory of failure is based the design of power transmission shafting ?

Ans. Maximum shear stress theory of failure.

Q. 275. What the ratio of width of key to diameter of shaft, ratio of width to thickness of rectangular key, taper on the rectangular sunk key.

Ans. w/d = 1:4, w/t = > one, taper on key = 1:100

Q. 276. State the Von Mises hypothesis of yielding of metals. *(UPSC CES 1985)*

Ans. As per this theory, failure by yielding is caused when the energy of distortion in a multi-axial stress system exceeds the energy of distortion in a simple tensile test. Since this theory considers the influence of all the three stresses, it is superior to maximum shear stress theory to predict failure of ductile materials.

Q. 277. What do you understand by basic static load rating of a bearing ?

(UPSC CES 1993)

Ans. The basic static load rating is defined as that radial load which corresponds to a total permanent deformation of rolling element and race at the most heavily stressed contact of 0.0001 of the ball or roller diameter.

Q. 278. What do you understand by basic dynamic load rating of bearing ?

Ans. It is that constant stationary radial load which a group of apparently identical ball bearings with stationary outer rings can endure for a rating life of one million revolutions of the inner rings.

Q. 279. What is the value of coefficient of friction in rolling contact bearings ?

Ans. 0.0018.

Q. 280. Life of roller bearing is given million number of cycles by ____ ?

Ans. $(C/P)^{10/3}$

Q. 281. For which application rolling contact bearings are used ?

Ans. In precision machine tools.

Q. 282. For which type of rolling contact bearings, cage is not needed ?

Ans. Needle roller bearings.

Q. 283. Define Sommerfeld number and bearing modulus.

Ans. Sommerfeld number for sleeve bearings $= \frac{\eta n}{p}\left(\frac{d}{c}\right)^2$

where η is the coefficient of absolute viscosity of lubricant

n = speed of shaft in rev/sec
p = pressure of oil in bearing
d = shaft diameter
c = clearance between bearing and shaft.

Bearing modulus = $\frac{\eta n}{p}$.

Q. 284. Why more than one full length leaves are provided in a leaf spring ? State the ratio of stress between full length and graduated leaves. *(UPSC CES 1993)*

Ans. If a single leaf spring is to be adopted with uniform, strength then width of leaf at centre will be too large to take the necessary bending at centre. To decrease the width, the diamond-shaped plate can be cut into several leaves and these can be stacked one over other.

The ratio of stress between full length and graduated leave is 1.5.

Q. 285. Explain the meaning of the following.

Hexagonal screw M 12 × 1.5 × 70 T-bolt 22 × 100. *(UPSC CES 1993)*

Ans. M 12 × 1.5 × 70 means screw of nominal diameter 12 mm, pitch 1.5 mm, and length 70 mm. T-bolt 22 × 100 means a T-bolt of width 22 mm and length 100 mm.

Q. 286. State the standard value of pulley groove angle and the minimum recommended angle of arc of contact for a V-belt. *(UPSC CES 1993)*

Ans. 40° and 120° respectively.

Q. 287. What type of rivetted joints are used for the longitudinal and circumferential joints of a cylindrical pressure vessel and why ? *(UPSC CES 1993)*

Ans. Longitudinal joint is a butt joint with two cover plates and circumferential joint is always a lap joint, with one ring overlapping the other alternately. Longitudinal joint is made butt to maintain the circularity of the shell.

Q. 288. What do you understand by the term proof stress ? What is the value of strain for 0.2% proof stress. *(UPSC CES 1995)*

Ans. Concept of proof stress is followed for materials which do not have well defined yield point. Proof stress in such cases is the stress at which the non-proportional elongation amounts to a specified % age of the original gauge length. The value of strain for 0.2% proof stress is 0.002.

Q. 289. What is standardisation ? Give its four advantages. *(UPSC CES 1993)*

Ans. Purpose of standardisation is to establish obligatory norms in order to minimise variety. Its advantages are

(*i*) It helps in manufacturings parts comparatively quickly and economically
(*ii*) Standards parts can be obtained readily and economically
(*iii*) Repairs and maintenance are simplified.
(*iv*) Mass production becomes possible.

Q. 290. A power screw has a helix angle α and coefficient of friction μ. Express the condition to be satisfied by the screw to be self locking. *(UPSC CES 1996)*

Ans. A power screw is self locking when $\tan^{-1} \mu > \alpha$.

Q. 291. State the modes of loading on a steel key connecting a belt driven pulley to a shaft. *(UPSC CES 1996)*

Ans. Modes of loading on a key are

(*i*) shearing failure (*ii*) crushing failure.

Q. 292. What is the phenomenon of creep in belt drives. *(UPSC CES 1994)*

Ans. Tension of belt on tighter side is greater than on slack side. Therefore belt material undergoes a change in strain as it passes around the pulley. The belt has a small relative motion, called creep, with respect to pulley to compensate for these strains. Thus belt creep is a movement of belt on pulley surface to compensate for change in length from tight to slack side.

Q. 293. If a thick pressure vessel of outside and inside diameter D and d is subjected to internal pressure p, then what will be values of maximum hoop stress, radial, and shear stresses.

Ans. Max. hoop stress $= \dfrac{D^2 + d^2}{D^2 - d^2} p$

Max. radial stress $= -p$; Max. shear stress $= \dfrac{D^2}{D^2 - d^2} p.$

Q. 294. The wall thickness of a spherical pressure vessel of same diameter and same material as cylindrical vessel and subjected to same pressure will be ..... ?

Ans. Half.

Q. 295. What do you mean by ligament efficiency ?

Ans. A plate in which holes are drilled at regular intervals gets weakened. If holes of diameter d are drilled distance p apart, then ligament efficiency $= \dfrac{p - d}{p}$.

Q. 296. Euler's critical load for a column with both ends hinged is found as 40 kN. What would be the change in critical load, if its both ends are fixed ? *(UPSC CES 1996)*

Ans. Equivalent length will be half and thus critical load in new case will be 4 times, *i.e.* 160 kN.

Q. 297. If stress in axial loading and bending cases be s, then what will be the strain energy/volume in these two cases ?

Ans. Strain energy per unit volume in axial loading will be $s^2/2E$ and in case of bending $s^2/6E$.

Q. 298. Whether residual tensile or residual compressive stress can increase the endurance limit ?

Ans. Residual compressive stress.

Q. 299. The tight side and slack side tensions in a running belt drive are respectively T_1 and T_2. What would be the belt tension, when the drive stops. *(UPSC CES 1997)*

Ans. $\dfrac{\sqrt{T_1} + \sqrt{T_2}}{4}$.

Q. 300. If the Poisson ratio of an elastic material is 0.3, determine the ratio of its elastic modulus to its shear modulus. *(UPSC CES 1997)*

Ans. $\dfrac{E}{G} = 2\left(1 + \dfrac{1}{m}\right) = 2\,(1 + 0.3) = 2.6.$

Q. 301. The elastic and shear moduli of an elastic material are respectively 2×10^{11} Pa and 8×10^{10} Pa respectively. Determine Poisson's ratio of the material. (UPSC CES 1996)

Ans. $\dfrac{E}{G} = 2\left(1 + \dfrac{1}{m}\right)$ or $\dfrac{2 \times 10^{11}}{8 \times 10^{10}} = 2.5.$; $\therefore \quad 1 + \dfrac{1}{m} = \dfrac{2.5}{2} = 1.25$; and $\dfrac{1}{m} = 0.25.$

Q. 302. For winches and cranes wire ropes are preferred to wires. Why ?

(UPSC CES 1998)

Ans. Wire rope is much more flexible than wire and thus preferred where bends are encountered such as in winch and crane applications.

Q. 303. What is the difference in Lang's lay & regular Lay on wire rope and what are their strong points ?

Ans. In Lang's lay rope, the lay of the strands and that of the wires are in the same direction, but in opposite direction in case of regular lay. In Lang's lay outer wires are bent on a larger arc of circle and so longer length of wire is exposed to wear and thus resistance to abrasion and wear or rope sheaves and drums is greater and the resistance to fatigue is higher due to greater flexibility.

However these are difficult to handle and liable to kink if slack. Regular lay rope has more structural stability, greater resistance to crushing and distortion, less tendency to rotate under load and has greater ease in handling.

Q. 304. What are the common profiles used for splines in machine elements ? *(UPSC CES 1998)*

Ans. Straight sided splines, triangular splines, and involute splines.

Q. 305. The hexagonal bolt proportions for pitch, head thickness, nut thickness, head and nut diameters etc are given in terms of nominal diameter. Why ? *(UPSC CES 1998)*

Ans. Nominal diameter is universally accepted parameter to designate threaded elements. Specifying all dimensions in terms of this parameter gives a clear idea of proportions of various elements.

Q. 306. What are preferred numbers and what are their advantages ? *(UPSC CES 1993)*

Ans. It is a series of numbers in a geometric progression, to be used in preference to random numbers.

These reduce unnecessary variations in size and minimise variety.

Q. 307. What are principale planes ? *(UPSC CES 1999)*

Ans. Principal planes are those planes on which shear stress is zero and only tensile or compressive loads are present.

These can be located by equation $\tan 2\theta = 2 s_s/(s_x - s_y)$.

Q. 308. What is octahedral plane and what are its direction cosines ?

Ans. A plane which is equally inclined to the three axes of reference is called the octahedral plane. Its direction cosines are $\pm\frac{1}{\sqrt{3}}, \pm\frac{1}{\sqrt{3}}, \pm\frac{1}{\sqrt{3}}$.

Q. 309. In R.C.C., why is steel reinforcement provided at the top of the neutral axis for a cantilever beam ? *(UPSC CES 1999)*

Ans. In cantilever beam, the top fibres above neutral axis are subjected to tensile loading and fibres below neutral axis are subjected to compression loading. Steel being good in tension is, therefore, placed at top of neutral axis in cantilever beam.

Q. 310. What is shear-concentration factor for a flat bar in tension having a circular hole ?

Ans. 2.50.

Q. 311. What is the value of Poisson's ratio for a non-dilatant material ?

Ans. 0.5.

Q. 312. What is endurance ratio ?

Ans. It is the ratio of fatigue limit to the tensile strength.

Q. 313. What is damage ratio ?

Ans. It is an indication of the 'used up' life of material subjected to a number of stress reversals at stress ranges above the fatigue limit. If N is fatigue life, and n is the number of reversals actually endured, then damage ratio $= \frac{N-n}{n}$.

Q. 314. What for GFRP stands for ?

Ans. Glass fibre reinforced plastic.

Q. 315. For power screws the Acme thread is not as efficient as square thread. Why ? Why still Acme thread is often preferred ?

Ans. Acme thread is not as efficient as square thread because of the additional friction due to the wedging action.

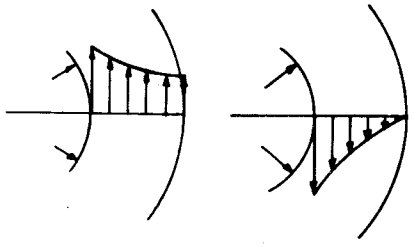
Acme thread is often preferred because it is easier to machine and permits the use of a split nut, which can be adjusted to take up for wear.

Q. 316. Under what condition a power screw becomes self locking ?

Ans. Power screw becomes self locking when the coefficient of thread friction is equal to or greater than the tangent of the thread lead angle.

Q. 317. Plot the distribution of tangential and radial stress in thick cylinder.

Ans. Figure on side shows the distribution of tangential and radial stress in thick cylinder.



Tangential stress Radial stress

Q. 318. Which experimental approaches are used to determine the stress concentration factors.

Ans. (*i*) Photo elasticity

(*ii*) Grid method

(*iii*) Brittle coating method

(*iv*) Electrical strain gauge method.

Q. 319. What is the difference between proof resilience and modulus of resilience ?

Ans. Proof resilience is the maximum strain energy which can be stored when a body is stressed upto the elastic limit. Modulus of resilience is the ratio of proof resilience and volume.

Q. 320. What do you understand by coaxing ?

Ans. Coaxing is the process of improvement in the fatigue properties obtained by understressing and then raising the stress in small increments.

Q. 321. What type of residual stress in parts subjected to cyclic loading increases the endurance limit ?

Ans. Compressive.

Q. 322. Most suitable theories of failure for brittle and ductile materials are :

Ans. Maximum normal stress theory and maximum distortion energy theory respectively.

Q. 323. Define a spring, explain its 5 functions, and how springs can be classified ?

Ans. A spring can be defined as an elastic body which deflects or distorts under the action of load, and regains its original shape after the load is removed.

5 functions of springs are to absorb energy and mitigate shock, apply definite force/torque, support moving masses for vibration isolation, control load/torque, store energy.

Springs may be classified as helical compression/tension, helical torsion, leaf/carriage, flat, spiral, belleville, disc etc.

Q. 324. Does the endurance strength increase or decrease as size increases beyond 7.5 mm ?

Ans. Decreases.

Q. 325. Compression springs are used more frequently than tension springs. Why ?

Ans. Compression springs do not need elaborate end connection arrangements, control is not lost if it breaks, and it costs less.

Q. 326. Why composite springs are used ?

Ans. These offer greater spring force in a given space, if one breaks other continues the function, and combination can be designed to offer non linear load vs. deflection characteristics.

Q. 327. What do you understand by surging of a spring ?

Ans. When compression springs used in machines operating near resonance frequency of spring, heavy vibrations will be experienced, the phenomenon being known as surging of spring.

Q. 328. If both spring wire diameter and its coil diameter be increased twice, then new natural frequency compared to earlier one will ..... ?

Ans. get halved.

Q. 329. How much frequency of fluctuating load be permitted on a helical compression spring ?

Ans. It should be twenty times less than the natural frequency of vibration of spring.

Q. 330. 5 coils of a spring with 25 active coils are cut. Will the stiffness of new spring be more less compared to old spring and how much ?

Ans. Stiffness of new spring with 20 coils will be more ; 1.25 times.

Q. 331. What are the advantages of preloading of bolts ?

Ans. For pressure vessels, initial tightening torque makes the joint leak proof. Preloading also reduces the amplitude of fluctuation in load and thus improves the fatigue strength of the parts.

Q. 332. In power screws, friction should be least and knuckle threads have minimum friction compared to other threads. Still it is rarely used. Why ?

Ans. Knuckle thread is difficult to manufacture.

Q. 333. Why acme threads are preferred compared to square threads for power screws ?

Ans. Acme threads can be manufactured using dies and thus cost of production is lower.

Q. 334. What is slenderless ratio in power screws ?

Ans. It is the ratio of unsupported length to the minimum radius of gyration.

Q. 335. For a compression spring not to buckle, what is the maximum ratio of length to coil diameter ?

Ans. 2.6.

Q. 336. Why provision is made in bicycle wheels to tighten the spokes ?

Ans. Tightening of spokes put them in tension which pulls the wheel inward and the rim becomes compressively stressed. In normal operation wheel rim is put to tensile stresses due to heating. The initial compressive stresses thus help wheel rim to withstand high tensile stresses and life of rim is more.

Q. 337. Why the rim of forged-steel wheels is cooled quickly by quenching ?

Ans. The quick cooling of rim causes contraction of rim on supporting surface. When supporting surface cools in normal way subsequently, it is subjected to tension and the rim is stressed in compression. Thus residual tensile stresses experienced by rim during normal operation do not cause thermal crack and their propagation is checked because of residual compressive stresses induced in the rim during manufacturing.

Q. 338. What type of joint is used to connect two rods subjected to (*a*) tensile loads only and (*b*) tensile or compressive loads ?

Ans. Knuckle joint and cotter joint respectively.

Q. 339. Which type of thread is best suited where power is to be transmitted in either direction ?

Ans. Square thread.

Q. 340. To reduce stress concentration in threads the bolt shank diameter should be made equal to ..... ?

Ans. Minor diameter of threads.

Q. 341. What do you understand by coaxing ?

Ans. Coaxing is the process of improving fatigue properties by operation at stresses under the indurance limit.

Q. 342. If both weight and length of a shaft are halved, then its natural frequency will ..... ?

Ans. increase 4 times.

Q. 343. What for circlips are used ?

Ans. Circlips are used to prevent axial motion of two concentric parts.

Q. 344. Why is it that round key is suitable for heavy duty service ?

Ans. A round key introduces low stress concentration.

Q. 345. For what application feather keys are used ?

Ans. Feather keys are used where a keyed gear or pulley has to slide along the shaft.

Q. 346. If shaft diameter is doubled, torque transmitting capacity increases ____ times.

Ans. 8

Q. 347. Keyway on shaft reduces its section and also causes stress concentration. How the strength of shaft with keyway is reduced compared to solid shaft ?

Ans. Strength of shaft with keyway

$$= \left(1 - 0.2 \times \frac{\text{width of key}}{\text{shaft dia.}} - 1.1 \times \frac{\text{thickness of key}}{\text{shaft dia}} \right) \times \text{strength of solid shaft}$$

Q. 348. For which component's design, Wahl stress factor is used ?

Ans. For design of close coiled helical spring.

Q. 349. If wire diameter of spring, its coil diameter and number of active coils be all halved, what happens to natural frequency of spring ?

Ans. Since $f \propto \frac{d}{D^2 n}$, frequency is increased 8 times.

Q. 350. Why a carriage spring is called as the beam of uniform strength ?

Ans. A carriage beam consists of several leaves stacked over each other, so that it can be considered as triangular leaf. For triangular leaf loaded as cantilever, the bending stress is same at all sections. For this reason it is called as the beam of uniform strength.

Q. 351. If energy absorbing capacity of a leaf spring is to be doubled, how much thickness of leaf needs to be increased, keeping all other factors same ?

Ans. Energy stored $\propto$ load, and load $\propto \frac{1}{t^2}$, $\therefore$ for double the load, thickness needs to be increased $\sqrt{2}$ times, *i.e.* 1.41 times.

Q. 352. Which key consists of two keys ?

Ans. Kennedy key.

Q. 353. If thickness of plate is increased four times, the rivet diameter will have to be increased ..... ?

Ans. two times.

Q. 354. The expected efficiency of a single rivetted lap joint is of the order of ..... ?

Ans. 50%.

Q. 355. A butt welded joint designed for static load of 10,000 N is subjected to impact load ? For joint to remain safe, how much impact load can be applied ?

Ans. 8,000 N.

Q. 356. Why longitudinal joint is made butt joint ?

Ans. To maintain the circularity of the vessel.

Q. 357. Whether rivet diameter or rivet hole diameter is used for calculating efficiency of rivetted joint ?

Ans. In pressure vessel hole diameter is used and in structural work diameter is of rivet is used for calculating forces and efficiency.

Q. 358. Which is the most economical process for prestressing a cylindrical pressure vessel ?

Ans. Auto-frettage.

Q. 359. What is the maximum diameter of the opening in a pressure vessel which does not require any compensation ?

Ans. 200 mm.

Q. 360. For a pressure vessel to the classified as thin vessel, the ratio of wall thickness to mean radius is less than.

Ans. 1/10.

Q. 361. Why a workpiece needs to be finished smoothly if endurance strength is the criterion ?

Ans. Surface finish plays important role in deciding endurance strength of a workpiece. Surface roughness introduces stress concentration. Physical properties of a workpiece are influenced with rough surface layer and it carries high residual stresses.

Q. 362. What is Wohler curve associated with ?

Ans. Wohler curve is associated with endurance limit. It is a plot of log of stress versus log of cycles.

Q. 363. How many cycles of reversal of stress treated as infinite life ?

Ans. 10^6 cycles.

Q. 364. Can the stress concentration factor be ignored under static loading for ductile materials ?

Ans. Yes.

Q. 365. Which test can determine the ductility and drawing properties of a sheet metal ?

Ans. Cupping test.

Q. 366. Give two examples of parts where the design criteria is rigidity and not the strength. *(UPSC CES 1999)*

Ans. In the case of shafts rigidity (*i.e.* torsional deformation and the lateral deflection) are important to ensure good performance of gears mounted on it. Here rigidity is important and not strength.

Similarly in design of machine beds, rigidity is more important to take care of machining allowances.

Q. 367. What is the difference between proof stress and proof resilience.

Ans. Proof stress is the stress at which the non-proportional elongation amounts to a specified %age of the original gauge length. Proof resilience is the maximum strain energy which can be stored in a material per unit volume.

Q. 368. What is the difference between closed coiled and open coiled helical spring ?

Ans. In closed coiled spring the slope of the helix of the coil is so small that bending effect can be neglected but in open coiled spring the slope of the helix of the coil is appreciable so that both bending and torsional stresses are introduced.

Q. 369. What is endurance ratio ?

Ans. It is the ratio of the fatigue limit to the tensile strength.

Q. 370. Distinguish between fatigue strength and fatigue limit. *(UPSC, CES 1999)*

Ans. The reduced tendency of a material to offer resistance to the applied stress under fluctuating load is called fatigue. The limiting stress below which a material will withstand a specified number of cycles of stress without fracture is called fatigue strength. Fatigue limit refers to the maximum stress below which a material can presumably endure or withstand an infinite number of cycles of stress.

Q. 371. What is the difference between ultimate strength and rupture strength ?

Ans. Ultimate strength is the ratio of breaking load and original cross section whereas rupture strength is the ratio of breaking load and final reduced area.

Q. 372. What is the difference between normal strain and natural strain ?

Ans. Normal strain corresponds to original length and natural strain corresponds to instantaneous length.

Q. 373. What is the difference between strut and column ?

Ans. Strut is a bar of a structure carrying an axial compressive load in any direction but column is a member that carries axial compressive load vertically.

Q. 374. It α is the groove angle of V belt, then friction μ of flat belt gets modified as ?

Ans. $\mu' = \mu \operatorname{cosec} \alpha/2$

Q. 375. Whether centrifugal tension of belt increases tension on tight side or slack side or both.

Ans. Centrifugal tension increases tension both on tight side and slack side.

Q. 376. For flat belt $T_t/T_s = e^{\mu\theta}$. If centrifugal tension is also considered, how this relationship gets modified ?

Ans. $\dfrac{T_t - T_c}{T_s - T_c} = e^{\mu\,\theta}$

Q. 377. What is the relationship between tight side tension and centrifugal tension for flat belt ?

Ans. $T_t = 3T_c$

Q. 378. What should be the magnitude of initial tension in the belt ?

Ans. $\dfrac{T_t + T_s + 2T_c}{2}$

Q. 379. Why slip occurs in belt drive ?

Ans. Slip occurs due to unequal elongation of belt due to tight and slack side tensions.

Q. 380. What is usually the pitch line velocity of belt drive ?

Ans. 20 m/s

Q. 381. What is the difference between slenderness ratio and buckling factor ?

Ans. Slenderness ratio is the ratio of length of column to the least radius of gyration but buckling factor is the ratio of equivalent length of column to least radius of gyration.

Q. 382. What is jockely-pulley drive arrangement ?

Ans. Jockey pulley is a small pulley incorporated between driver and driven pulley near small pulley and so placed that it increases the arc of contact on the small pulley and is used where the speed ratio is high and centre distance is low.

Q. 383. For what purpose fast and loose pulley drives used ?

Ans. There are used where the driven shaft can be stopped without stopping the line shaft.

Q. 384. At what velocity of belt, the maximum power is transmitted ?

Ans. Maximum power in a flat belt is transmitted at velocity of

$$\sqrt{\frac{\text{working stress for belt material per unit width of belt}}{3 \times \text{density of belt material}}}$$

Q. 385. What is the minimum angle of arc of contact for a flat belt drive ?

Ans. 155°.

Q. 386. The purpose of crowning of flat belt pulley is to ..... ?

Ans. avoid running off belt.

Q. 387. Why slip in V-belt is less in comparison to slip in flat belt ?

Ans. The coefficient of friction for flat belt is of the order of 0.13 and that for V-belt is $\mu/\sin \beta$ (β = semi-included angle of belt). Thus effective coefficient of friction for V-belt may be of the order of 0.38 to 0.57 and thus slip is lesser.

Q. 388. How many cross-sections of V-belts are commonly available ?

Ans. Five. (denoted by symbols *A*, *B*, *C*, *D* and *E*) ·

Q. 389. What is the reason for speed variation in a chain drive ?

Ans. Polygonal action.

Q. 390. Why ferodo is preferred for friction lining ?

Ans. Due to its high heat resistance.

Q. 391. In which type of brake the direction of rotation does not change the torque capacity ?

Ans. In internal expanding shoe brake.

Q. 392. How the torque capacity of a brake should be increased ?

Ans. By increasing the width of the shoe.

Q. 393. Under what condition a brake is said to be self energising ?

Ans. When the direction of moment due to frictional force and due to external force help operate the brake.

Q. 394. In which type of clutch the number of springs used is one only ?

Ans. Cone clutch.

Q. 395. Why multiple plate clutch is used on two wheelers ?

Ans. due to small size

Q. 396. What is the maximum transmission ratio in a chain drive ?

Ans. 7.

Q. 397. What is the difference between flexible and non-flexible elements in transmission of power ?

Ans. In flexible elements the centre distance between the driving and driven members can be changed conveniently but not in non-flexible elements.

Q. 398. If both coil diameter and wire diameter of a close coiled helical spring be halved, then shear stress in new spring compared to earlier one will increase ..... ?

Ans. 4 times.

Q. 399. What does Wahl correction factor account for in helical springs ?

Ans. It accounts for both direct shear and curvature effects.

Q. 400. In order to stress all the leaves of laminated spring to the same extent, the full length leaves are given a greater radius of curvature than the graduated leaves. What is the criterion for gap between full leaf and graduated leaf ?

Ans. Gap should be such that under maximum load, the total deflection of graduated leaves will be greater than of full length leaf by an amount of gap between two leaves.

Q. 401. For angular misalignment of upto 30°, what type of flexible coupling is used ?

Ans. Hooke's or universal flexible coupling.

Q. 402. Which coupling would you recommend to act as a safety device against over load ?

Ans. Slip coupling.

Q. 403. What is the ratio of average shear stress to the maximum shear stress in a beam with a square cross-section ?

Ans. 2/3.

Q. 404. What are residual stresses ? How these are produced and how it can be used to our advantage ?

Ans. Residual stresses are the system of stresses which exist in a body when it is free from external forces. Residual stresses are produced whenever a body undergoes nonuniform plastic deformation. For example, consider a metal sheet which is being rolled under conditions such that plastic flow occurs only near the surfaces of the sheet.

In cold rolling of a material, the surface fibers of the sheet are cold-worked and tend to elongate, while the center of the sheet is unchanged. Since the sheet must remain a continuous whole, the surface and center of the sheet undergo a strain accommodation. The center fibers tend to restrain the surface fibers from elongating, while the surface fibers seek to stretch the central fibers of the sheet. The result is a residual-stress pattern in the sheet which consists of a high compressive stress at the surface and a tensile residual stress at the center of the sheet. In general, the sign of the residual stress which is produced by inhomogeneous deformation will be opposite to the sign of the plastic strain which produced the residual stress.

Q. 405. Why residual stresses are only elastic stresses ?

Ans. The maximum value which the residual stress can reach is the elastic limit of the material. A stress in excess of this value, with no external force to oppose it, will relieve itself by plastic deformation until it reaches the value of the yield stress.

Q. 406. For what purposes, the analysis of variance used ?

Ans. It is used to determine whether variances in two or more populations are significantly different.

Q. 407. A thin walled cylindrical vessel of wall thickness t and diameter d is filled with gas to a gauge pressure p. The maximum shear stress on the vessel of wall will be ____.

Ans. Max. shear stress $= \dfrac{p_1 - p_2}{2} = \dfrac{\dfrac{p\,d}{2t} - \dfrac{pd}{4t}}{2} = \dfrac{pd}{8}$.

Q. 408. What is the value of the max. principal strain in a thin cylindrical tank ?

Ans. Principal strain $= \dfrac{p\,d}{2t\,E} - \dfrac{pd}{4t\,E\,m}$.

Q. 409. Two helical tensile springs are of same material and have identical coil diameter and both have same weight but wire diameter are d and $d/2$. Ratio of their stiffness will be ..... ?

Ans. Since weight is same,

$$\therefore \qquad \frac{\pi}{4}(d)^2 \times n_1 = \frac{\pi}{4}\left(\frac{d}{2}\right)^2 \times n_2 \text{ and } \quad \frac{n_1}{n_2} = \frac{1}{4}$$

spring striftness $\alpha \frac{d^4}{n}$

$$\therefore \quad \frac{k_1}{k_2} = \frac{d^4}{(d/2)^2} \times \frac{n_2}{n_1} = 16 \times 4 = 64.$$

Q. 410. In a bi-axial stress problem, stresses in x and y directions are 200 MPa and 100 MPa. What will be maximum principal stress ?

Ans. Maximum principal stress

$$= \frac{\sigma_x + \sigma_y}{2} + \frac{1}{2}\sqrt{(\sigma_x - \sigma_y)^2 + 4\sigma_{xy}^2}$$

$$= \frac{200 + 100}{2} + \frac{1}{2}\sqrt{(200 - 100)^2} = 150 + 50 = 200 \text{ MPa}.$$

Q. 411. Which theory of failure will you use for aluminium components under steady loading ?

Ans. Max. shear stress theory.

Q. 412. What is the Euler's critical buckling load for a slender column of length l and flexural rigidity EI built in at the base and free at top ?

Ans. $\frac{\pi^2 EI}{4l^2}$.

Q. 413. Two shafts are of same material, one being twice the diameter of other. The ratio of their transmitted powers will be ?

Ans. 8.

Q. 414. What is the ratio of maximum shear stress to average shear stress in a rectangular beam ?

Ans. 1.5.

Q. 415. What does the total area under the stress-strain curve of M.S. specimen tested upto failure under tension represent ?

Ans. ultimate strength.

Q. 416. What will be the true strain for a low carbon steel bar which is doubled in length by forging ?

Ans. 0.693.

Q. 417. A block of steel is loaded by a tangential force on its top surface while the bottom surface is held rigidly. What would be reason for this block to deform ?

Ans. It will be deformed due to shear and bending.

Q. 418. If deflection under load P of a cantilever beam of length L is $PL^3/3EI$, then strain energy due to bending will be ..... ?

Ans. Strain energy $= \frac{1}{2} P \cdot \delta = \frac{1}{2} P \times \frac{Pl^3}{3EI} = \frac{P^{L^3}}{6EI}$.

Q. 419. The outside diameter of a hollow shaft is twice its inside diameter. The ratio of the torque carrying capacity of hollow shaft to that of solid shaft of same material and same outside diameter is ..... ?

Ans. 15/16.

Q. 420. When a fluid is said to be Newtonian ?

Ans. When the shear stress is directly proportional to the velocity gradient.

Q. 421. In adiabatic flow with friction, how the stagnation temperature behaves along a streamline ?

Ans. It remains constant.

Q. 422. In order to burn 1 kg of methane gas completely, minimum number of kgs of oxygen needed is ..... ?

Ans. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

16 kg 64 kg

1 kg needs 4 kg of O_2.

Q. 423. What is foot valve and where it is located ?

Ans. A foot valve is a check valve. It is installed at suction line's bottom in a centrifugal pump.

Q. 424. What is priming and why it is done ?

Ans. Priming is the removal of air from the water ways of the pump by filling them with liquid to be pumped. Without priming, pump will not be able to suck liquid and develop pressure.

Q. 425. What is the object of 2 stage compression ?

Ans. For high compression ratio, the temperature range can be divided between two cylinders and intercooling is porsible.

Q. 426. Why pipe lines after compressor often start leaking ?

Ans. In the absence of after cooler, hot gases heat the pipes and get cooled when compressor is shut down. This repetition of cycle induces leaky joints.

Q. 427. Why the percent of capacity reduction in reciprocating compressors is greater than the percent of cylinder clearance ?

Ans. It is so because the piston must travel back part of its return stroke before clearance space air has expanded to atmospheric pressure and permitting free air to flow into the cylinder.

Q. 428. What is the effect of increase in clearance of a reciprocating compressor ?

Ans. An increase in clearance requires a larger compressor to deliver the same amount of gas, and thus more power.

Q. 429. Why circulating of cooling water of air around the reciprocating compressor cylinder desirable ?

Ans. The cooling medium takes away the heat equivalent of work done on gas in compressor. It takes less work to compress gas isothermally than isentropically. This way power to compress same volume can be reduced.

Q. 430. Explain the difference between fluid, liquid and gas ?

Ans. Fluid is a substance capable of flowing and which conforms to the shape of the containing vessel.

Liquid is practically incompressible and occupies definite volume and has free surfaces.

Gas is compressible fluid and a given mass of gas expands until it occupies all portions of the containing vessel.

Q. 431. When a fluid can be said to be in equilibrium ?

Ans. Fluids in equilibrium can't sustain tangential or shear forces.

Q. 432. Define fluid mechanics ?

Ans. It represents that branch of applied mechanics which deals with the behaviour of fluids at rest and in motion.

Q. 433. Explain the difference between relative density, viscosity and kinematic viscosity ?

Ans. Relative density is that pure number which denotes the ratio of the mass of a body to the mass of an equal volume of a substance taken as a standard. This standard is usually water (at 4°C)

for solids and liquids, and air free of CO_2 or hydrogen (at 0°C and 1 atmosphere = 1.013×10^5 Pa pressure) for gases.

Viscosity of a fluid is thát property which determines the amount of its resistance to a shearing force. It is due primarily to interaction between fluid molecules.

Kinematic viscosity is the ratio of absolute viscosity and mass density. (Its unit is m^2/s).

Q. 434. What are Newtonian fluids ?

Ans. Fluids which follow the relation : absolute viscosity $\mu = \frac{\tau}{dv/dy}$, where τ = shear stress and $\frac{dv}{dy}$ = gradient of velocity with distance between a fixed plate and moving plate (at velocity V).

Q. 435. What is vapour pressure and when it becomes important ?

Ans. Vapour pressure is the partial pressure created by the vapour molecules when evaporation takes place within an enclosed space. It becomes important when negative pressures are involved.

Q. 436. Explain absolute viscosity ?

Ans. It is the ratio of shear stress and the gradient of velocity with distance between a fixed plate and moving plate (Its unit is $Pa \cdot s$).

Q. 437. Define surface tension ?

Ans. Surface tension of a liquid is the work that must be done to bring enough molecules from inside the liquid to the surface to form one new unit area of that surface. (Its unit is Nm/m^2 or N/m).

Q. 438. What is capillarity and when liquid rises or falls ?

Ans. Capillarity : The rise or fall of a liquid in a capillary tube caused by surface tension. The magnitude of rise or fall depends on the relative magnitudes of the cohesion of the liquid and the adhesion of the liquid to the walls of the containing vessel. Capillarity is of importance in tubes smaller than 10 mm diameter.

Rise of liquid : Liquids rise (in capillary tube) when they wet and adhesion of the liquid to the walls is greater than the cohesion of the liquid.

Fall of liquid : Liquids fall (in capillary tube) when they do not wet and the cohesion of the liquid is greater than the adhesion of the liquid to the walls.

Q. 439. What is the difference between perfect and real fluids ?

Ans. Perfect fluids are treated as if all tangential forces created by friction can be ignored.

Real fluids refer to the cases in which friction must properly be taken into account.

Q. 440. Define fluid compressibility.

Ans. It is defined as $\frac{1}{\rho}\frac{\partial \rho}{\partial p}$.

Q. 441. When the motion of fluid is fully known ?

Ans. The motion of a fluid is fully known when the velocity of each of its particles can be specified.

Q. 442. Define fluid.

Ans. A fluid is a substance that can't remain at rest under the action of any shear force.

Q. 443. What is Eulerian and Lagrangian description ?

Ans. Eulerian description expresses velocities as functions of position and time, such as

$$u = 2x^2y, \quad v = -2xy^2, \quad w = 0.$$

Lagrangian description expresses fluid by motion by means of particle coordinates as functions of time ; such as $x = x\ (t\ ;\ x_0, y_0)$, $y = y\ (t\ ; x_0, y_0)$.

Q. 444. State continuity equation in Cartesian form ?

Ans. It is represented as $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$.

Q. 445. What is nonbarotropic fluid ?

Ans. Fluid such as air for which the density is not a single-valued function of the pressure (aerostatics).

Q. 446. On account of which property, the falling drops of rain acquire spherical shape.

Ans. Surface tension.

Q. 447. How you can define standard atmospheric pressure ?

Ans. By international agreement, the standard atmospheric pressure is defined as 101.325 kN/m^2.

Q. 448. What do you understand by acoustic velocity ?

Ans. Acoustic velocity is the speed of a small pressure (sound) wave in a fluid.

Q. 449. Explain the difference between centipoise and centistoke ?

Ans. Centipoise is the unit of dynamic viscosity. It is equal to $\frac{1}{100}$ of poise, and poise $= 0.1\ Pa \cdot s$. Value of dynamic viscosity of water at 20°C is approximately equal to 1 Centipoise.

Centistoke is the unit of kinematic viscosity and is equal to $\frac{1}{100} \times$ stoke. Stoke is defined as 1 square centimeter per second.

Q. 450. What is saybolt seconds universal ?

Ans. Saybolt Seconds Universal (SSU) is the unit of viscosity and is equal to the time required for a gravity flow of 60 *cc* through saybolt universal viscometer.

Q. 451. Explain difference between cohesion, adhesion and capillarity ?

Ans. Cohesion is the attraction of like molecules.

Adhesion is the attraction of unlike mocecules for each other.

Capillarity is the elevation or depression of a liquid surface in contact with a solid.

Q. 452. Explain difference between fluid pressure, gauge pressure, difference in pressure, bar pressure and pressure head.

Ans. Fluid pressure is transmitted with equal intensity in all directions and acts normal to any plane.

Gauge pressure represents pressure above atmospheric pressure. It is equal to unit weight of the liquid (ρg) multiplied by the height of desired point above free surface.

Difference in pressure between any two points at different levels in a liquid = unit weight of liquid × difference in elevation.

Bar pressure : Gauge pressure in bar is obtained by dividing the gauge pressure in pascal by 10^5.

Pressure head : Pressure head '*h*' represents the height of a column of homogeneous fluid that will produce a given intensity of pressure $\left(h = \frac{p}{\rho g} \right)$.

Q. 453. What is bulk modulus of elasticity ?

Ans. It represents the compressibility of a fluid. It is the ratio of the change in unit pressure to the corresponding volume change per unit of volume.

Q. 454. What is isentropic exponent ?

Ans. It is the ratio of the specific heat of a gas at constant pressure to the specific heat at constant volume.

Q. 455. At what speed the pressure disturbances travel ?

Ans. Pressure disturbances imposed on a fluid move in waves at a velocity equal to that of sound through the fluid whose magnitude

$$= \sqrt{\frac{\text{bulk modulus of elasticity}}{\text{density}}} = \sqrt{\frac{\text{isentropic exponent} \times \text{pressure}}{\text{density}}}$$

$$= \sqrt{\text{isentropic exponent} \times \text{gas constant} \times \text{absolute temperature}}$$

Q. 456. Explain difference between ideal fluid and non-newtonian fluid.

Ans. Ideal fluid is one for which resistance to shearing deformation is zero.

Non-newtonian fluids deform in such a way that shear stress is not proportional to the rate of shearing deformation.

Q. 457. Explain the difference between poise and stoke.

Ans. Poise is the unit of viscosity in CGS unit and is measured in dyne sec/cm^2 1 poise = 10^{-1} *Pa s*

Stoke is the unit of kinematic viscosity in CGS units and is measured in cm^2/s.

Q. 458. How does the pressure in an isothermal atmosphere behave ?

Ans. It increases exponentially with elevation.

Q. 459. The centre of pressure for a plane surface immersed vertically in a static liquid compared to centroid of area is always ..... ?

Ans. below.

Q. 460. What is buoyant force equal to ? Define centroid of the area.

Ans. Volume of liquid displaced.

Centroid of the area : The point at which the area might be concentrated and still leave unchanged the first moment of the area around any axis. It is also the centre of gravity.

Q. 461. Define vapour pressure and on what parameters it depends ?

Ans. The pressure exerted when a solid or liquid is in equilibrium with its own vapour is called vapour pressure. It is a function of the substance and its temperature.

Q. 462. Explain the difference between steady flow, one dimensional flow, two dimensional flow and three dimensional flow ?

Ans. If at every point in the continuum, the local velocity and other fluid property, remains unchanged with time, it is referred to as steady flow.

One dimensional flow is one in which a line is necessary to describe the velocity profile.

Two dimensional flow is one in which an area is necessary to describe the velocity profile.

Three dimensional flow is one in which a volume is necessary to describe the velocity profile.

Q. 463. What is aquifer and explain difference between confined and unconfined aquifers.

Ans. Groundwater occurs in permeable, water-bearing geologic formations known as aquifers.

Confined aquifer : It is a relatively high-permeable, water-bearing formation.

Unconfined aquifer : It is a water-bearing formation with a free water table, below which the soil is saturated.

Q. 464. What do you understand by flurial hydraulics ?

Ans. The channels may be classified as rigid boundary or mobile boundary channels. Mobile boundary channels include rivers and unlined alluvial canals, the boundaries of which are made of loose soil which can be easily eroded and transported by flowing water. The study of flow of water in mobile boundary channels is dealt in flurial hydraulics.

Q. 465. By which instruments the shear stress in fluids can be measured directly ?

Ans. By Stanton tube or Preston tube.

Q. 466. On what factors does the pressure at a point as a static mass of liquid depends upon ?

Ans. Specific weight of liquid and the depth below the free liquid surface.

Q. 467. What is the difference between hoop or longitudinal tension and circumferential tension ?

Ans. Hoop tension is created in the walls of a cylinder subjected to internal pressure. For thin walled cylinder ($t < 0.1\ d$), hoop stress = pressure × radius/thickness.

Longitudinal tension in thin-walled cylinders closed at the ends is equal to half the hoop tension.

Q. 468. How much force is exterted by liquid ?

Ans. Force exerted by a liquid on a plane area A is equal to the product of the unit weight ρg of the liquid, the depth h_{cg} of the centre of gravity of the area, and the area.

Q. 469. What is centre of pressure and how it is determined ?

Ans. The line of action of the force exerted by a liquid on a plane area passes through the centre of pressure which can be located by the formula $h_{cp} = \frac{I_{cg}}{h_{cg} A} T + hcg$, where I_{cg} is the moment of inertia of the area about its centre of gravity axis.

Q. 470. Explain the difference between horizontal and vertical components of hydrostatic force ?

Ans. The horizontal component of the hydrostatic force on any surface is equal to the normal force on the vertical projection of the surface and acts through the centre of pressure for the vertical projection.

Vertical component of the hydrostatic force on any surface is equal to the weight of the volume of liquid above the area and passes through the c.g. of the volume.

Q. 471. What should be diameter of capillary tube to avoid correction for effect of capillarity in manometer ?

Ans. Greater than 6 mm.

Q. 472. How much hydrostatic pressure acts on a curved surface ?

Ans. The horizontal component of the total hydrostatic pressure force on any surface is always equal to the total pressure on the vertical projection of the surface, and can be located through the centre of pressure of this projection.

The vertical component of the total hydrostatic pressure force on any surface is always equal to the weight of the entire water column above the surface extending vertically to the free surface, and can be located through the centroid of this column.

Q. 473. How much is the horizontal component of force on a curved surface ?

Ans. Force on a vertical projection of the curved surface.

Q. 474. State Archimedes principle.

Ans. Any weight, floating or immersed in a liquid, is acted upon by a buoyant force equal to the weight of the liquid displaced. This force acts through the centre of buoyancy, *i.e.* the c.g. of the displaced liquid.

Q. 475. What do you understand by centre of buoyancy ?

Ans. Centre of buoyancy is the centre of gravity of the displaced liquid and buoyant force acts through it.

Q. 476. How one can establish stability of submerged body and floating body ?

Ans. A submerged body floats in stable equilibrium when the centre of gravity of the body lies directly below the centre of buoyancy.

A floating body is in stable equilibrium when its centre of gravity lies below the centre of buoyancy.

Q. 477. What is neutral equilibrium ?

Ans. A submerged body is in neutral equilibrium for all positions when the centre of gravity of body coincides with the centre of buoyancy.

Q. 478. On what factors the stability of floating objects depends ?

Ans. Stability of floating objects depends upon whether righting or overturning moment is developed when the centre of gravity and centre of buoyancy move out of vertical alignment due to the shifting of position of centre of buoyancy.

Q. 479. What happens during translation of liquid ?

Ans. When a liquid is moved horizontally/vertically at constant accelerations without relative motion between particles, then for horizontal motion, the surface of liquid becomes an inclined plane, the slope being

$$= \tan^{-1} \frac{\text{linear acceleration } (a)}{\text{gravitational acceleration } (g)}.$$

For vertical motion, the pressure at any point in liquid $= \rho g h \left(1 \pm \frac{a}{g} \right)$.

(+ *ve* sign for constant upward acceleration and – *ve* sign with constant downward acceleration).

Q. 480. What is paraboloid of revolution during rotation of fluid ?

Ans. The free surface of the liquid in a rotating vessel attains the form of a paraboloid of revolution. The equation of the parabola is $y = \frac{\omega^2}{2g} x^2$.

(x, and y are coordinates of any point in the surface measured from the vertex in the axis of revolution, and ω = constant angular velocity).

Q. 481. What are the conditions for stability of buoyant bodies ?

Ans. A floating body is stable if the centre of gravity is below the metacentre.

A submerged body is stable if the centre of gravity is below the centre of buoyancy.

Q. 482. Define pipe flow ?

Ans. It refers to full water flow in closed conduits of circular cross section under a certain pressure gradient.

Q. 483. How much is vertical component of pressure force on a submerged curved surface ?

Ans. The weight of liquid vertically above the curved surface.

Q. 484. What is meant by the terminal velocity of particles settling in a liquid or gaseous medium ?

Ans. When a particle is released from rest in a stationary fluid it accelerates initially under the action of a force equal to the difference between its weight and the buoyancy force. This acceleration decreases owing to the drag force acting on particle resulting from the relative motion between the particle and the fluid and this drag force increases with particle velocity. At particular value of velocity of particle (terminal velocity), the sum of drag and buoyancy force equals the weight of the particle and particle acceleration is zero and particle continues to fall with a constant velocity (terminal velocity) (V_t).

$$\frac{\pi D^3}{6} (\rho_s - \rho) g = 3\pi \mu D V_t$$

Q. 485. What is cavitation parameter ?

Ans. Cavitation parameter characterises the susceptibility of the system to cavitation. It is defined as $\frac{p - p_v}{\rho V^2/2}$

p = absolute pressure at point under consideration

p_v = vapour pressure of liquid

ρ = mass density of liquid

v = reference velocity of flow of liquid

Q. 486. How much pressure is exerted on closed rotating vessel ?

Ans. The pressure in a closed vessel gets increased by rotating the vessel. The pressure increase between a point in the axis of rotation and at point x away from the axis is $= \rho g \frac{\omega^2}{2g} x^2$.

Q. 487. Explain the difference between one and two dimensional flow ?

Ans. True one-dimensional flow occurs when the direction and magnitude of the velocity at all points are identical. Velocities and accelerations normal to the streamline are negligible. Two dimensional flow occurs when the fluid particles, move in planes or parallel planes and the stream-line patterns are identical in each plane.

Q. 488. What is the difference between irrotational and rotational flow ?

Ans. Irrotational flow : An ideal fluid flow in which no shear stresses occur and hence no torques exist. Rotational motion of fluid particles about their own mass centres can not exist. It can be represented by a flow net.

Rotational flow occurs when the velocity of each particle varies directly as the distance from the centre of rotation.

Q. 489. Explain the difference between steady and unsteady flows.

Ans. In steady flow, at any point, the velocity of successive fluid particles is the same at successive periods of time.

Flow is unsteady when conditions at any point in a fluid change with time.

Q. 490. What is the difference between uniform and non-uniform flows ?

Ans. Uniform flow occurs when the magnitude and direction of the velocity do not change from point to point in the fluid.

Non uniform flow occurs when velocity, depth, pressure, etc. change from point to point in the fluid flow.

Q. 491. Explain the difference between stream lines and stream tube.

Ans. Stream lines are imaginary curves drawn through a fluid to indicate the direction of motion in various sections of the flow of the fluid system. There can be no flow across a streamline at any point.

Stream tube represents elementary portions of a flowing fluid bounded by a group of streamlines which confine the flow.

Q. 492. Explain equation of continuity and energy equation.

Ans. Equation of continuity results from the principle of conservation of mass. For steady flow, the mass of fluid passing all sections in a stream of fluid per unit time is the same,

i.e. $$\rho_1 A_1 V_1 = \rho_2 A_2 V_2 = \text{constant}$$

Energy equation results from application of the principle of conservation of energy to fluid flow. In the direction of flow, as per the energy principle,

energy at entry + energy added – energy loss – energy extracted = energy at outlet.

This equation for steady flow of incompressible fluids in which the change of internal energy is negligible, is

$$\frac{p_1}{\rho g}+\frac{V_1^2}{2g}+Z_1+H_A-H_L-H_E=\frac{p_2}{\rho g}+\frac{V_2^2}{2g}+Z_2$$

Q. 493. Define vorticity ?

Ans. It equals twice the angular velocity.

Q. 494. What is irrotational flow ?

Ans. If a flow is uniform in one region (without rotation), this property is conserved as the fluid moves into a region of space where the motion is not uniform, and the flow is termed irrotational flow.

Q. 495. What is one-seventh power law ?

Ans. According to one-seventh power law of turbulent, velocity variation corresponds to a much favoured velocity profile and the mean velocity increases as the one-seventh power of the distance from the boundary wall.

Q. 496. What is the difference between source, sink and doublet ?

Ans. A 3-D source is a point from which fluid is imagined to be issued radially at a uniform rate in all direction. A-2-D source is a line from which fluid is imagined to be issued at right angles to the line from every point on it at a uniform rate in all direction.

A-3-D sink is a point towards which fluid is imagined to flow radially at uniform rate from all directions.

A doublet is defined as a combination of a source of strength 'm' and a sink of strength '- m', placed a small distance δs apart which are allowed to approach each other ($\delta s \to 0$) in such a manner that the product of their strength and the distance between them ($m\delta s$) remains a finite constant (μ = strength of doublet).

Q. 497. What is the magnitude of buoyant force and where does the line of action of buoyant force act ?

Ans. It is equal to the volume of the liquid displaced. The line of action of buoyant force acts through the centroid of the displaced volume of the fluid.

Q. 498. What is metacentre ?

Ans. Metacentre is the point at the intersection of the buoyancy with the vertical axis of the body.

Q. 499. Define Prandtl's pitot-static tube.

Ans. It is a combination of pressure probe and pitot tube. It is widely used for pressure measurements in wind-tunnel installations.

Q. 500. Define the term fluid friction.

Ans. The deformation of real fluids is resisted by forces caused by internal friction or viscosity. Viscosity is that property of a real fluid which creates shear forces (fluid friction) between two fluid elements.

Q. 501. What is Poiseuille's law.

Ans. In laminar flow, total flow rate is proportional to the gradient (geometric gradient or slope plus the pressure gradient) and to the fourth power of the radius of pipe

or $$Q=\frac{p_1-p_2}{l}\frac{\pi r^4}{8\mu}$$

Q. 502. Define shear velocity.

Ans. It is equal to $\sqrt{\frac{\tau_o}{\rho}}$, where τ_o is the shear stress along the wall and ρ = density of fluid.

Q. 503. Define friction factor for circular pipe.

Ans. It is defined as $\frac{8\,\tau_o}{\rho\,\bar{v}^2}$, where τ_o = wall shear stress, $\bar{v}$ = mean velocity

Q. 504. What are isobaric surfaces ?

Ans. Isobaric surfaces are surfaces of constant pressure. Also called surface of constant potential or equipotential surfaces. At every point in a liquid the isobaric surface is at right angles to the body force at that point.

Q. 505. Define the term 'pressure gradient'.

Pressure gradient (grad p) = $\rho K = \rho\,(ix + jy + kz)$

where i, j, and k are the unit vectors in the direction of the axes of the coordinate system.

The pressure gradient in a fluid is equal to the body force per unit volume and acts in the same direction.

The magnitude of pressure gradient is

$$|\ \text{grad}\, p\ | = \sqrt{\left(\frac{\partial p}{\partial x}\right)^2 + \left(\frac{\partial p}{\partial y}\right)^2 + \left(\frac{\partial p}{\partial z}\right)^2}.$$

Q. 506. Explain what you understand by the term hydrostatic paradox ?

Ans. Hydrostatic paradox is the phenomenon that the floor load of water in vessels of different shapes carrying water at same level depends only on the area of the bottom surface and not on the shape of the vessel.

Q. 507. Define buoyancy in brief.

Ans. Buoyancy is the vertical force exerted on the body by the fluid at rest. The buoyancy of a submerged body in a fluid at rest is equal to the weight of the fluid displaced by the body and it acts upward through the centre of gravity of the displaced volume (the centre of buoyancy).

Q. 508. What is the necessary condition for a body to float in stable equilibrium ?

Ans. Metacentre should be above the centre of gravity.

Q. 509. If liquid rotates at constant angular velocity about a vertical axis as a rigid body, then how its pressure varies at various radial distances ?

Ans. As square of the radial distance.

Q. 510. How does the velocity vary along radius in a free vortex ?

Ans. It decreases with radius.

Q. 511. What type of flow will occur when liquid discharges at constant rate through a long, straight tapering pipe ?

Ans. Steady non-uniform flow.

Q. 512. What does continuity equation represent ?

Ans. It relates mass rate of flow along a stream tube.

Q. 513. Under what condition steady flow occurs ?

Ans. When conditions do not change with time at any point.

Q. 514. State 3 formulae for shear stress for turbulent flow.

Ans. Shear stress for turbulent flow

$$\tau = (\mu + \eta)\,\frac{dv}{dy}$$

η = a factor depending upon the density of the fluid and the fluid motion. It represents the effects of turbulent action. μ represents effects of viscous action.