48. The value engineering technique in which experts of the same rank assemble for product development is called

(*a*) Delphi
(*b*) brain storming
(*c*) morphological analysis
(*d*) direct expert comparison

Sol. **(b)** Value engineering technique in which experts of the same rank assemble for product development is called brain storming.

49. Earliest finish time can be regarded as

(*a*) EST + duration of activity.
(*b*) EST – duration of activity.
(*c*) LFT + duration of activity.
(*d*) LFT – duration of activity.

Sol. **(a)** Statement (a) is correct.

50. Consider an activity having a duration time of T_{ij}. E is the earliest occurrence time and L the latest occurrence time (see figure given).

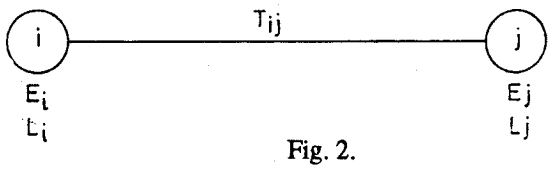


Fig. 2.

Consider the following statements in this regard :

1. Total float = $L_j - E_i - T_{ij}$
2. Free float = $E_j - E_i - T_{ij}$
3. Slack of the tail event = $L_j - E_i$

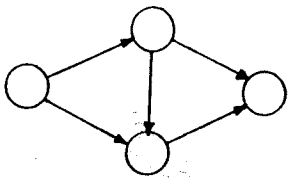
Of these statements

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

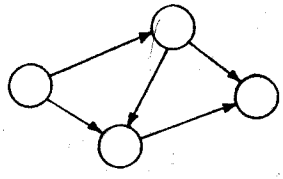
Sol. **(a)** All the three statements are correct.

51. Which one of the following networks is correctly drawn ?

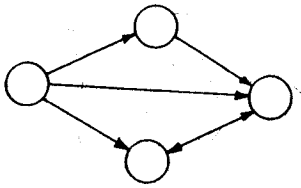
(*a*)



(*b*)



(*c*)



(*d*)

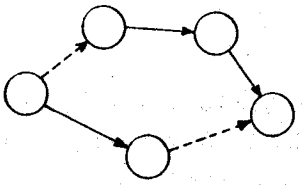


Fig. 3.

Sol. (*d*) Diagram (*d*) is correct as in all other diagrams backward arrows are seen which is not correct.

52. A PERT network has three activities on critical path with mean time 3, 8 and 6, and standard deviation 1, 2 and 3 respectively. The probability that the project will be completed in 20 days is

(*a*) 0.50 (*b*) 0.66

(*c*) 0.84 (*d*) 0.95

Sol. (*c*) The standard deviation of all activities on critical path

$$\sigma_{CP} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2}$$

$$= \sqrt{1^2 + 2^2 + 2^2} = \sqrt{9} = 3$$

Probability of project completion in a given time $p = \phi(Z)$

where

$$Z = \frac{\text{given time} - (\text{sum of mean time of all activities})}{\sigma_{CP}}$$

$$= \frac{20 - (3 + 8 + 6)}{3} = \frac{3}{3} = 1$$

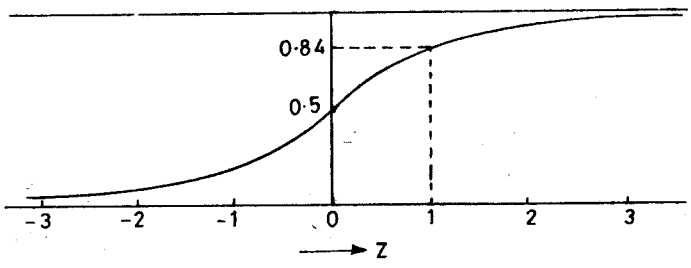


Fig. 4.

Plot of Z *vs.* probability looks as shown in Fig. 4 Corresponding to $Z = 1$, $p = 0.84$.

53. The software package used for computer simulation is known as

(*a*) GPSS (*b*) HTPM

(*c*) CRAFT (*d*) COMSOAL

Sol. (*d*) COMSOAL is the software package used for computer simulation.

The following thirteen items consist of two statements, one labelled the 'Assertion A' and the other labelled the 'Reason R'. You are to examine these two statements carefully and decide if the Assertion A and the Reason R are individually true and if so, whether the Reason is a correct explanation of the Assertion. Select your answers to these items using the codes given below and mark your answer sheet accordingly.

Codes :

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

(*b*) Both A and R are true and but R is not a correct explanation of A

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

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

54. **Assertion A :** The rotor system shown in Fig. A is equivalent to the rotor system shown in Fig. B in so far as torsional vibration is concerned.

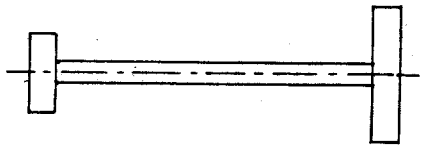


Fig. A

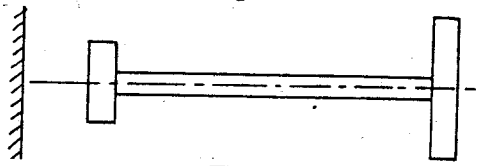


Fig. B

Fig. 5

Reason R : Each torsional system has two rotors carried by a shaft.

Sol. *(d)* Assertion A is not correct because two equivalent systems in regard to torsional vibrations are those which twist through exactly the same angle as the actual shaft, when equal and opposite torque are applied to the two rotors. Due to one rotor being restrained, above condition will not apply. However reason R is true since both systems in Fig. A & B have two rotors carried by a shaft.

55. **Assertion A :** When one body drives another by direct contact, their contact points must have equal components of velocity normal to the surfaces at the point of contact.

Reason R : Two points in the same body must have the same component of velocity relative to the third body, in the direction of the line joining the two points.

Sol. *(a)* Code *(a)* is applicable in this case.

56. **Assertion A :** The resultant unbalanced force at any instant would be the minimum when half of the reciprocating parts is balanced by a rotating weight fixed opposite the crank, but the common practice is to balance two-thirds of the reciprocating parts.

Reason R : Unbalanced force along the line of stroke is more harmful than that in a direction perpendicular to it.

Sol. *(c)* Assertion A is true but reason R is false. In fact the introduction of balance masses causes unbalanced forces perpendicular to the line of the stroke. At high speed, these may be large enough to cause lifting of the wheel from the rails.

57. **Assertion A :** The load placed at the top of the screw in a mechanical screw jack is prevented from rotation by providing a swivelling mechanism.

Reason R : When the screw in a mechanical screw jack rotates, the load kept on top of it moves axially up or down.

Sol. *(d)* In this case A is false but R is true.

58. **Assertion A :** When a pair of spur gears of the same material is in mesh, the design analysis is based on the smaller wheel.

Reason R : For a pair of gears of the same material in mesh "the strength factor" of the smaller wheel is less than that of the larger wheel.

Sol. (*c*) A is true but R is false because strength factor is function of module and is same for gear and pinion. It is due to more wear of pinion that design analysis is based on the smaller wheel.

59. **Assertion** : For a negative rake tool, the specific cutting pressure is smaller than for a positive rake tool under otherwise identical conditions.

Reason R : The shear strain undergone by the chip in the case of negative rake tool is larger.

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

60. **Assertion A :** Gun barrels are made of thick cylindrical tubes "shrunk fit" one inside the other to withstand high internal explosive pressure.

Reason R : The hoop stress induced due to shrink fit in the inner cylindrical tube is compressive in nature whereas the hoop stress due to internal explosive pressure in the same tube is tensile in nature.

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

61. **Assertion A :** Soluble oils are employed with broaching machine.

Reason R : Soluble oils have excellent cooling effect.

Sol. (*a*) Both A and R are true. Also R provides correct explanation for A.

62. **Assertion A :** Direct extrusion requires larger force than indirect extrusion.

Reason R : In indirect extrusion of cold steel, zinc phosphate coating is used.

Sol. (*b*) Both A and R are true but R is not correct explanation of A. Zinc phosphate coating is used to prevent metal contact.

63. **Assertion A :** No separate feed motion is required during broaching.

Reason R : The relative heights of successive teeth in a broach gradually increase.

Sol. (*a*) Both A and R are true. Also R gives satisfactory explanation for A.

64. **Assertion A :** Fracture surface of grey cast iron is dark.

Reason R : Failure takes place along the weak cementite plates.

Sol. (*a*) Both A and R are true. Also R gives satisfactory explanation for A.

65. **Assertion A :** In waiting line model, it is assumed that arrival rate is described by a Poisson probability distribution.

Reason R : The arrival rate is a probabilistic variable and queue discipline is first come first served.

Sol. (*a*) Both A and R are true. Also R gives satisfactory explanation for A.

66. **Assertion A :** Computer simulation can be used for seemingly intractable problems, those that are difficult or complex to solve mathematically.

Reason R : Simulation guarantees the optimal solution.

Sol. (*b*) Both A and R are true but R is not the explanation for A.

67. Which of the following are inversions of a double slider crank chain ?

1. Whitworth return motion.
2. Scotch Yoke.
3. Oldham's Coupling.
4. Rotary engine.

Select correct answer using the codes given below :

Codes :

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

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

Sol. (*c*) Scoth Yoke and Oldman's coupling are the inversions of double slider crank chain.

68. Match List I with List II and select the correct answer using the codes given below the lists

List I	**List II**
A. Governor	1. Pantograph device
B. Automobile differential	2. Feed-back control
C. Dynamic Absorber	3. Epicyclic train
D. Engine Indicator	4. Two-mass oscillator

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

Sol. (*c*) Code (*c*) provides correct matching.

69. Consider the following statements :

Coriolis component of acceleration depends on

1. velocity of slider.
2. angular velocity of the link.
3. acceleration of slider.
4. angular acceleration of link.

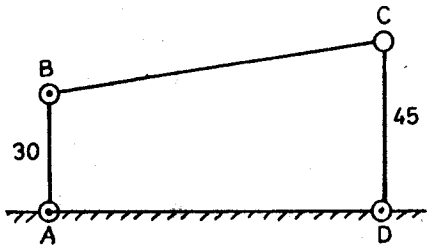
Of these statements

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

(*c*) 2 and 4 are correct (*d*) 1 and 4 are correct

Sol. (*a*) Statements 1 and 2 are correct.

70. ABCD is a four-bar mechanism in which AB = 30 cm and CD = 45 cm. AB and CD are both perpendicular to fixed link AD, as shown in the figure. If velocity of B at this condition is V, then velocity of C is



(*a*) V (*b*) $\frac{3}{2}V$

(*c*) $\frac{9}{4}V$ (*d*) $\frac{2}{3}V$

Sol. (*a*) Velocity or $C = \frac{45}{30}V = \frac{3}{2}V$

71. Match List I with List II and select the correct answer using the codes given below the lists :

List I *(Forces)*	**List II** *(Mathematical expressions)*
A. Inertia Force	1. $C\frac{dy}{dt}$
B. Spring force	2. $M\frac{d^2y}{dt^2}$
C. Damping force	3. $M\omega^2R$
D. Centrifugal force	4. Ky

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

Sol. (*b*) Code (*b*) provides correct matching.

72. In gears, inteference takes place when

(a) the tip of a tooth of a mating gear digs into the portion between base and root circles
(b) gears do not move smoothly in the absence of lubrication
(c) pitch of the gear is not same
(d) gear teeth are undercut

Sol. (*a*) In gears, interference takes place when the tip of a tooth of a mating gear digs into the portion between base and root circle.

73. Match List I with List II and select the correct answer using the codes given below the lists :

List I	**List II**
A. Quadric cycle chain	1. Elliptic trammel
B. Single slider crank chain	2. Rapsons slide
C. Double slider crank chain	3. Ackerman steering
D. Crossed slider crank chain	4. Eccentric mechanism
	5. Pendulum pump

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

Sol. (*d*) (*d*) provides correct matching

74. In a flat collar pivot bearing, the moment due to friction is proportional to (r_1 and r_2 are the outer and inner radii respectively)

(*a*) $\frac{r_1^2 - r_2^2}{r_1 - r_2}$ (*b*) $\frac{r_1^2 - r_2^2}{r_1 + r_2}$

(*c*) $\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}$ (*d*) $\frac{r_1^3 - r_2^3}{r_1 - r_2}$

Sol. (*c*) Moment due to friction in flat collar pivot bearing is $\propto \frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}$

75. A friction circle is drawn when a journal rotates in bearing. Its radius depends on the coefficient of friction and the

(*a*) magnitudes of the forces on the journal
(*b*) angular velocity of the journal
(*c*) clearance between the journal and the bearing
(*d*) radius of the journal

Sol. (*d*) Friction circle's radius = $\mu \times r$ (r = radius of the journal)

76. If the rotating mass of a rim type fly wheel is distributed on another rim type flywheel whose mean radius is half mean radius of the former, then energy stored in the latter at the same speed will be

(*a*) four times the first one (*b*) same as the first one
(*c*) one-fourth of the first one (*d*) one and a half times the first one

Sol. (c) Energy stored $\propto I\omega^2$, also $I \propto k^2$ (k = radius of gyration which is function of radius of wheel)

$\therefore$ If radius is reduced to half, then energy stored will be reduced to one-fourth.

77. A flywheel is fitted to the crankshaft of an engine having 'E' amount of indicated work per revolution and permissible limits of co-efficients of fluctuation of energy and speed as K_e and K_s respectively. The kinetic energy of the flywheel is then given by

(*a*) $\frac{2K_eE}{K_s}$ (*b*) $\frac{K_eE}{2K_s}$

(*c*) $\frac{K_eE}{K_s}$ (*d*) $\frac{K_sE}{2K_e}$

Sol. (*b*) Kinetic energy $= \frac{K_eE}{2K_s}$

78. A Hartnell governor has its controlling force F given by

$$F = p + qr,$$

Where r is the radius of the balls and p and q are constants.

The governor becomes isochronous when

(*a*) $P = 0$ and q is positive (*b*) p is positive and $q = 0$
(*c*) p is negative and q is positive (*d*) p is positive and q is also positive

Sol. (*a*) For isochronous governor $F = qr$

So p should be zero and q be + ve.

79. The plots of controlling force versus radii of rotation of the balls of spring controlled governors are shown in the given diagram. A stable governor is characterised by the curve labelled

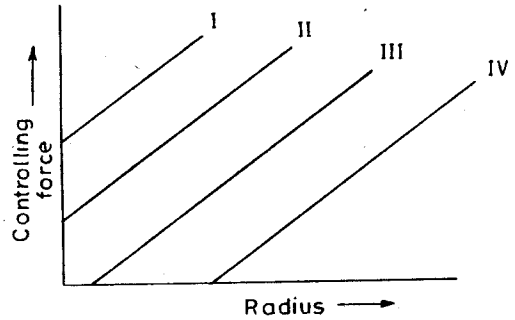


Fig. 7

(*a*) I (*b*) II

(*c*) III (*d*) IV

Sol. (*d*) For stable governor, $F = qr–p$ which is possible with curve IV.

80. A system in dynamic balance implies that

(*a*) the system is critically damped (*b*) there is no critical speed in the system

(*c*) the system is also statically balanced (*d*) there will be absolutely no wear of bearings.

Sol. (*c*) A system in dynamic balance implies that the system is also statically balanced.

81. For a twin cylinder V-engine, the crank positions for Primary reverse cranks and Secondary direct cranks are given in the following diagrams :

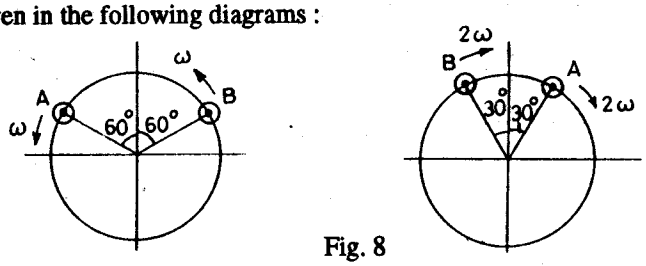


Fig. 8

The engine is a

(*a*) 60° V-engine (*b*) 120° V-engine

(*c*) 30° V-engine (*d*) 150° V-engine

Sol. (*a*) The engine is 60°V-engine.

82. Which one of the following can completely balance several masses revolving in different planes on a shaft ?

(*a*) A single mass in one of the planes of the revolving masses

(*b*) A single mass in a different plane

(*c*) Two masses in any two planes

(*d*) Two equal masses in any two planes

Sol. (*c*) Correct choice is (*c*).

83. With symbols having the usual meanings, the single degree of freedom system,

$$m\ddot{x} + c\dot{x} + kx = F \sin \omega t$$

represents

(*a*) free vibration with damping
(*b*) free vibration without damping
(*c*) forced vibration with damping
(*d*) forced vibration without damping

Sol. (*c*) Since the equation involves $c\dot{x}$ and $F \sin \omega t$, it means it is case of forced vibrations with damping.

84. In the two-rotor system shown in the given figure, ($I_1 < I_2$), a node of vibration is situated

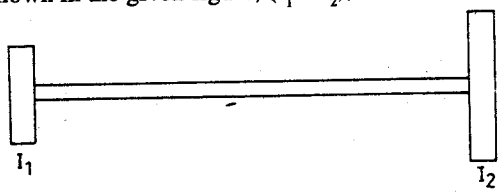


Fig. 9

(*a*) between I_1 and I_2 but nearer to I_1
(*b*) between I_1 and I_2 but nearer to I_2
(*c*) exactly in the middle of the shaft
(*d*) nearer to I_1 but outside

Sol. (*b*) Node of vibration is situated closer to rotor having high moment of inertia.

85. A simple spring mass vibrating system has a natural frequency of N. If the spring stiffness is halved and the mass is doubled, then the natural frequency will become

(*a*) N/2
(*b*) 2N
(*c*) 4N
(*d*) 8N

Sol. (*a*) Natural frequency of vibration $f_n \propto \sqrt{\frac{k}{m}}$

In new system $f_n \propto \sqrt{\frac{k/2}{2m}} \propto \frac{1}{2}\sqrt{\frac{k}{m}}$

i.e. it is halved.

86. For the single degree of freedom system shown in the figure, the mass M rolls along an incline of α. The natural frequency of the system will

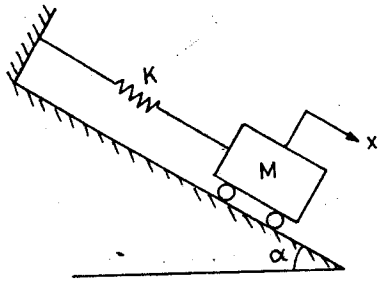


Fig. 10

(*a*) increase as α increases
(*b*) decrease as α increases
(*c*) be independent of α
(*d*) increase initially as α increases and then decrease with further increase in α

Sol. **(a)** As the angle of indination increases, the mass m will be more and more predominant and the natural frequency of vibration will increase.

87. For the system shown in the given figure the moment of inertia of the weight W and the ball about the pivot point is I_0. The natural frequency of the system is given by

$$f_n = \frac{1}{2\pi}\sqrt{\frac{Ka^2 - Wb}{I_o}}$$

The system will vibrate when

(*a*) $b < \frac{Ka^2}{W}$ (*b*) $b = \frac{Ka^2}{W}$

(*c*) $b > \frac{Ka^2}{W}$ (*d*) a = 0

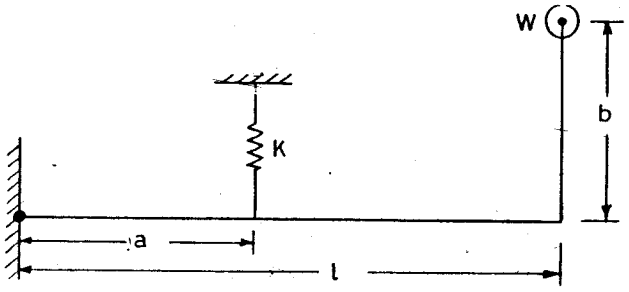


Fig. 11

Sol. (*a*) For system to vibrate, f_n should be positive, which is possible when $b < \frac{Ka^2}{W}$

88. Rotating shafts tend of vibrate violently at whirling speeds because

(*a*) the shafts are rotating at very high speeds
(*b*) bearing centre line coincides with the shaft axis
(*c*) the system is unbalanced
(*d*) resonance is caused due to the heavy weight of the rotor

Sol. (*d*) Choice (*d*) is correct.

89. Critical speed of a shaft with a disc supported in between is equal to the natural frequency of the system in

(*a*) transverse vibrations
(*b*) torsional vibrations
(*c*) longitudinal vibrations
(*d*) longitudinal vibrations provided the shaft is vertical.

Sol. (*a*) Choice (*a*) is correct.

90. In an automobile service station, an automobile is in a lifted up position by means of a hydraulic jack. A person working in the service station gave a tap to one rear wheel and made it rotate by one revolution. The rotation of another rear wheel is

(*a*) zero
(*b*) also one revolution in the same direction
(*c*) also one revolution but in the opposite direction
(*d*) unpredictable

Sol. (*a*) When one rear wheel is rotated, other is free.

91. Match List I with List II and select the correct answer using the codes given below the lists :

List I *(Standard tooth forms)*	**List II** *(Advantages or disadvantages)*
A. 20° and 25° systems	1. Results in lower loads on bearing
B. $14\frac{1}{2}$ stub-tooth system	2. Broadest at the base and strongest in bending
C. 25° Full depth system	3. Obsolete
D. 20° Full depth system	4. Standards for new applications

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

Sol. (*a*) Code (*a*) provides correct matching.

92. In involute gears the pressure angle is

(*a*) dependent on the size of teeth (*b*) dependent on the size of gears

(*c*) always constant (*d*) always variable

Sol. (*c*) The pressure angle is always constant in involute gears.

93. Match List I with List II and select the correct answer using the codes given below the lists :

List I *(Type of joint)*	**List II** *(Mode of jointing members)*
A. Cotter joint	1. Connects two rods or bars permitting small amount of flexibility
B. Knuckle joint	2. Rigidly connects two members
C. Turn buckle	3. Connects two rods having threaded ends
D. Riveted joint	4. Permanent fluid-tight joint between two flat pieces
	5. Connects two shafts and transmits torque

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

Sol. (*b*) Code (*b*) provides correct matching.

94. The most efficient riveted joint possible is one which would be as strong in tension, shear and bearing as the original plates to be joined. But this can never be achieved because

(*a*) rivets cannot be made with the same material
(*b*) rivets are weak in compression
(*c*) there should be at least one hole in the plate reducing its strength
(*d*) clearance is present between the plate and the rivet

Sol. (*c*) Riveted joint can't be as strong as original plates, because there should be at least one hole in the plate reducing its strength.

95. Which of the following stresses are associated with the tightening of a nut on a stud ?

1. Tensile stresses due to stretching of stud.
2. Bending stresses of stud.
3. Transverse shear stresses across threads.
4. Torsional shear stresses in threads due to frictional resistance.

Select the correct answer using the codes given below :

Codes :

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

Sol. **(a)** Statements at 1, 2 and 3 are correct.

96. The frictional torque for square thread at mean radius while raising load is given by

(W = load R_o = Mean Radius

ϕ = Angle of friction, α = Helix angle)

(*a*) $WR_o \tan(\phi - \alpha)$ (*b*) $WR_o \tan(\phi + \alpha)$
(*c*) $WR_o \tan \alpha$ (*d*) $WR_o \tan \phi$

Sol. (*b*) Frictional toque = $WR_o \tan(\alpha + \phi)$

97. In a delt drive, if the pulley diameter is doubled keeping the tension and belt width constant, then it will be necessary to

(*a*) increase the key length (*b*) increase the key depth
(*c*) increase the key width (*d*) decrease the key length

Sol. (*c*) Due to twice incease in diameter of pulley, torque on key is double and has to be resisted by key width. Length can't be increased as belt width is same.

98. Consider the following statements :

For increasing the fatigue strength of welded joints it is necessary to employ

1. grinding. 2. coating.
3. hammer peening.

Of the above statements

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

Sol. (*c*) Statements at 1 and 3 are correct.

99. The following data refers to an open belt drive :

	Pulley A	**Pulley B**
Purpose.....	Driving	Driven
Diameter.....	450 mm	750 mm
Angle of contact.....	$\theta_A = 150$	$\theta_B = 210°$
Coefficient of friction between belt and pulley	$f_A = 0.36$	$f_B = 0.22$

The ratio of tensions may be calculated using the relation $(T_1/T_2) = \exp(z)$ where z is

(*a*) $f_A\theta_A$ (*b*) $f_B\theta_B$

(*c*) $(f_A + f_B)(\theta_A + \theta_B)/4$ (*d*) $(f_A\theta_A + f_B\theta_B)/2$

Sol. (*a*) $\frac{T_1}{T_2} = e^{f_A Q_A}$ (f & Q are taken for smaller pulley)

100. In a multiple V belt drive, when a single belt is damaged, it is preferable to change the complete set to

(a) reduce vibration (*b*) reduce slip

(c) ensure uniform loading (*d*) ensure proper alignment

Sol. (c) If a single belt breaks, all belts are replaced to ensure uniform loading.

101. Design of shafts made of brittle materials is based on

(*a*) Guest's theory (*b*) Rankine's theory

(*c*) St. Venant's theory (*d*) Von Mises theory

Sol. (*b*) Rankine's theory or maximum principle stress theory is most commonly assumed for brittle materials.

102. Principal stresses at a point in plane stressed element are $\sigma_x = \sigma_y = 500$ kg/cm^2.

Normal stress on the plane inclined at 45° to x-axis will be

(*a*) 0 (*b*) 500 kg/cm^2

(*c*) 707 kg/cm^2 (*d*) 1000 kg/cm^2

Sol. (*b*) When stresses are alike, then normal stress σ_n on plane inclined at angle 45° is

$$\sigma_n = \sigma_y \cos^2\theta + \sigma_x \sin^2\theta$$

$$= \sigma_y\left(\frac{1}{\sqrt{2}}\right)^2 + \sigma_x\left(\frac{1}{\sqrt{2}}\right)^2 = 500\left[\frac{1}{2} + \frac{1}{2}\right] = 500\text{kg/cm}^2$$

103. State of stress in a plane element is shown in figure 12. Which one of the following figures (Fig. 13) is the correct sketch of Mohr's circle of the state of stress ?

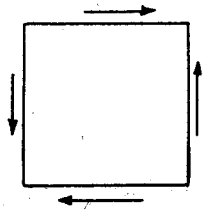


Fig. 12

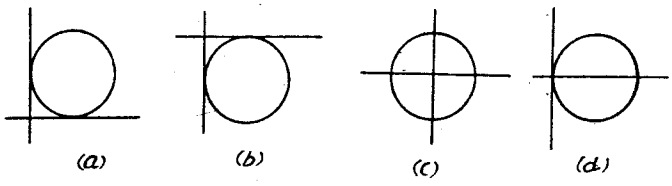


Fig. 13

Sol. (*c*) Circle at (*c*) is correct sketch of Mohr's circle.

104. A steel rod of 1 sq. cm. cross sectional area is 100 cm long and has a Young's modulus of elasticity 2×10^6kgf/cm^2. It is subjected to an axial pull of 2000 kgf. The elongation of the rod will be

(*a*) 0.05 cm (*b*) 0.1 cm

(*c*) 0.15 cm (*d*) 0.20 cm

Sol. (*b*)

$$E = \frac{\text{stress}}{\text{strain}} = \frac{2000\text{kg/1cm}^2}{\delta l/100}, \quad 2 \times 10^6 = \frac{20 \times 10^5}{\delta l}$$

$$\delta l = \frac{1}{10} = 0 \cdot 1 \text{ cm.}$$

105. If the area of cross-section of a wire is circular and if the radius of this circle decreases to half its original value due to the stretch of the wire by a load, then the modulus of elasticity of the wire be

(*a*) one-fourth of its original value (*b*) halved

(*c*) doubled (*d*) unaffected

Sol. (*d*) Since modulus of elasticity is the property of material, it will be same uner all the conditions.

106. Match List I with List II and select the correct answer using the codes given below the lists :

List I *(Material properties)*	**List II** *(Tests to determine material properties)*
A. Ductility	1. Impact test
B. Toughness	2. Fatigue test
C. Endurance limit	3. Tension test
D. Resistance to penetration	4. Hardness test

Codes :

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

Sol. (*c*) Code at (*c*) provides the correct matching.

107. If a material had a modulus of elasticity of 2.1×10^6 kgf/cm^2 and a modulus of rigidity of 0.8×10^6 kgf/cm^2 then the approximate value of the Poisson's ratio of the material would be

(*a*) 0.26 (*b*) 0.31

(*c*) 0.47 (*d*) 0.5

Sol. (*b*) $E = 2C\left(1 + \frac{1}{m}\right)$ or $2 \cdot 1 \times 10^6 = 2 \times 0 \cdot 8 \times 10^6\left(1 + \frac{1}{m}\right)$

or $\frac{2 \cdot 1}{1 \cdot 6} = 1 + \frac{1}{m}$ and $\frac{1}{m} = \frac{2 \cdot 1}{1 \cdot 6} - 1 = \frac{0 \cdot 5}{1 \cdot 6} = 0 \cdot 31$

108. Match List I with List II and select the correct answer using the codes given below the lists :

List I *(Condition of beam)*	**List II** *(Bending moment diagram)*
A. Subjected to bending moment at the end of a cantilever.	1. Triangle
B. Cantilever carrying uniformly distributed load over the whole length.	2. Cubic parabola
C. Cantilever carrying linearly varying load from zero at the fixed end to maximum at the support.	3. Parabola
D. A beam having load at the centre and supported at the ends.	4. Rectangle

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

Sol. (*b*) Code (*b*) provides correct matching.

109. The figure given below shows a bending moment diagram for the beam CABD :

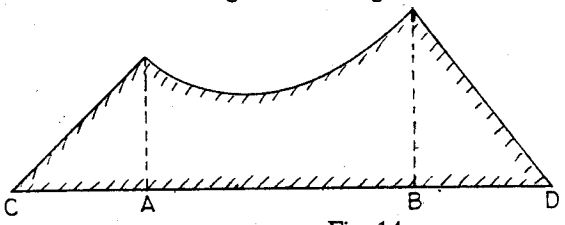
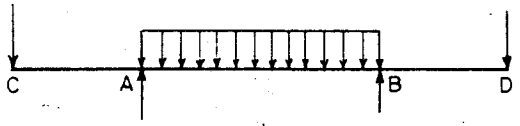


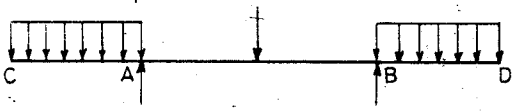
Fig. 14

Load diagram for the above beam will be

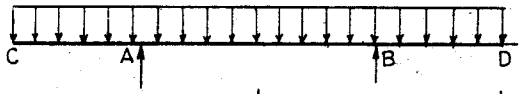
(*a*)



(*b*)



(*c*)



(*d*)

Fig. 15

Sol. (*a*) Load diagram at (a) is correct because B.M. diagram between A and B is parabola which is possible with uniformely distributed load in this region.

110. A beam *AB* is hinge-supported at its ends and is loaded by couple P.c. as shown in the given figure. The magnitude of shearing force at a section x of the beam is

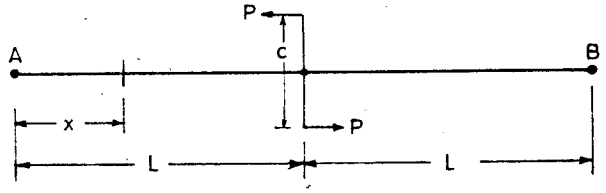


Fig. 16

(*a*) 0 (*b*) P

(*c*) *P/2L* (*d*) *P.c./2L*

Sol. **(d)** If F be the shearing force at section x (say at point A), then taking moments about B, $F \times 2L = Pc$

or $F = \frac{Pc}{2L}$ Thus shearing force in zone $x = \frac{Pc}{2L}$

111. A simply supported beam of rectangular section 4 cm by 6 cm carries a mid-span concentrated load such that the 6 cm side lies parallel to line of action of loading ; deflection under the load is δ. If the beam is now supported with the 4 cm side parallel to line of action of loading, the deflection under the load will be

(*a*) 0.44δ (*b*) 0.67δ

(*c*) 1.5δ (*d*) 2.25δ

Sol. **(*d*)** Deflection at centre with contentrated load in centre and simply supported beam $\delta = \frac{Wl^3}{48EI}$

i.e. $\delta \propto \frac{1}{I}$ $\left(I = \frac{bd^3}{12}\right)$

Deflection will be more with 4 cm side parallel to load than with 6 cm side parallel to load

$\therefore$ New deflection $= \frac{\delta \times 6^3 \times 4 \times 12}{4^3 \times 6 \times 12} = 2{\cdot}25\delta$

112. A shaft was initially subjected to bending moment and then was subjected to torsion. If the magnitude of bending moment is found to be the same as that of the torque, then the ratio of maximum bending stress to shear stress would be

(*a*) 0.25 (*b*) 0.50

(*c*) 2.0 (*d*) 4.0

Sol. (*c*)

When subjected to bending, $\frac{M}{I} = \frac{p}{y}$ or p (bending stress) $= \frac{M}{I} \times r = \frac{M}{\frac{\pi}{4} r^3} \times r = \frac{4M}{\pi r^3}$

When subjected to torsion $\frac{T}{J} = \frac{f_s}{r}$ or $\frac{T(=M)}{\frac{\pi r^4}{2}} = \frac{f_s}{r}$

Ratio of bending stress and shear stress $= \frac{4M}{\pi r^3} \times \frac{\pi r^3}{2M} = 2.$

113. A horizontal beam with square cross-section is simply supported with sides of the square horizontal and vertical and carries a distributed loading that produces maximum bending stress σ in the beam. When the beam is placed with one of the diagonals horizonal the maximum bending stress will be.

(a) $\frac{1}{\sqrt{2}}\sigma$ (b) σ

(c) $\sqrt{2}\sigma$ (d) 2σ

Sol. **(a)** Bending stress $= \frac{M}{Z}$

For rectangular beam with sides horizontal and vertical, $Z = \frac{a^3}{6}$

For same section with diagonal horizontal, $Z = \frac{a^3\sqrt{2}}{6}$

$\therefore$ Ratio of two stresses $= \frac{1}{\sqrt{2}}$

114. Shear stress distribution diagram of a beam of rectangular cross-section, subjected to transverse loading will be

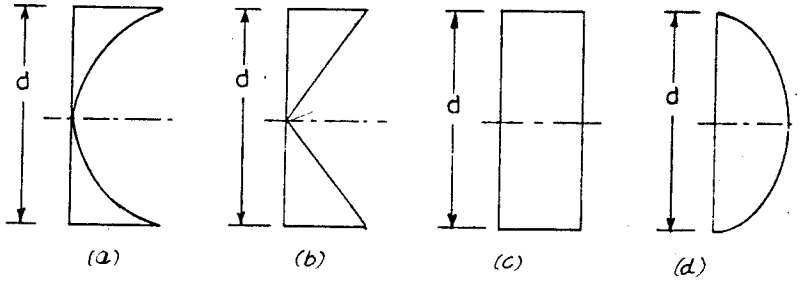


Fig. 17

Sol. **(d)** Figure 17 at (*d*) shows the correct shear stress distribution for a beam of rectangular cross section subjected to transverse loading.

115. In the assembly of pulley, key and shaft

(*a*) pulley is made the weakest (*b*) key is made the weakest

(*c*) key is made the strongest (*d*) all the three are designed for equal strength

Sol. **(b)** Key is made the weakest so that it is cheap and easy to replace in case of failure.

116. Cirumferential and longitudinal strains in a cylindrical boiler under internal steam pressure are ε_1 and ε_2 respectively. Change in volume of the boiler cylinder per unit volume will be

(*a*) $\varepsilon_1 + 2\varepsilon_2$ (*b*) $\varepsilon_1\varepsilon_2^2$

(*c*) $2\varepsilon_1 + \varepsilon_2$ (*d*) $\varepsilon_1^2\varepsilon_2$

Sol. **(c)** Volumetric stream = 2 × circumferential strain + longitudinal strain

117. A metal pipe of 1m diameter contains a fluid having a pressure of 10 kgf/cm^2. If the permissible tensile stress in the metal is 200 kgf/cm^2, then the thickness of the metal required for making the pipe would be

(*a*) 5mm (*b*) 10 mm

(*c*) 20 mm (*d*) 25 mm

Sol. **(d)**

$$\text{Hoop stress} = \frac{pd}{2t}$$

or $$200 = \frac{10 \times 100}{2 \times t}$$

or $$t = \frac{1000}{400} = 2 \cdot 5 \text{ cm}$$

118. A length of 10 mm diameter steel wire is coiled to a close coiled helical spring having 8 coils of 75 mm mean diameter, and the spring has a stiffness K. If the same length of wire is coiled to 10 coils of 60 mm mean diameter, then the spring stiffness will be

(*a*) K (*b*) 1.25K
(*c*) 1.56K (*d*) 1.95K

Sol. (*c*) Stiffness of spring $K = \frac{Cd^4}{64R^3n}$

R = mean coil radius = $\frac{75}{2}$ mm

n = no. of coils = 8

d = wire diameter (is same is both cases)

C is same in both cases $K_1 \propto \frac{1}{\left(\frac{75}{2}\right)^3 \times 8}$

and $K_2 \propto \frac{1}{\left(\frac{60}{2}\right)^3 \times 10}$

$\therefore$ $K_2 = K_1 \times \left(\frac{75}{60}\right)^3 \times \frac{8}{10} = 1 \cdot 56K_1$

119. The buckling load will be maximum for a column, if

(*a*) one end of the column is clamped and the other end is free
(*b*) both ends of the column are clamped
(*c*) both ends of the column are hinged
(*d*) one end of the column is hinged and the other end is free

Sol. (*b*) Buckling load of a column will be maximum when both ends are clamped.

120. If the principal stresses corresponding to a two-dimensional state of stress are σ_1 and σ_2 is greater than σ_2 and both are tensile, then which one of the following would be the correct criterion for failure by yielding, according to the maximum shear stress criterion ?

(*a*) $\frac{(\sigma_1 - \sigma_2)}{2} = \pm \frac{\sigma_{yp}}{2}$ (*b*) $\frac{\sigma_1}{2} = \pm \frac{\sigma_{yp}}{2}$

(*c*) $\frac{\sigma_2}{2} = \pm \frac{\sigma_{yp}}{2}$ (*d*) $\sigma_1 = \pm 2\sigma_{yp}$

Sol. (*a*) According to maximum shear stress criterion, the criterion for failure by yielding is when $\frac{\sigma_1 - \sigma_2}{2} = \pm \frac{\sigma_{yp}}{2}$

Civil Services Examination (Preliminary)

MECHANICAL ENGINEERING—1994

Time allowed : 2 hours

Max. marks : 300

1. If the cross-section of a member is subjected to a uniform shear stress of intensity 'q', then the strain energy stored per unit volume is equal to (C = modulus of rigidity)

(*a*) $2q^2/C$ (*b*) $2C/q^2$

(*c*) $q^2/2C$ (*d*) $C/2q^2$.

Sol. (*c*). Strain energy stored per unit volume = $q^2/2C$.

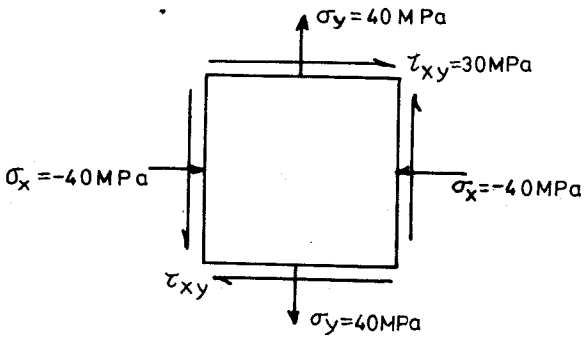
2. For a linearly elastic, isotropic and homogeneous material, the number of elastic constants required to relate stress and strain is

(*a*) two (*b*) three

(*c*) four (*d*) six.

Sol. (*c*). For a linearly elastic, isotropic and homogeneous material, the number of elastic constants required to relate stress and strain is four, *viz.* E, G, K and ν.

3. The state of stress at a point in a loaded member is shown in the figure. The magnitude of maximum shear stress is



(*a*) 10 MPa [1 MPa = 10 kg/cm^2]

(*b*) 30 MPa

(*c*) 50 MPa

(*d*) 100 MPa.

Sol. (*c*). The maximum value of shear stress

$$= \sqrt{\left(\frac{\sigma_y - \sigma_x}{2}\right)^2 + \tau_{xy}^{\ 2}} = \sqrt{\left(\frac{40+40}{2}\right)^2 + 30^2}$$

$$= \sqrt{40^2 + 30^2} = \sqrt{1600 + 900} = \sqrt{2500} = 50 \text{ MPa}.$$

4. A rod of length 'l' and cross-sectional area 'A' rotates about an axis passing through one end of the rod. The extension produced in the rod due to centrifugal forces is (w is the weight of the rod per unit length and ω is the angular velocity of rotation of the rod)

(*a*) $\omega wl^2/gE$ (*b*) $\omega^2 wl^3/3gE$

(*c*) $\omega^2 wl^3/gE$ (*d*) $3gE/\omega^2 wl^3$.

Sol. (*c*). Centrifugal force = $\omega^2 \times$ radius $\times \dfrac{\text{weight}}{g}$

$$= \omega^2 l \frac{wlA}{g} = \frac{\omega^2 wl^2 A}{g}$$

$\therefore$ Stress due to this force = $\dfrac{\omega^2 wl^2 A}{gA} = \dfrac{\omega^2 wl^2}{g}$

$$\frac{\text{stress}}{\text{strain}} = E$$

or $$\frac{\delta l}{l} = \frac{\text{stress}}{E} \text{ and } \delta l = \frac{\text{stress} \times l}{E} = \frac{\omega^2 w l^2 \times l}{gE} = \frac{\omega^2 w l^3}{gE}$$

5. The unit of elastic modulus is the same as those of

(*a*) stress, shear modulus and pressure (*b*) strain, shear modulus and force

(*c*) shear modulus, stress and force (*d*) stress, strain and pressure

Sol. (*a*). The unit of elastic modulus is same as of stress, shear modulus and pressure.

6. In the case of an engineering material under unidirectional stress in the x-direction, the Poisson's ratio is equal to (symbols have the usual meanings)

(*a*) $\varepsilon_y/\varepsilon_x$ (*b*) ε_y/σ_x

(*c*) ε_y/σ_x (*d*) σ_y/ε_x.

Sol. (*a*). Poisson's ratio = $\varepsilon_y/\varepsilon_x$.

7. Young's modulus of elasticity and Poisson's ratio of a material are 1.25×10^5 MPa and 0.34 respectively. The modulus of rigidity of the material is

(*a*) 0.4025×10^5 MPa (*b*) 0.4664×10^5 MPa

(*c*) 0.8375×10^5 MPa (*c*) 0.9469×10^5 MPa

Sol. (*b*). $$E = 2C\left(1 + \frac{1}{m}\right)$$

$$1.25 \times 10^5 = 2C\,(1.34) \quad \text{or} \quad C = \frac{1.25 \times 10^5}{2.68} = 0.4664 \times 10^5 \text{ MPa}$$

8. A beam carries a uniformly distributed load and is supported with two equal overhangs as shown in figure 'A'. Which one of the following correctly shows the bending moment diagram for the beam?

Fig. A

(*a*) 

(*b*) 

(*c*) 

(*d*) 

Sol. (*a*). Fig. (*a*) shows the correct bending moment diagram for the loading shown in Fig. (*A*).

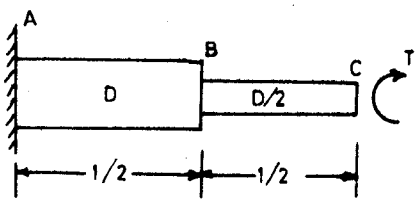
9. A circular shaft fixed at A has diameter D for half of its length and diameter $D/2$ over the other half. What is the rotation of C relative to B if the rotation of B relative to A is 0.1 radian ?

(*a*) 0.4 radian

(*b*) 0.8 radian

(*c*) 1.6 radian

(*d*) 3.2 radian



Sol. (*c*). $$\frac{T}{J} = \frac{C\theta}{L} \quad \text{or} \quad \theta \propto \frac{1}{J}$$ (T, L and C remaining same in both cases)

or $$\theta \propto \frac{1}{d^4}$$

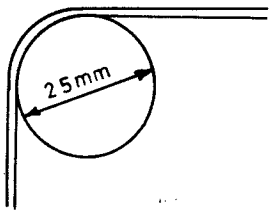
In this case $$\frac{0.1}{\theta} = \frac{(d/2)^4}{d^4} \quad \text{or} \quad \theta = 1.6 \text{ radian.}$$

10. If two shafts of the same length, one of which is hollow, transmit equal torques and have equal maximum stress, then they should have equal

(*a*) polar moment of inertia (*b*) polar modulus of section
(*c*) diameter (*d*) angle of twist.

Sol. (*b*). $\frac{T}{J}=\frac{s_s}{r}$; Since T and s_s are same for hollow and solid shaft, so $\frac{J}{r}$, *i.e.* polar modulus of section should also be same.

11. A 0.2 mm thick tape goes over a frictionless pulley of 25 mm diameter. If E of the material is 100 GPa, then the maximum stress induced in the tape is



(*a*) 100 MPa (*b*) 200 MPa
(*c*) 400 MPa (*d*) 800 MPa

Sol. (*d*). $\frac{s}{y}=\frac{E}{R}$, $E=100\times10^3$ MPa

$$y=\frac{0.2}{2}=0.1\text{ mm}=0.1\times10^{-3}\text{ m} \quad , \quad R=\frac{25}{2}=12.5\times10^{-3}\text{ m}$$

$$\therefore \quad s=\frac{100\times10^3\times0.1\times10^{-3}}{12.5\times10^{-3}}=800\text{ MPa.}$$

12. The ratio of circumferential stress to longitudinal stress in a thin cylinder subjected to internal hydrostatic pressure is

(*a*) 1/2 (*b*) 1
(*c*) 2 (*d*) 4.

Sol. (*c*). Ratio of circumferential to longitudinal stress in thin cylinder = 2.

13. The ends of the leaves of a semi-elliptical leaf spring are made triangular in plan in order to

(*a*) obtain variable I in each leaf
(*b*) permit each leaf to act as a overhanging beam
(*c*) have variable bending moment in each leaf
(*d*) make M/I constant throughout the length of the leaf.

Sol. (*d*). The ends of the leaves of a semi-elliptical leaf spring are made rectangular in plan in order to make M/I constant throughout the length of the leaf.

14. Consider the following characteristics

1. The cutting edge is normal to the cutting velocity.
2. The cutting forces occur in two directions only.
3. The cutting edge is wider than the depth of cut.

The characteristics applicable to orthogonal cutting would include

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

Sol. (*a*). Characteristics 1 and 2 are applicable to orthogonal cutting.

15. The time (in minutes) for drilling a hole is given by $t=\frac{\text{Depth of the hole}+h}{\text{Feed}\times\text{RPM}}$

where 'h' is the

(*a*) length of the drill (*b*) drill diameter
(*c*) flute length of the drill (*d*) cone height of the drill.

Sol. (*d*). Time for drilling is to cover depth of hole + cone height of drill

16. Major operations in the manufacture of steel balls used for Ball Bearings are given below

1. Oil lapping
2. Cold heading
3. Annealing
4. Hardening
5. Rough grinding

The correct sequence of these operations is

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

Sol. (*c*). The correct sequence for manufacture of steel balls used for ball bearings is cold heading, annealing, hardening, rough grinding, and oil lapping.

17. Stroke of a shaping machine is 250 mm. It makes 30 double strokes per minute. Overall average speed of operation is

(*a*) 3.75 m/min (*b*) 5.0 m/min
(*c*) 7.5 m/min (*d*) 15.0 m/min.

Sol. (*c*). Average speed of operation $= \frac{250}{1000} \times 30 = 7.5$ m/min.

18. Which of the following methods can be used for manufacturing 2 metre long seamless metallic tubes?

1. Drawing
2. Extrusion
3. Rolling
4. Spinning

Select the correct answer using the codes given below

Codes :

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

Sol. (*b*). Seamless metallic tubes of 2 m length can be manufactured only by process of extrusion followed by rolling.

19. A standard dividing head is equipped with the following index plates

1. Plate with 15, 16, 17, 18, 19, 20 holes circles
2. Plate with 21, 23, 27, 29, 31, 33 holes circles
3. Plate with 37, 39, 41, 43, 47, 49 holes circles

For obtaining 24 divisions on a work piece by simple indexing

(*a*) hole plate 2 alone can be used (*b*) hole plates 1 and 2 can be used
(*c*) hole plates 1 and 3 can be used (*d*) any of the three hole plates can be used.

Sol. (*d*). No. of turns in simple indexing $= \frac{40}{N} = \frac{40}{24} = 1\frac{2}{3}$.

Thus index plate having holes in multiple of 3 can be used. For plate 1, we can use 18 holes, plate 2 — 21 holes, plate 3 — 39 holes. Thus any of the three hole plates can be used.

20. Chills are used in casting moulds to

(*a*) achieve directional solidification (*b*) reduce possibility of blow holes
(*c*) reduce the freezing time (*d*) increase the smoothness of cast surface.

Sol. (*a*). Chills help in achieving directional solidification.

21. In a blanking operation to produce steel washer, the maximum punch load used is 2×10^5 N. The plate thickness is 4 mm and percentage penetration is 25. The work done during this shearing operation is

(*a*) 200 J (*b*) 400 J
(*c*) 600 J (*d*) 800 J.

Sol. (*a*). Work $= \dfrac{\text{Max. punch load}}{\text{1/fraction of penetration}} \times \text{thickness} = \dfrac{2 \times 10^5}{1/0.25} \times \dfrac{4}{1000} = 200$ J.

22. Consider the following factors

1. Clearance between the punch and the die is too small.
2. The finish at the corners of the punch is poor.
3. The finish at the corners of the die is poor.
4. The punch and die alignment is not proper.

The factors responsible for the vertical lines parallel to the axis noticed on the outside of a drawn cylindrical cup would include

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

Sol. (*d*). Factors 1, 3 and 4 are responsible for vertical lines parallel to the axis noticed on the outside of a drawn cylindrical cup.

23. In gas welding of mild steel using an oxy-acetylene flame, the total amount of acetylene consumed was 10 litre. The oxygen consumption from the cylinder is

(*a*) 5 litre (*b*) 10 litre
(*c*) 15 litre (*d*) 20 litre.

Sol. (*b*). Usually neutral flame is used for welding mild steel. Thus acetylene and oxygen are used in same ratio.

24. A multispindle automat performs four operations with times 50, 60, 65 and 75 seconds at each of its work centres. The cycle time (time required to manufacture one work piece) in seconds will be

(*a*) 50 + 60 + 65 + 75 (*b*) (50 + 60 + 65 + 75)/4
(*c*) 75/4 (*d*) 75.

Sol. (*a*). Time required to manufacture one work piece is sum of time for each operation.

25. To reduce the consumption of synthetic resins, the ingredient added is

(*a*) accelerator (*b*) elastomer
(*c*) modifier (*d*) filler.

Sol. (*d*). Filler is used upto 50% to reduce the consumption of synthetic resins.

26. Work study involves

(*a*) only method study (*b*) only work measurement
(*c*) method study and work measurement (*d*) only motion study.

Sol. (*c*). Work study involves method study and work measurement.

27. Consider the following advantages

1. Lower in-process inventory
2. Higher flexibility in rescheduling in case of machine breakdown
3. Lower cost in material handling equipment

When compared to process layout, the advantages of product layout would include

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

Sol. (*b*). Advantages 1 and 3 are true for product layout.

28. The following activities are to be performed in a particular sequence for routing a product

1. Analysis of the product and breaking it down into components
2. Determination of the lot size
3. Determination of operations and processing time requirement

4. Taking make or buy decisions

The correct sequence of these activities is

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

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

Sol. **(*a*).** The correct sequence for routing is as per code (*a*), *i.e.* 1, 2, 3, 4.

29. Consider the following situations

1. Loads are uniform
2. Materials move relatively continuously
3. Movement rate is variable
4. Routes do not vary

For material transportation, conveyors are used when the prevailing conditions include

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

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

Sol. **(*b*).** Conveyors are used where loads are uniform, materials move relatively continuously, and routes are fixed.

30. A systematic job improvement sequence will consist of

(*i*) Motion Study

(*ii*) Time Study

(*iii*) Job Enrichment

(*iv*) Job Enlargement

An optimal sequence would consist of

(*a*) *i, ii, iii* and *iv* (*b*) *ii, i, iii* and *iv*

(*c*) *iii, i, ii* and *iv* (*d*) *iii, iv, i* and *ii.*

Sol. **(a).** Optimal sequence is as per code (*a*).

31. Money required for the purchase of stores, payment of wages etc. is known as

(*a*) Block Capital (*b*) Reserved Capital

(*c*) Authorised Capital (*d*) Working Capital.

Sol. **(*d*).** Money required for the purchase of stores payment of wages, etc. is known as working capital.

32. Fixed investments for manufacturing a product in a particular year is Rs. 80,000/-. The estimated sales for this period is Rs. 2,00,000/-. The variable cost per unit for this product is Rs. 4/-. If each unit is sold at Rs. 20/-, then the break even point would be

(*a*) 4,000 (*b*) 5,000

(*c*) 10,000 (*d*) 20,000.

Sol. **(*b*).** For break even point, Fixed cost (F) + variable cost (V) × quantity (N)

= selling price (S) × quantity (N)

or $$N = \frac{F}{S - V} = \frac{80000}{20 - 4} = 5{,}000.$$

33. If orders are placed once a month to meet an annual demand of 6,000 units, then the average inventory would be

(*a*) 200 (*b*) 250

(*c*) 300 (*d*) 500.

Sol. **(*d*).** Inventory of 1 month is essential in this case, *i.e.* 500 units.

34. The reading of the pressure gauge fitted on a vessel is 25 bar. The atmospheric pressure is 1.03 bar and the value of g is 9.81 m/s^2. The absolute pressure in the vessel is

(*a*) 23.97 bar (*b*) 25.00 bar
(*c*) 26.03 bar (*d*) 34.84 bar.

Sol. (*c*). Absolute pressure = gauge pressure + atmospheric pressure
$= 25 + 1.03 = 26.03$ bar.

35. A mixture of gases expands from 0.03 m^3 to 0.06 m^3 at a constant pressure of 1 MPa and absorbs 84 kJ of heat during the process. The change in internal energy of the mixture is

(*a*) 30 kJ (*b*) 54 kJ
(*c*) 84 kJ (*d*) 114 kJ.

Sol. (*b*). $\delta Q = du + \delta W = du + pdV$

or $84 \times 10^3 \text{ J} = du + 1 \times 10^6 (0.06 - 0.03) = du + 30 \text{ kJ}$

or $du = 84 - 30 \text{ kJ} = 54 \text{ kJ}$

36. Match List I with List II and select the correct answer using the codes given below the lists

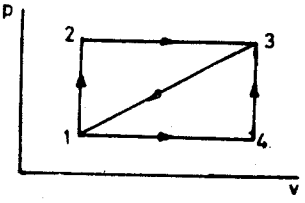
List I	*List II*
A. Mechanical work	1. Clausius-Clapeyron equation
B. $\oint \frac{dQ}{T} \le 0$	2. Gibb's equation
C. Zeroth Law	3. High grade energy
D. H-TS	4. Concept of temperature

Codes :

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

Sol. (*a*). Code (*a*) provides correct matching.

37. Given that the path 1-2-3, a system absorbs 100 kJ as heat and does 60 kJ work while along the path 1-4-3 it does 20 kJ work (see figure given). The heat absorbed during the cycle 1-4-3 is



(*a*) –140 kJ (*b*) –80 kJ
(*c*) –40 kJ (*d*) + 60 kJ.

Sol. (*d*). $Q_{123} = U_{13} + W_{123}$

or $100 = U_{13} + 60$ and $U_{13} = 100 - 60 = 40$ kJ

$Q_{143} = U_{13} + W_{143} = 40 + 20 = 60$ kJ.

38. In a cyclic heat engine operating between a source temperature of 600°C and a sink temperature of 20°C, the *least* rate of heat rejection per kW net output of the engine is

(*a*) 0.460 kW (*b*) 0.505 kW
(*c*) 0.588 kW (*d*) 0.650 kW

Sol. (*b*). Max. efficiency $= \frac{T_1 - T_2}{T_2} = \frac{873 - 293}{293} = \frac{580}{293}$

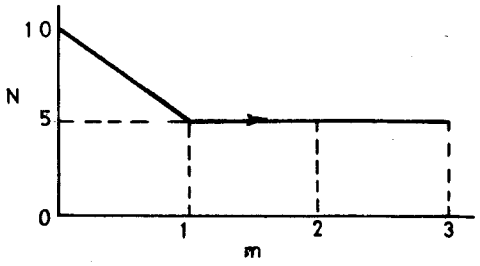
$\therefore \quad \frac{1 \text{ kW}}{\text{Least heat rejection}} = \frac{580}{293}$ and Least heat rejection $= \frac{1 \times 293}{580} = 0.505$ kW.

39. In a steam condenser, the partial pressure of steam and air are 0.06 bar and 0.007 bar respectively. The condenser pressure is

(*a*) 0.067 bar (*b*) 0.06 bar
(*c*) 0.053 bar (*d*) 0.007 bar.

Sol. (*a*). Condenser pressure = partial pressure of steam + partial pressure of air
$= 0.06 + 0.007 = 0.067$ bar.

40. The given figure shows the variation of force in an elementary system which undergoes a process during which the plunger position changes from 0 to 3 m. If the internal energy of the system at the end of the process is 2.5 J higher, then the heat absorbed during the process is



(*a*) 15 J (*b*) 20 J
(*c*) 25 J (*d*) 30 J.

Sol. (*b*). Total work $= 5 \times 3 + \frac{1}{2} \times 5 \times 1 = 15 + 2.5 = 17.5$ J

$$\delta Q = du + \delta W = 2.5 + 17.5 = 20 \text{ J}.$$

41. The fundamental unit of enthalpy is

(*a*) MLT^{-2} (*b*) ML^2T^{-1}
(*c*) ML^2T^{-2} (*d*) ML^3T^{-2}.

Sol. (*c*). The fundamental unit of enthalpy is ML^2T^{-2}.

42. Increase in entropy of a system represents

(*a*) increase in availability of energy (*b*) increase in temperature
(*c*) decrease in pressure (*d*) degradation of energy.

Sol. (*d*). Increase in entropy of a system represents degradation of energy.

43. A Carnot engine receiving heat at 400 K has an efficiency of 25%. The C.O.P. of a Carnot refrigerator working between the same temperature limits is

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

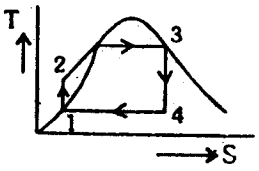
Sol. (*d*) $\eta = \frac{T_1 - T_2}{T_2}$; or $0.25 = \frac{400 - T_2}{T_2}$ or $T_2 + 0.25T_2 = 400$

or $T_2 = \frac{400}{1.25} = 320°$ K ; $\text{COP} = \frac{T_2}{T_1 - T_2} = \frac{320}{400 - 320} = \frac{320}{80} = 4.$

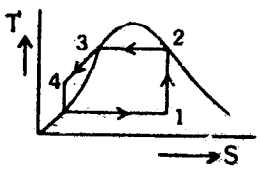
44. The correct representation of a simple Rankine cycle on a T-S diagram is

Sol. (*a*). Correct representation of Rankine cycle on T-S diagram is as per fig. (*a*).

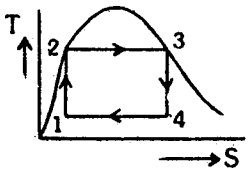
(*a*)



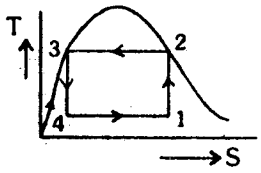
(*b*)



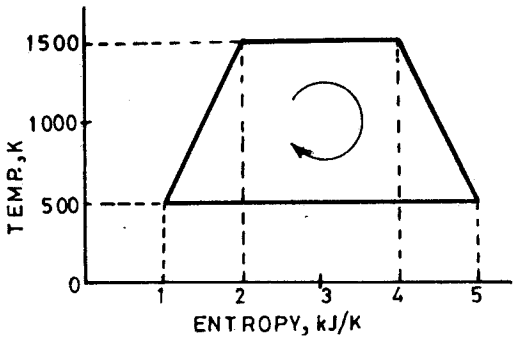
(*c*)



(*d*)



45. The efficiency of a reversible cyclic process undergone by a substance as shown in the given diagram is



(*a*) 0.40 (*b*) 0.55
(*c*) 0.66 (*d*) 0.80.

Sol. (*c*). $\eta = \frac{T_1 - T_2}{T_1} = \frac{1500 - 500}{1500} = \frac{1000}{1500} = 0.66.$

46. Otto cycle efficiency is higher than Diesel cycle efficiency for the same compression ratio and heat input because, in Otto cycle

(*a*) combustion is at constant volume (*b*) expansion and compression are isentropic
(*c*) maximum temperature is higher (*d*) heat rejection is lower.

Sol. (*d*). For same heat input and same compression ratio, in case of Otto cycle, efficiency is higher because the heat rejection is lower.

47. The isothermal efficiency of a reciprocating compressor is defined as

(*a*) $\frac{\text{actual work done during compression}}{\text{isothermal work done during compression}}$

(*b*) $\frac{\text{adiabatic work done during compression}}{\text{isothermal work done during compression}}$

(*c*) $\frac{\text{isothermal work done during compression}}{\text{actual work done during compression}}$

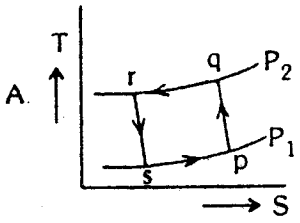
(*d*) $\frac{\text{isothermal work done during compression}}{\text{actual work done during adiabatic compression}}$.

Sol. (*d*). Isothermal efficiency of a reciprocating compressor is ratio of isothermal work and work during adiabatic compression.

48. Match List I with List II and select the correct answer using the codes given below lists

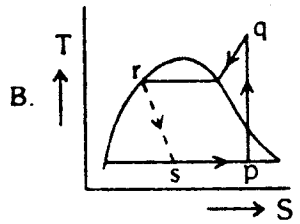
List I *List II*

A.



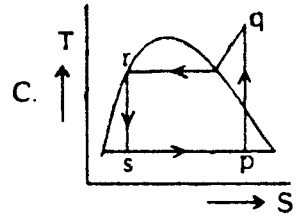
1. Vapour compression cycle using expansion valve

B.



2. Bell-Coleman cycle (gas compression cycle)

C.



3. Vapour compression cycle using expansion engine

Codes :

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

Sol. (*d*). Code (*d*) provides correct matching.

49. In the absorption refrigeration cycle, the compressor of the vapour compression refrigeration cycle is replaced by

(*a*) liquid pump (*b*) generator
(*c*) absorber and generator (*d*) absorber, liquid pump and generator.

Sol. (*d*). The compressor of vapour compression refrigeration cycle is replaced by absorber, liquid pump and generator in the absorption refrigeration cycle.

50. The C.O.P. of a Carnot refrigeration cycle *decreases* on

(*a*) decreasing the difference in operating temperatures
(*b*) keeping the upper temperature constant and increasing the lower temperature
(*c*) increasing the upper temperature and keeping the lower temperature constant
(*d*) increasing the upper temperature and decreasing the lower temperature

Sol. (*d*). COP of Carnot refrigerator $\frac{T_2}{T_1 - T_2}$ will decrease if upper temperature T_1 is increased and T_2 is decreased.

51. Desert coolers are suitable for hot and very dry outside conditions because

(*a*) water is recirculated in the spray

(*b*) heat is neither added nor removed from the water

(*c*) wet bulb depression $(t - t')$ is very large

(*d*) large quantity of air can be conditioned.

Sol. (*c*). Desert coolers are suitable for hot and dry atmosphere because wet bulb depression is very large.

52. In an auditorium, the heat generated due to the occupants and the electric lights and other equipments is 100 kW. The rate of generation of excess moisture is 60 kg/hr. If an air-conditioner is supplying conditioned air to the auditorium at the rate of 500 m^3/min, then the sensible heat factor (SHF) for the auditorium is

(*a*) 0.27 (*b*) 0.40

(*c*) 0.73 (*d*) 0.95.

Sol. (*d*). Sensible heat = 100 kW

$$\text{Latent heat} = \frac{\text{kg moisture}}{\text{kg of dry air}} \times \text{heat removed in kJ to condense water}$$

$$= \frac{60 \text{ kg}}{\text{hr}} \times \frac{\text{density } (0.85 \text{ m}^3/\text{kg})}{500 \times 60 \text{ m}^3/\text{hr}} \times 2500 = 4.25 \text{ kJ} = 4.25 \text{ kW}$$

$$\therefore \text{SHF} = \frac{SH}{SH + LH} = \frac{100}{100 + 4.25} = \frac{100}{104.25} = 0.95.$$

53. A room air is at a DBT of T_r and relative humidity ϕ_r. The effective temperature of the room is

(*a*) the temperature at which the room air is saturated but gives the same feeling of comfort as the actual state of the room air

(*b*) the temperature at which the room air is at 50% relative humidity but gives the same feeling of comfort as the actual state of the room air

(*c*) the temperature at which the room air is completely dry but gives the same feeling of comfort as the actual state of the room air

(*d*) none of the above.

Sol. (*d*). None of definitions given fits effective temperature of room.

54. Consider the following statements

I. Low value of the bypass factor for an air-conditioning equipment signifies higher performance of the equipment

II. Bypass factor for an air-conditioning equipment signifies the fraction of ambient air mixed with the air to be conditioned.

III. Bypass factor for an air-conditioning equipment signifies the fraction of the air to be conditioned coming in contact with the conditioning surface.

Of these statements

(*a*) I and III are correct (*b*) I and II are correct

(*c*) III alone is correct (*d*) II alone is correct.

Sol. (*a*). Statements I and III are correct.

55. It is desired to condition the outside air from 70% RH and 45°C dry bulb to 50% RH and 25°C db room condition. The practical arrangement would be

(*a*) cooling and dehumidification
(*b*) dehumidification and pure sensible cooling
(*c*) cooling and humidification
(*d*) dehumidification.

Sol. (*a*). To reduce temperature and relative humidity, cooling and dehumidification process has to be followed.

56. Consider the following statements

1. Boilers rated above 500 MW are not necessarily supercritical boilers.
2. Power plant boilers are generally once-through boilers.
3. Blow down at regular intervals is done to remove solids.

Of these statements

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

Sol. (*d*). Statements 1 and 3 are correct.

57. In a boiler, feed water supplied per hour is 205 kg while coal fired per hour is 23 kg. Net enthalpy rise per kg of water is 145 kJ for conversion to steam. If the calorific value of coal is 2050 kJ/kg then the boiler efficiency will be

(*a*) 78%
(*b*) 74%
(*c*) 62%
(*d*) 59%.

Sol. (*c*). Boiler efficiency $= \dfrac{\text{heat utilised}}{\text{heat supplied by coal}} = \dfrac{205 \times 145}{23 \times 2050} = 0.62.$

58. The degree of reaction of a turbine is the ratio of enthalpy drop in

(*a*) moving blades to enthalpy drop in the stage
(*b*) fixed blades to enthalpy drop in the stage
(*c*) moving blades to enthalpy drop in fixed blades
(*d*) fixed blades to enthalpy drop in moving blades

Sol. (*a*). Degree of reaction of a turbine is the ratio of enthalpy drop in moving blades to enthalpy drop in the stage.

59. With reference to supersaturated flow through a steam nozzle, which of the following statements are true ?

1. Steam is subcooled.
2. Mass flow rate is more than the equilibrium rate of flow.
3. There is loss in availability.
4. Index of expansion corresponds to wet steam conditions.

Select the correct answer using the codes given below

Codes :

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

Sol. (*a*). Statements 1, 2 and 3 are correct for supersaturated flow in nozzle.

60. Consider the following statements :

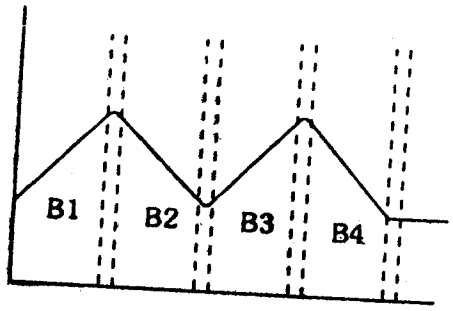
1. Almost all flow losses take place in the diverging part of a nozzle.
2. Normal shocks are likely to occur in the converging part of a nozzle.
3. Efficiency of reaction turbines is higher than that of impulse turbines.

Of these statements

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

Sol. (*d*). Statements 1 and 3 are correct.

Q. 61. In the given figure, B1, B2, B3 and B4 represent blade passages in an impulse turbine. Consider the following statements in this regard



1. The solid line represents velocity variation.
2. The solid line represents pressure variation.
3. B2 and B4 are rotor passages.
4. B1 and B3 are rotor passages.

Of these statements

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

Sol. (*b*). Solid lines represent velocity variation. Velocity drops in rotor passages and increases in stator passages.

62. The impulse turbine rotor efficiency will have a maximum value of $0.5 \cos^2 \alpha_1$ where α_1 is the nozzle exit flow angle, if the

(*a*) blades are equiangular
(*b*) blade velocity coefficient is unity
(*c*) blades are equiangular and frictionless
(*d*) blade solidity is 0.65.

Sol. (*c*). Impulse turbine rotor $\eta = (1 + kc)\dfrac{\cos^2 \alpha_1}{2}$

If friction factor $K = 0$, and $C = \dfrac{\cos \gamma}{\cos \beta} = 1$ *i.e.* blades are equiangular then $\eta_{max} = 0.5 \cos^2 \alpha_1$.

63. Energy conversion takes place only in one row of nozzle blades and later the steam glides over the rotor and guide blade rows in the case of

(*a*) De Laval turbine
(*b*) Rateau turbine
(*c*) Parson's turbine
(*d*) Curtis turbine.

Sol. (*d*). Energy conversion in one stage followed by a series of rotor and guide blades (velocity compounding) take place in Curtis turbine.

64. In a 50% reaction turbine stage, the tangential component of absolute velocity at rotor inlet is 537 m/s and blade velocity is 454 m/s. The power output in kW per kg of steam will be

(*a*) 302
(*b*) 282
(*c*) 260
(*d*) 248.

Sol. (*b*). When reaction is 50%, then work done $= \dfrac{V_b}{1000}(2V_i \cos \alpha - V_b)$ kJ/kg

$V_i \cos \alpha = 537$, $V_b = 454$

$\therefore$ Work done $= \dfrac{454}{1000}(2 \times 537 - 454) = \dfrac{454}{1000} \times 620 = 282$ kW/kg.

65. Which of the following statements are *false* ?

1. Soot blowers are used generally in oil fired boilers.
2. There will be at least three safety valves on the boiler drum
3. Recuperative heating is better than regenerative heating in the case of air pre-heaters.

Select the correct answer using the codes given below

Codes :

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

(*c*) 2 and 3 (*d*) 1 and 3.

Sol. **(c).** Soot blowers are not only used in oil fired boilers, but also on coal fired boilers. Thus statemenr 1 is wrong.

66. Match List I with List II and select the correct answer using the codes given below the lists

List I	*List II*
A. Propeller turbine	1. Impulse turbine
B. Tangential turbine	2. Kaplan turbine
C. Reaction is zero	3. Gas turbine
D. Reaction turbine	4. Pelton turbine.

Codes :

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

Sol. **(c).** The correct matching is provided by code (*c*).

67. A jet of water issues from a nozzle with a velocity of 20 m/s and it impinges normally on a flat plate moving away from it at 10 m/s. If the cross-sectional area of the jet is 0.02 m^2 and the density of water is taken as 1000 kg/m^3, then the force developed on the plate will be

(*a*) 10 *N* (*b*) 100 *N*

(*c*) 1000 *N* (*d*) 2000 *N*.

Sol. **(d).** Force on plate $= wa\,(V-u)\,(V-u)$

$= 1000 \times 0.02 \times (10)^2$

$= 2000\ N.$

68. In the case of Pelton turbine installed in a hydraulic power plant, the gross head available is the vertical distance between

(*a*) forebay and tail race (*b*) reservoir level and turbine inlet

(*c*) forebay and turbine inlet (*d*) reservoir level and tail race.

Sol. **(b).** In case of Pelton wheel, heat available is vertical distance between reservoir level and turbine inlet.

69. The moderator used in a fast breeder nuclear reactor is

(*a*) graphite or liquid sodium

(*b*) graphite or beryllium oxide

(*c*) graphite, liquid sodium or beryllium oxide

(*d*) none of the above.

Sol. **(a).** Graphite or liquid sodiun could be used as moderator for fast breeder nuclear reactor.

70. Match List I with List II and select the correct answer using the codes given below the lists

List I (Turbines)	*List II (Specific speeds in MKS units)*
A. Kaplan turbine	1. 10 to 35
B. Francis turbine	2. 35 to 60
C. Pelton wheel with single jet	3. 60 to 300
D. Pelton wheel with two or more jets	4. 300 to 1000

Codes :

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

Sol. (*c*). The correct matching is as per code (*c*).

71. A hydraulic coupling belongs to the category of

(*a*) power absorbing machines (*b*) power developing machines
(*c*) energy generating machines (*d*) energy transfer machines.

Sol. (*d*). A hydraulic coupling transfers power from motor to driven equipment.

72. For pumping molasses, it is preferable to employ

(*a*) reciprocating pump (*b*) centrifugal pump with double shrouds
(*c*) open impeller pump (*d*) multistage centrifugal pump.

Sol. (*c*). For pumping molasses, it is preferable to use open impeller pump.

73. In the case of a centrifugal pump, cavitation will occur if

(*a*) it operates above the minimum net positive suction head
(*b*) it operates below the minimum net positive suction head
(*c*) the pressure at the inlet of the pump is above the atmospheric pressure
(*d*) the pressure at the inlet of the pump is equal to the atmospheric pressure.

Sol. (*b*). Cavitation occurs if pump operates below the minimum net positive suction head.

74. A circular disc of radius '*r*' is submerged vertically in a static fluid upto a depth '*h*' from the free surface. If $h > r$, then the position of centre of pressure will

(*a*) be directly proportional to *h* (*b*) be inversely proportional to *h*
(*c*) be directly proportional to *r* (*d*) not be a function of *h* or *r*.

Sol. (*d*). Since centre of pressure is $\frac{IG}{A\bar{x}}$ below c.g., it is not a function of *h* or *r* alone.

75. If a cylindrical wooden pole, 20 cm in diameter, amd 1 m in height is placed in a pool of water in a vertical position (the specific gravity of wood is 0.6), then it will

(*a*) float in stable equilibrium (*b*) float in unstable equilibrium
(*c*) float in neutral equilibrium (*d*) start moving horizontally.

Sol. (*b*). Pole will float with 0.6 m inside water and 0.4 m above water surface. Metacentre is below c.g. and thus pole will float in unstable equilibrium.

76. An inclined manometer, inclined at 30° to the horizontal, measures the pressure differential between two locations of a pipe carrying water. If the manometric liquid is mercury (specific gravity 13.6) and the manometer showed a level difference of 20 cm, then the pressure head difference of water between the two tappings will be

(*a*) 1.26 m (*b*) 1.36 m
(*c*) 2.52 m (*d*) 2.72 m.

Sol. (*b*). Since manometer shows 20 cm and this beingt inclined at 30°, vertical level of mercury $= 20 \sin 30° = 10$ cm

$\therefore$ difference in pressure $= \frac{10}{100} \text{ m} \times 13.6 = 1.36 \text{ m}.$

77. An open tank contains water to a depth of 2 m and oil over it to a depth of 1 m. If the specific gravity of oil is 0.8, then the pressure intensity at the interface of the two fluid layers will be

(*a*) 7848 N/m^2 (*b*) 8720 N/m^2
(*c*) 9347 N/m^2 (*d*) 9750 N/m^2.

Sol. (*a*). Pressure at interface is due to head of oil = 1 m × 0.8 (sp. gr. of oil)

Pressure in N/m^2 $= \rho gh = 1000 \times 9.81 \times 0.8 = 7848$ N/m^2.

78. Consider the following statements

For a body totally immersed in a fluid,

I. the weight acts through the centre of gravity of the body.

II. the upthrust acts through the centroid of the body

Of these statements

(*a*) both I and II are true (*b*) I is true but II is false
(*c*) I is false but II is true (*d*) neither I nor II is true.

Sol. (*b*). Statement I is true and II is false, since upward thrust acts through centroid of displaced fluid.

79. The components of velocity u and v along x- and y- direction in a 2-D flow problem of an incompressible fluid are

1. $u = x^2 \cos y$; $v = -2x \sin y$
2. $u = x + 2$; $v = 1 - y$
3. $u = xyt$; $v = x^3 - y^2t/2$
4. $u = ln\, x + y$; $v = xy - y/x$

Those which would satisfy the continuity equation would include

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

Sol. (*a*). Equations 1, 2 and 3 satisfy the continuity equation.

80. A simple Pitot tube can be used to measure which of the following quantities ?

1. Static head
2. Datum head
3. Dynamic head
4. Friction head
5. Total head

Select the correct answer using the codes given below

Codes :

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

Sol. (*b*). Simple pitot tube can measure static, dynamic and total head.

81. Flow takes place at Reynolds Number of 1500 in two different pipes with relative roughness of 0.001 and 0.002. The friction factor

(*a*) will be higher in the case of pipe with relative roughness of 0.001.
(*b*) will be higher in the case of pipe having relative roughness of 0.002

(*c*) will be the same in both the pipes
(*d*) in the two pipes cannot be compared on the basis of data given.

Sol. (*c*). For Re < 1500, *i.e.* laminar flow, the friction factor is independent of relative roughness of pipe.

82. A fluid jet is discharging from a 100 mm nozzle and the vena contracta formed has a diameter of 90 mm. If the coefficient of velocity is 0.95, then the coefficient of discharge for the nozzle is
(*a*) 0.855 (*b*) 0.81
(*c*) 0.9025 (*d*) 0.7695.

Sol. (*d*). $C_c = \frac{A_v}{A} = \frac{\frac{\pi}{4}(90)^2}{\frac{\pi}{4}(100)^2} = 0.81$, $C_v = 0.95$

$\therefore$ $C_d = C_c \times C_v = 0.81 \times 0.95 = 0.7695$

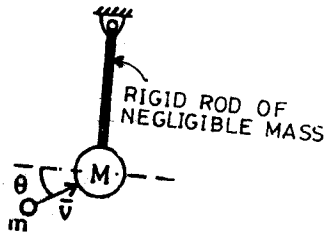
83. The shear stress in turbulent flow is
(*a*) linearly proportional to the velocity gradient
(*b*) proportional to the square of the velocity gradient
(*c*) dependent on the mean velocity of flow
(*d*) due to the exchange of energy between the molecules.

Sol. (*b*). The shear stress in turbulent flow is proportional to the square of the velocity gradient.

Directions. *The following fifteen items consist of two statements, one labelled the 'Assertion A' and the other labelled the 'Reason R'. You are to examine these two statements carefully and decide if the Assertion A and the Reason R are individually true and if so, whether the Reason is a correct explanation of the Assertion. Select your answers to these items using the codes given below and mark your answer sheet accordingly.*

Codes :
(*a*) Both A and R are true and R is the correct explanation of A
(*b*) Both A and R are true but R is not a correct explanation to A
(*c*) A is true but R is false
(*d*) A is false but R is true.

84. As shown in the given figure, a bullet of mass m and initial velocity $\bar{v}$ hits M and gets embedded into M.



Assertion (A) : Just before and after collision, the total linear momentum of m and M together is conserved only in the horizontal direction and not in the vertical direction.
Reason (R) : The total kinetic energy of m and M together is not conserved.

Sol. (*c*). Assertion is true but reason is false because total kinetic energy of m and M together is conserved.

85. Assertion (A) : A cam and follower is an example of a higher pair.
Reason (R) : The two elements have surface contact when the relative motion takes place.

Sol. (*c*). Assertion is correct but reason is false because two elements nave line contact and not surface contact.

86. Assertion (A) : Every rotating shaft has whirling speeds.
Reason (R) : Eccentricity of rotors on rotating shafts is unavoidable.

Sol. (*a*). Both assertion and reason are true and R is a correct explanation of A.

87. Assertion (A) : Endurance limits for all materials are always less than the ultimate strength of the corresponding materials.

Reason (R) : Stress concentration in a machine part due to any dislocation is very damaging when the part is subjected to variable loading.

Sol. (*a*). Both assertion and reason are true and R is a correct explanation of A.

88. Assertion (A) : In a loaded beam, if the shear force diagram is a straight line parallel to the beam axis, then the bending moment diagram is a straight line inclined to the beam axis.

Reason (R) : When shear force at any section of a beam is zero or changes sign, the bending moment at that section is maximum.

Sol. (*b*). Both assertion and reason are true but R is not a correct explanation of A.

89. Assertion (A) : The characteristic feature of High Speed Steel is its red hardness.

Reason (R) : Chromium and cobalt in High Speed Steel promote martensite formation when the tool is cold worked.

Sol. (*c*). Assertion is true but reason is false because martensite formation takes place by heat treatment and not by cold working.

90. Assertion (A) : Cemented carbide tool tips are produced by powder metallurgy.

Reason (R) : Carbides cannot be melted and cast.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

91. Assertion (A) : Gang process chart is an aid in studying the activities of a group of people working together.

Reason (R) : Gang process chart analyses the cycle or routine followed by each member of the gang.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

92. Assertion (A) : Job shop production leads to large work-in-process inventory.

Reason (R) : Jobbing production is used to manufacture medium demand variety production.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

93. Assertion (A) : FIFO rules for sequencing is accepted easily by all as it appears fair to all.

Reason (R) : FIFO rule is optimum for most scheduling situations.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

94. Assertion (A) : Although a heat pump is a refrigerating system, the coefficient of performance differs when it is operating on the heating cycle.

Reason (R) : It is the condenser heat that is useful (the desired effect) instead of the refrigerating effect.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

95. Assertion (A) : Freon-12 is odourless and its leakage cannot be easily detected. However, it is preferred in comfort air-conditioning.

Reason (R) : It is almost impossible for Freon-12 leakage to attain a fatal concentration.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

96. Assertion (A) : A gas turbine power plant is very sensitive to turbine and compressor inefficiencies.

Reason (R) : In a gas turbine power plant, a large portion of the turbine work is consumed by the compressor.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

97. Assertion (A) : For the same limits of boiler pressure and temperature, the specific steam consumption of ideal Carnot cycle is less than that of ideal Rankine cycle.

Reason (R) : For the same limits of boiler pressure and temperature, Carnot cycle is more efficient than Rankine cycle.

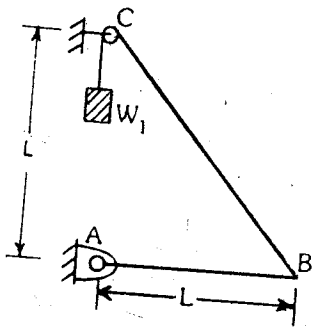
Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

98. Assertion (A) : Entropy change for a reversible adiabatic process is zero.

Reason (R) : There is no heat transfer in an adiabatic process.

Sol. (*a*). Both assertion and reason are true and R is correct explanation of A.

99. A uniform, heavy rod AB of length L and weight W is hinged at A and tied to a weight W_1 by a string at B.



The massless string passes over a frictionless pulley (of negligible dimension) at C as shown in the figure. If the rod is in equilibrium at horizontal configuration, then

(*a*) $W_1 = W$

(*b*) $W_1 = W/2$

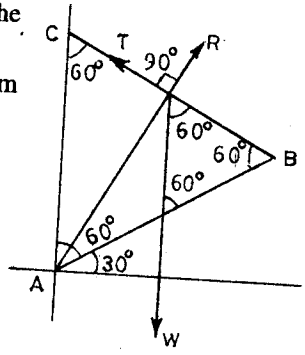
(*c*) $W_1 = \sqrt{2}\,W$

(*d*) $W_1 = W/\sqrt{2}$

Sol. (*d*). If T be tension string BC and since it passes over smooth pulley C, $T = W_1$.

Reaction at B is $\frac{W}{2}$, $\therefore$ $\frac{W}{2} = T\cos 45° = W_1 \times \frac{1}{\sqrt{2}}$ or $W_1 = \frac{W\sqrt{2}}{2} = \frac{W}{\sqrt{2}}$

100. A uniform boom AB (see given figure) pinned at A is held by the cable BC in the position shown.



If the tension in the cable is 200 kgf, then the weight of the boom and the reaction of the pin at A on the boom are respectively

(*a*) 300 kgf; $100\sqrt{3}$ kgf, 30°

(*b*) 400 kgf; $100\sqrt{3}$ kgf, 60°

(*c*) 300 kgf; $200\sqrt{3}$ kgf, 30°

(*d*) 400 kgf; $200\sqrt{3}$ kgf, 60°.

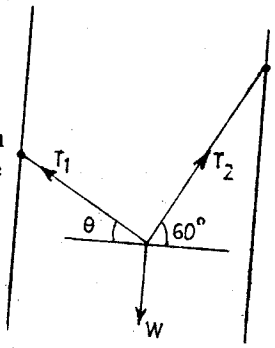
Sol. (*d*). $$\frac{W}{\sin 90°} = \frac{T}{\sin(90+60)} = \frac{R}{\sin(90+30)}$$

$$W = \frac{200\times 2}{1} = \frac{R\times 2}{\sqrt{3}}$$

$\therefore$ $W = 400$ kgf and $R = 200\sqrt{3}$ kgf

and angle R makes with horizontal = 60°.

101. A weight W is supported by two cables as shown in the given figure. The tension in the cable making angle θ will be the minimum when the value of θ is



(*a*) 0°

(*b*) 30°

(*c*) 45°

(*d*) 60°

Sol. (*b*). T_1 should be minimum

$$\frac{T_1}{\sin 150°} = \frac{T_2}{\sin (90+\theta)} = \frac{W}{\sin\{180-(60+\theta)\}} = \frac{W}{\sin (90+30-\theta)}$$

Since $T_1 \propto \frac{1}{\sin (90+\theta)}$, for T_1 to be least θ should be minimum

Also $T_1 \propto \frac{W}{\sin (90+30-\theta)}$, Again for min. value of T_1, θ should be 30°.

102. An elevator weighing 10,000 kgf attains an upward velocity of 4 m/s in two seconds with uniform acceleration. The tension in the cable will be approximately

(*a*) 8,000 kgf
(*b*) 10,000 kgf
(*c*) 12,000 kgf
(*d*) 20,000 kgf.

Sol. (*a*). Tension in cable $= W - ma = 10000 - \frac{10000}{9.81} \times 2 \equiv 8000$ kgf.

$$a = \frac{v-4}{t} = \frac{4}{2} = 2 \text{ m/s}^2.$$

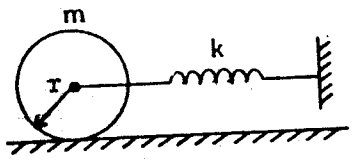
103. A body in motion will be subjected to Corioli's acceleration when that body is

(*a*) in plane rotation with variable velocity
(*b*) in plane translation with variable velocity
(*c*) in plane motion which is a resultant of plane translation and rotation
(*d*) restrained to rotate while sliding over another body.

Sol. (*d*). A body is subjected to Corioli's acceleration when that body is restrained to rotate while sliding over another body.

104. A disc of mass '*m*' and radius '*r*' is attached to a spring of stiffness '*k*'. During its motion, the disc rolls on the ground. When released from some stretched position, the centre of the disc will execute harmonic motion with a time period of

(*a*) $2\pi\sqrt{\frac{m}{ak}}$
(*b*) $2\pi\sqrt{\frac{m}{k}}$
(*c*) $2\pi\sqrt{\frac{3m}{2k}}$
(*d*) $2\pi\sqrt{\frac{2m}{k}}$

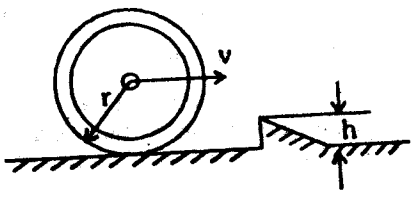


Sol. (*b*). $m \times a = kx$ or $a = \frac{k}{m}x$

$\therefore$ Time period of oscillation $= 2\pi\sqrt{\frac{m}{k}}$.

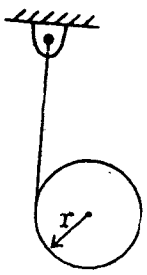
105. A wheel of centroidal radius of gyration '*k*' is rolling on a horizontal surface with constant velocity. It comes across an obstruction of height '*h*'. Because of its rolling speed, it just overcomes the obstruction. To determine *v*, one should use the principle(s) of conservation of

(*a*) energy
(*b*) linear momentum
(*c*) energy and linear momentum
(*d*) energy and angular momentum.



Sol. (*a*). It must use the principle of conservation of energy.

106. A cord is wrapped around a cylinder of radius 'r' and mass 'm' as shown in the given figure. If the cylinder is released from rest, the velocity of the cylinder, after it has moved through a distance 'h' will be



(*a*) $\sqrt{2gh}$ (*b*) $\sqrt{gh}$

(*c*) $\sqrt{4gh/3}$ (*d*) $\sqrt{gh/3}$.

Sol. (*a*). Since cylinder falls freely under effect of gravity, it follows basic law of motion and $v^2 = 2gh$ and $v = \sqrt{2gh}$.

107. Consider the following statements

1. A round bar in a round hole form a turning pair.
2. A square bar in a square hole forms a sliding pair.
3. A vertical shaft in a footstep bearing forms a successful constraint.

Of these statements

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

(*c*) 1 and 3 are correct (*d*) 1, 2 and 3 are correct.

Sol. (*d*). All the statements are correct.

108. The connection between the piston and cylinder in a reciprocating engine corresponds to

(*a*) completely constrained kinematic pair (*b*) incompletely constrained kinematic pair

(*c*) successfully constrained kinematic pair (*d*) single link.

Sol. (*a*). Connection between piston and cylinder corresponds to a completely constrained kinematic pair.

109. A bicycle remains stable in running through a bend because of

(*a*) gyroscopic action (*b*) Coriolis' acceleration

(*c*) centrifugal action (*d*) radius of curved path.

Sol. (*c*). A bicycle remains stable in running through a bend because of centrifugal action.

110. The Whitworth quick return mechanism is formed in a slider-crank chain when the

(*a*) coupler link is fixed (*b*) longest link is a fixed link

(*c*) slider is a fixed link (*d*) smallest link is a fixed link.

Sol. (*a*). The Whitworth quick return mechanism is formed in a slider crank chain when the coupler link is fixed.

111. For an involute gear, the ratio, pitch circle radius/base circle radius is (ϕ is the pressure angle)

(*a*) $\sin\phi$ (*b*) $\cos\phi$

(*c*) $\sec\phi$ (*d*) $\operatorname{cosec}\phi$.

Sol. (*b*). $\dfrac{\text{pitch circle radius}}{\text{basic circle radius}} = \cos\phi$.

112. The most suitable bearing for carrying very heavy loads with slow speed is

(*a*) hydrodynamic bearing (*b*) ball bearing

(*c*) roller bearing (*d*) hydrostatic bearing.

Sol. (*d*). The most suitable bearing for carrying very heavy loads with slow speed is hydrostatic bearing.

113. Thrust bearings of the sliding type are often provided with multiple sector-shaped bearing pads of the tilting type instead of a continuous annular bearing surface in order to

(*a*) distribute the thrust load more non-uniformly

(*b*) provide limited adjustments to shaft misalignments

(*c*) enable the formation of a wedge-shaped oil film

(*d*) enable lubricating oil to come into contact with the total bearing area.