Q.54. The assignment algorithm is applicable to which of the following combined situations for the purpose of improving productivity ?
1. Identification of sales force-market. 2. Scheduling of operator-machine.
3. Fixing machine-location.
Select the correct answer using the codes given below :
Codes :
(*a*) 1, 2 and 3 (*b*) 1 and 3 (*c*) 2 and 3 (*d*) 1 and 2

Ans. (*c*)

Q.55. Compiler translates
(*a*) Assembly language to machine language (*b*) Machine language to high level language
(*c*) High level language to machine language (*d*) High level language to assembly language

Ans. (*d*)

Q.56. For a M/M/1 : ∞/FCFS queue, the mean arrival rate is equal to 10 per hour and the mean service rate is 15 per hour : The expected queue length is
(*a*) 1.33 (*b*) 1.53 (*c*) 2.75 (*d*) 3.20

Ans. (*a*)
$$\rho = \frac{\lambda}{\mu} = \frac{10}{15} = \frac{2}{3}$$

$$\text{Expected length of queue} = \frac{\rho^2}{1-\rho} = \frac{(2/3)^2}{1-\frac{2}{3}} = 1\frac{1}{3}.$$

Q.57. When the FORTRAN IV statement
I = 21/2 + 3/2 * 5
is executed, the result stored in the memory will be
(*a*) 18.0 (*b*) 18 (*c*) 15 (*d*) 17

Ans. (*b*)

Q.58. What will be the output at the end of the execution of the following program ?
```
Y = 20
X = 2
DO 10 k = 2, 10, 5
X = X*2 + X
IF (X.GT.Y) GO TO 20
10 CONTINUE
20 PRINT, X
```
(*a*) 2 (*b*) 6 (*c*) 18 (*d*) 54

Ans. (*d*)

Directions :

The following 12 (twelve) 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 true and R is the correct explanation of A
(*b*) Both A and R are true 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

Q.59. *Assertion* (*A*) : The number of vehicles arriving per unit time at a vehicle maintenance shop at any instant of time can be assessed if the probability of that number and the average rate of arrivals is known.
Reason (*R*) : The vehicles, '*k*' arriving at a vehicle maintenance shop with probability $p(k)$ is given by

$$p(k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

Ans. (*a*)

Q.60. *Assertion* (*A*) : In job design, instead of each job consisting of a single task, a large group of tasks are clustered for a job holder.
Reason (*R*) : A single job should encompass not only production tasks but also the set up, scheduling and control tasks related to the operation.
Ans. (*b*)

Q.61. *Assertion* (*A*) : Walking beam transfer mechanism is used to convey aluminium and other soft non-ferrous products.
Reason (*R*) : This mechanism provides positive movement of products without sliding from station to station.
Ans. (*a*)

Q.62. *Assertion* (*A*) : Stiffening members, such as webs and ribs, used on a casting should be liberally provided.
Reason (*R*) : They will provide additional strength to a cast member.
Ans. (*a*)

Q.63. *Assertion* (*A*) : The first draw in deep drawing operation can have up to 60% reduction, the second draw up to 40% reduction and, the third draw of about 30% only.
Reason (*R*) : Due to strain hardening, the subsequent draws in a deep drawing operation have reduced percentages.
Ans. (*a*)

Q.64. *Assertion* (*A*) : Refining the grain size of a polycrystal line material renders it harder and stronger.
Reason (*R*) : Grain boundaries provide easy paths to dislocation motion.
Ans. (*a*)

Q.65. *Assertion* (*A*) : Plastic deformation in metals and alloys is a permanent deformation under load. This property is useful in obtaining products by cold rolling.
Reason (*R*) : Plastic or permanent deformation in metal or alloy is caused by movement or dislocations.
Ans. (*c*)

Q.66. *Assertion* (*A*) : Carbon would form an interstitial solid solution with iron.
Reason (*R*) : The atomic radius of iron is smaller than that of carbon.
Ans. (*c*)

Q.67. *Assertion* (*A*) : Cast iron is generally hard, brittle and wear resistant.
Reason (*R*) : Cast iron contains more than 20% carbon and as such the percentage cementite in it is higher.
Ans. (*a*)

Q.68. *Assertion* (*A*) : If the bending moment along the length of a beam is constant, then the beam cross-section will not experience any shear stress.
Reason (*R*) : The shear force acting on the beam will be zero everywhere along the length.
Ans. (*a*)

Q.69. *Assertion* (*A*) : Hydrostatic lubrication is more advantageous when compared to hydrodynamic lubrication during starting and stopping the journal in its bearing.

Reason (*R*) : In hydrodynamic lubrication, the fluid film pressure is generated by the rotation of the journal.

Ans. (*b*)

Q.70. *Assertion* (*A*) : High speed turbines are run at a suitable speed above the critical speed of the shaft.
Reason (*R*) : The deflection of the shaft above the critical speed is negative, hence the effect of eccentricity of the rotor mass is neutralised.

Ans. (*c*)

Q.71. Two geared shafts *A* and *B* having moments of inertia I_a and I_b and angular acceleration α_a and α_b respectively are meshed together. B rotates at *G* times the speed of *A*. If the gearing efficiency of the two shafts in η, then in order to accelerate *B*, the torque which must be applied to *A* will be

(*a*) $I_a \alpha_a + G^2 I_b \alpha/\eta$ (*b*) $G^2 I_a \alpha_a/\eta$ (*c*) $G^2 I_a \alpha_a/\eta$ (*d*) $G^2 I_b \alpha_b/\eta$

Ans. (*a*)

Q.72. Which of the following pair(s) is/are correctly matched ?

I. Four bar chain .... Oscillating-oscillating converter
II. Inertia governor .... Rate of change of engine speed
III. Hammer blow .... Reciprocating unbalance.

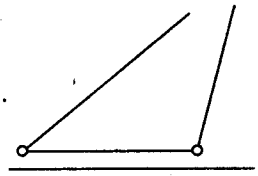
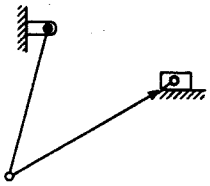
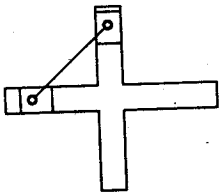
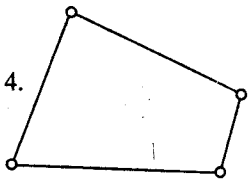
Select the correct answer using the codes given below :

Codes :

(*a*) I alone (*b*) I, II and III (*c*) II and III (*d*) I and III

Ans. (*c*)

Q.73. Which of the following are examples of a kinematic chain ?

1. 
2. 
3. 
4. 

Select the correct answer using the codes given below :

Codes :

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

Ans. (*d*)

Q.74. Which of the following pairs are correctly matched ? Select the correct answer using the codes given below the pairs.

Mechanism		*Chain from which derived*
1. Whitworth quick return motion	...	Single slider crank chain
2. Oldham's coupling	...	Four bar chain
3. Scotch Yoke	...	Double slider crank chain

Codes :

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

Ans. (*c*)

Q.75. In S.H.M., with respect to the displacement vector, the positions of Velocity vector and Acceleration vector will be respectively

(*a*) 180° and 90° (*b*) 90° and 180° (*c*) 0° and 90° (*d*) 90° and 0°

Ans. (*b*)

Q.76. When a slider moves with a velocity 'V' on a link rotating at an angular speed of ω, the Corioli's component of acceleration is given by

(*a*) $\sqrt{2}\,V\omega$ (*b*) $V\omega$ (*c*) $\frac{V\omega}{2}$ (*d*) $2\,V\omega$

Ans. (*d*)

Q.77. The total number of instantaneous centres for a mechanism consisting of 'n' links is

(*a*) $n/2$ (*b*) n (*c*) $\frac{n-1}{2}$ (*d*) $\frac{n\,(n-1)}{2}$

Ans. (*d*)

Q.78. Two links OA and OB are connected by a pin joint at 'O'. The link OA turns with angular velocity ω_1 radians per second in the clockwise direction and the link OB turns with angular velocity ω_2 radians per second in the anticlockwise direction. If the radius of the pin at 'O' is 'r', then the rubbing velocity at the pin joint 'O' will be

(*a*) $\omega_1.\omega_2.r$ (*b*) $(\omega_1 - \omega_2)\,r$ (*c*) $(\omega_1 + \omega_2)\,r$ (*d*) $(\omega_1 - \omega_2)\,2r$

Ans. (*c*)

Q.79. In a cam drive, it is essential to off-set the axis of a follower to

(*a*) decrease the side thrust between the follower and guide
(*b*) decrease the wear between follower and cam surface
(*c*) take care of space limitation
(*d*) reduce the cost

Ans. (*b*)

Q.80. The working surface above the pitch surface of the gear tooth is termed as

(*a*) addendum (*b*) dedendum (*c*) flank (*d*) face

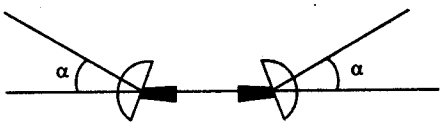
Ans. (*a*)

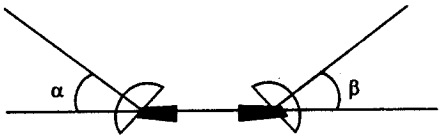
Q.81. In the case of a flywheel, the maximum fluctuation of energy is the

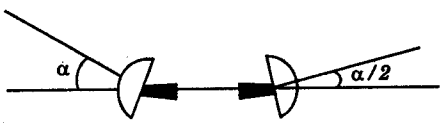
(*a*) sum of maximum and minimum energies
(*b*) difference between the maximum and minimum energies
(*c*) ratio of the maximum and minimum energy
(*d*) ratio of the minimum and maximum energy

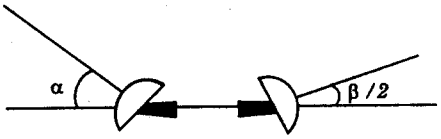
Ans. (*b*)

Q.82. Which one of the following figures representing Hooke's jointed inclined shaft system will result in a velocity ratio of unity ?

(*a*) 

(*b*) 

(*c*) 

(*d*) 

Ans. (*a*)

Q.83. Given that m = mass of the ball of the governor,
ω = angular velocity of the governor and
g = acceleration due to gravity,
the height of Watt's governor is given by

(*a*) $\frac{g}{2\omega^2}$ (*b*) $\frac{g}{\omega^2}$ (*c*) $\frac{\sqrt{2g}}{\omega^2}$ (*d*) $\frac{2g}{\omega^2}$

Ans. (*b*)

Q.84. Match List-I with List-II and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. End thrust	1. Plain bearing
B. No cage	2. Ball bearing
C. More accurate centering	3. Needle bearing
D. Can be overloaded	4. Tapered roller bearing

Codes :

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

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

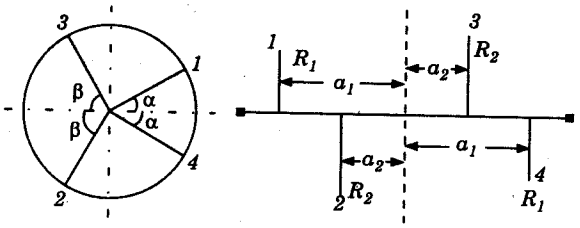
Ans. (*d*)

Q.85. For a given fractional change of speed, if the displacement of the sleeve is high, then the governor is said to be

(*a*) hunting (*b*) isochronous (*c*) sensitive (*d*) stable

Ans. (*c*)

Q.86. A four-cylinder symmetrical in-line engine is shown in the given figure. Reciprocating weights per cylinder are R_1 and R_2, and the corresponding angular disposition of the crank are α and β. Which one of the following equations should be satisfied for its primary force balance ?



(*a*) $a_1 \tan \alpha = a_2 \tan \beta$

(*b*) $\cos \alpha = \frac{1}{2} \sec \beta$ (*c*) $R_1 a_1 \sin 2a = -R_2 a_2 \sin 2b$ (*d*) $a_1 \cos a = R_2 \cos b$

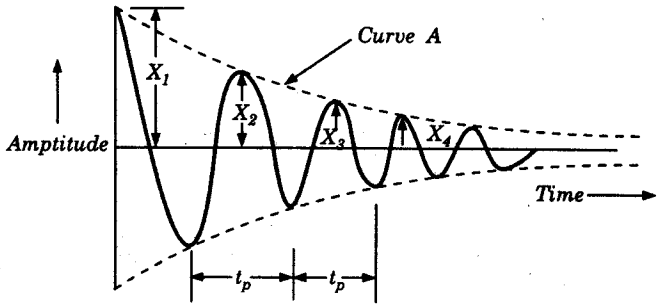
Ans. (*d*)

Q.87. In a multicylinder in-line internal combustion engine, even number of cylinders is chosen so that

(*a*) uniform firing order is obtained (*b*) the couples are balanced
(*c*) primary forces are balanced (*d*) secondary forces are balanced

Ans. (*a*)

Q.88.



The amplitude versus time curve of a damped-free vibration is shown in the above figure. Curve labelled 'A' is

(*a*) a logarithmic decrement curve (*b*) an exponentially decreasing curve
(*c*) a hyperbolic curve (*d*) a linear curve

Ans. (*a*)

Q.89. If a mass '*m*' oscillates on a spring having a mass m_s and stiffness '*k*', then the natural frequency of the system is given by

(*a*) $\sqrt{\dfrac{k}{m+\dfrac{m_s}{3}}}$ (*b*) $\sqrt{\dfrac{k}{\dfrac{m}{3}+m_s}}$ (*c*) $\sqrt{\dfrac{3k}{m+m_s}}$ (*d*) $\sqrt{\dfrac{k}{m+m_s}}$

Ans. (*a*)

Q.90. Match List-I with List-II and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. Node and mode	1. Geared vibration
B. Equivalent inertia	2. Damped-free vibration
C. Log decrement	3. Forced vibration
D. Resonance	4. Multi-rotor vibration

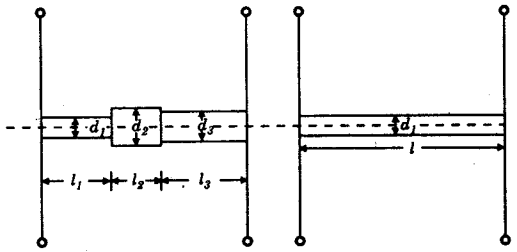
Codes :

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

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

Ans. (*b*)

Q.91.



Two shafts are shown in the above figure. These two shafts will be torsionally equivalent to each other if their

(*a*) polar moment of inertias are the same (*b*) total angle of twists are the same
(*c*) lengths are the same (*d*) strain energies are the same

Ans. (*b*)

Q.92. The critical speed of a uniform shaft with a rotor at the centre of the span can be reduced by

(*a*) reducing the shaft length (*b*) reducing the rotor mass
(*c*) increasing the rotor mass (*d*) increasing the shaft diameter

Ans. (*b*)

Q.93. Consider the following characteristics :

1. Small interference. 2. Strong tooth.
3. Low production cost. 4. Gear with small number of teeth.

Those characteristics which are applicable to Stub 20° involute system would include

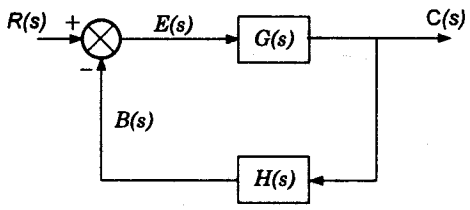
(*a*) 1 alone (*b*) 2, 3 and 4 (*c*) 1, 2 and 3 (*d*) 1, 2, 3 and 4

Ans. (*d*)

Q.94. A physical system is translated into functional block diagram of the type shown in the figure. The command input $r(t)$ and controlled output $c(t)$ of this basic system are given by

$(a)\ \dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+\dfrac{G(s)}{H(s)}}$ $(b)\ \dfrac{C(s)}{R(s)} = \dfrac{H(s)}{1+G(s)H(s)}$

$(c)\ \dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1-G(s)H(s)}$ $(d)\ \dfrac{C(s)}{R(s)} = \dfrac{G(s)}{1+G(s)H(s)}$



Ans. (b)

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

1. Tensile stress due to the stretching of bolt
2. Bending stress due to the bending of bolt
3. Crushing and shear stresses in threads
4. Torsional shear stress due to frictional resistance between the nut and the bolt.

Select the correct answer using the codes given below

Codes

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

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

Ans. (d) There is no chance of bending stress due to bending of bolt.

Q.96. The shearing area of a key of length 'L', breadth 'b' and depth 'h' is equal to

$(a)\ b \times h$ $(b)\ L \times h$

$(c)\ L \times b$ $(d)\ L \times (h/2)$

Ans. (c)

Q.97. Match List-I (Machine element) with List-II (Cause of failure) and select the correct answer using the codes given below the lists :

List-I	***List-II***
A. Axle	1. Shear stress
B. Cotter	2. Tensile/compressive stress
C. Connecting rod	3. Wear
D. Journal bearing	4. Bending stress

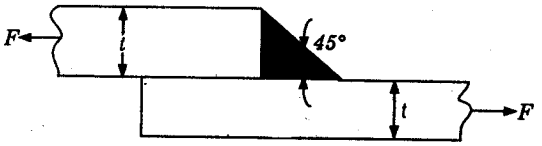
Codes :

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

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

Ans. (a)

Q.98. Two metal plates of thickness 't' and width 'w' are joined by a fillet weld of 45° as shown in given figure. When subjected to a pulling force 'F', the stress induced in the weld will be



$(a)\ \dfrac{F}{wt \sin 45°}$ $(b)\ \dfrac{F}{wt}$ $(c)\ \dfrac{F \sin 45°}{wt}$ $(d)\ \dfrac{2F}{wt}$

Ans. (a)

Q.99. Consider the following statements :
A splined shaft is used for
1. transmitting power
2. holding a flywheel rigidly in position
3. moving axially the gear wheels mounted on it
4. mounting V-belt pulleys on it.
Of these statements
(*a*) 2 and 3 are correct
(*b*) 1 and 4 are correct
(*c*) 2 and 4 are correct
(*d*) 1 and 3 are correct
Ans. (*d*)

Q.100. When two shafts are neither parallel nor intersecting, power can be transmitted by using
(*a*) a pair of spur gears
(*b*) a pair of helical gears
(*c*) an Oldham's coupling
(*d*) a pair of spiral gears
Ans. (*c*)

Q.101. In the assembly design of shaft, pulley and key, the weakest member is
(*a*) pulley
(*b*) key
(*c*) shaft
(*d*) none
Ans. (*b*)

Q.102. In the formulation of Lewis equation for toothed gearing, it is assumed that tangential tooth load F_t, acts on the
(*a*) pitch point
(*b*) tip of the tooth
(*c*) root of the tooth
(*d*) whole face of the tooth
Ans. (*b*)

Q.103. For a two-dimensional state stress ($\sigma_1 > \sigma_2$, $\sigma_1 > 0$, $\sigma_2 < 0$) the designed values are most conservative if which one of the following failure theories were used ?
(*a*) Maximum principal strain theory
(*b*) Maximum distortion energy theory
(*c*) Maximum shear stress theory
(*d*) Maximum principal stress theory
Ans. (*d*)

Q.104. Match List-I with List-II and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. Single-plate friction clutch	1. Scooters
B. Multi-plate friction clutch	2. Rolling mills
C. Centrifugal clutch	3. Trucks
D. Jaw clutch	4. Mopeds

Codes :

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

Ans. (*c*)

Q.105. Which of the following stresses are associated with the design of pins in bushed pin-type flexible coupling ?
1. Bearing stress
2. Bending stress
3. Axial tensile stress
4. Transverse shear stress
Select the correct answer using the codes given below
Codes :
(*a*) 1, 3 and 4
(*b*) 2, 3 and 4
(*c*) 1, 2 and 3
(*d*) 1, 2 and 4
Ans. (*d*)

Q.106. The state of plane stress at a point is described by $\sigma_x = \sigma_y = \sigma$ and $\tau_{xy} = 0$. The normal stress on the plane inclined at 45° to the x-plane will be

(*a*) σ (*b*) $\sqrt{2}\sigma$ (*c*) $\sqrt{3}\sigma$ (*d*) 2σ

Ans. (*a*)

Q.107. Consider the following statements :

State of stress in two dimensions at a point in a loaded component can be completely specified by indicating the normal and shear stresses on

1. a plane containing the point
2. any two planes passing through the point
3. two mutually perpendicular planes passing through the point

Of these statements

(*a*) 1, and 3 are correct (*b*) 2 alone is correct

(*c*) 1 alone is correct (*d*) 3 alone is correct

Ans. (*c*)

Q.108. For a composite consisting of a bar enclosed inside a tube of another material when compressed under a load 'W' as a whole through rigid collars at the end of the bar. The equation of compatibility is given by (suffixes 1 and 2) refer to bar and tube respectively

(*a*) $W_1 + W_2 = W$ (*b*) $W_1 + W_2 = \text{constant}$

(*c*) $\dfrac{W_1}{A_1E_1} = \dfrac{W_2}{A_2E_2}$ (*d*) $\dfrac{W_1}{A_1E_2} = \dfrac{W_2}{A_2E_1}$

Ans. (*a*)

Q.109. A tapering bar (diameters of end sections being d_1 and d_2) and a bar of uniform cross-section 'd' have the same length and are subjected the same axial pull. Both the bars will have the same extension if 'd' is equal to

(*a*) $\dfrac{d_1 + d_2}{2}$ (*b*) $\sqrt{d_1 d_2}$ (*c*) $\sqrt{\dfrac{d_1 d_2}{2}}$ (*d*) $\sqrt{\dfrac{d_1 + d_2}{2}}$

Ans. (*b*)

Q.110. The number of independent elastic constants required to express the stress-strain relationship for a linearly elastic isotropic material is

(*a*) one (*b*) two (*c*) three (*d*) four

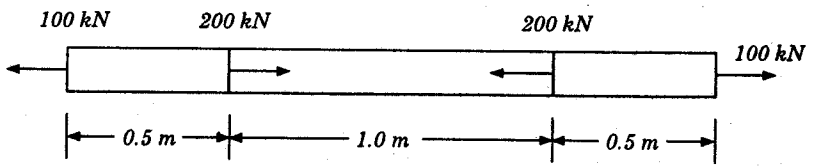
Ans. (*c*)

Q.111. The deformation of a bar under its own weight as compared to that when subjected to a direct axial load equal to its own weight will be

(*a*) the same (*b*) one-fourth (*c*) half (*d*) double

Ans. (*c*)

Q.112.

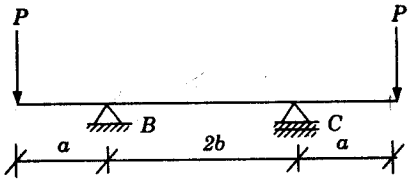


A slender bar of 100 mm^2 cross-section is subjected to loading as shown in the above figure. If the modulus of elasticity is taken as 200×10^9 Pa, then the elongation produced in the bar will be

(*a*) 10 mm (*b*) 5 mm (*c*) 1 mm (*d*) nil

Ans. (*a*)

Q.113.

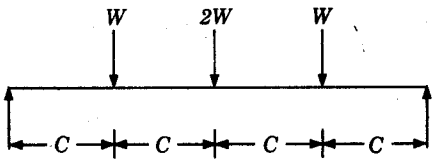


For the beam shown in the above figure, the elastic curve between the supports B and C will be

(*a*) circular (*b*) parabolic (*c*) elliptic (*d*) a straight line

Ans. (*a*)

Q.114.

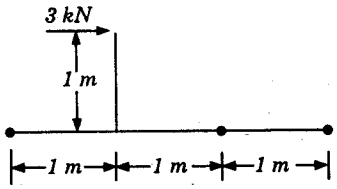


A simply supported beam is loaded as shown in the above figure. The maximum shear force in the beam will be

(*a*) zero (*b*) *W* (*c*) 2*W* (*d*) 4*W*

Ans. (*c*)

Q.115.



A lever is supported on two hinges at *A* and *C*. It carries a force of 3 kN as shown in the above figure. The bending moment *B* will be

(*a*) 3 kN-m (*b*) 2 kN-m (*c*) 1 kN-m (*d*) zero

Ans. (*a*)

Q.116. Two hollow shafts of the same material have the same length and outside diameter. Shaft 1 has internal diameter equal to one-third of the outer diameter and shaft 2 has internal diameter equal to half of the outer diameter. If both the shafts are subjected to the same torque, the ratio of their twists θ_1/θ_2 will be equal to

(*a*) 16/81 (*b*) 8/27 (*c*) 19/27 (*d*) 243/256

Ans. (*d*) $Q \propto \frac{1}{J} \quad \therefore \frac{Q_1}{Q_2} = \frac{d_1^4 - (d_1/2)^4}{d_1^4 - (d_1/3)^4} = \frac{\frac{15}{16}d_1^4}{\frac{80}{81}d_1^4} = \frac{15}{16} \times \frac{81}{80} = \frac{243}{256}$

Q.117. A simply supported beam of constant flexural rigidity and length $2L$ carries a concentrated load 'P' at its mid-span and the deflection under the load is δ. If a cantilever beam of the same flexural rigidity and length 'L' is subjected to load 'P' at its free end, then the deflection at the free end will be

(*a*) $\frac{1}{2}\delta$ (*b*) δ (*c*) 2δ (*d*) 4δ

Ans. (*c*) δ for beam $= \frac{(W/2L)^3}{48EI} = \frac{WL^3}{6EI}$; δ for cantilever $= \frac{WL^3}{3EI}$

Q.118. A solid shaft of diameter 100 mm, length 1000 mm is subjected to a twisting moment 'T'. The maximum shear stress developed in the shaft is 60 N/mm^2. A hole of 50 mm diameter is now drilled throughout the length of the shaft. To develop a maximum shear stress of 60 N/mm^2 in the hollow shaft, the torque 'T' must be reduced by

(*a*) $T/4$ (*b*) $T/8$ (*c*) $T/12$ (*d*) $T/16$

Ans. (*d*) $s_s = \frac{Tr}{J} = \frac{T \cdot 16}{\pi d^3} = \frac{T' 16d}{d^4 - (d/2)^4} = \frac{T' \cdot 16 \times 16}{15d^3}$ $\therefore T' = \frac{15}{16}T$, $\therefore$ Reduction $= \frac{T}{16}$.

Q.119. A circular shaft is subjected to the combined action of bending, twisting and direct axial loading. The maximum bending stress σ, maximum shearing force $\sqrt{3}\sigma$ and a uniform axial stress σ (compressive) are produced. The maximum compressive normal stress produced in the shaft will be

(*a*) 3σ (*b*) 2σ (*c*) σ (*d*) zero

Ans. (*b*) Max. normal compressive stress

$$= \frac{\sigma_x + \sigma_y}{2} - \sqrt{\left(\frac{\sigma_y - \sigma_x}{2}\right)^2 + \sigma_s^2}$$

$$= \frac{-\sigma + \sigma}{2} - \sqrt{\left(\frac{\sigma + \sigma}{2}\right)^2 + (\sqrt{3}\sigma)^2} = \sqrt{\sigma^2 + 3\sigma^2} = 2\sigma$$

Q.120. Two closed-coil springs are made from the same small diameter wire, one wound on 2.5 cm diameter core and the other on 1.25 cm diameter core. If each spring had 'n' coils, then the ratio of their spring constants would be

(*a*) 1/16 (*b*) 1/8 (*c*) 1/4 (*d*) 1/2

Ans. (*b*) Spring constant $\propto \frac{1}{D^3}$. $\therefore$ Ratio of 2.5 cm and 1.25 cm diameter core $= \left(\frac{1.25}{2.5}\right)^3 = \frac{1}{8}$.

I.E.S. (Objective)

MECHANICAL ENGINEERING–1999

PAPER–I

Time Allowed : Two Hours *Maximum Marks : 200*

INSTRUCTIONS

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET DOES NOT HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS, ETC. IF SO, GET IT REPLACED BY A COMPLETE REST BOOKLET.
2. ENCODE CLEARLY THE TEST BOOKLET SERIES **A, B, C, D** AS THE CASE MAY BE IN THE APPROPRIATE PLACE IN THE ANSWER SHEET.
3. You have to enter your Roll Number on the Testbooklet in the Box provideed alongside. DO NOT write anything else on the Test Booklet.
4. This Test Booklet contains **120** items (questions). Each item comprises four responses (answers). You will select the response which you want to mark on the Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose only one response for each item.
5. You have to mark all your responses ONLY on the separate Answer Sheet provided. See directions in the Answer Sheet.
6. All items carry equal marks. Attempt ALL items. Your total marks will depend only on the number of *correct* responses marked by you in the Answer Sheet.
7. Before you proceed to mark in the Answer Sheet the response to various items in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per instructions sent to you with your Admission Certificate.
8. After you have completed filling in all responses onthe Answer Sheet and the examiantion has concluded, you should hand over to the invigilator *only the Answer Sheet.* You are permitted to take away with you the Test Booket and rough sheets issued to you.

Q.1. Consider the following emissions of an IC engine :
1. CO 2. HC 3. NO_x 4. Particulates
Which of these emissions cause photochemical smog ?
(*a*) 1 and 4 (*b*) 1 and 2 (*c*) 2 and 3 (*d*) 3 and 4

Ans. (*c*) Smog refers to smoke plus fog. Photochemical smog occurs due to Hydrocarbons and nitrogen oxides.

Q.2. Velocity of flame propagation in the SI engine is maximum for a fuel-air mixture which is
(*a*) 10% richer than stoichiometric (*b*) equal to stoichiometric
(*c*) more than 10% richer than stoichiometric (*d*) 10% leaner than stoichiometric

Ans. (*d*)

Q.3. Divided chamber diesel engines use lower injection pressures compared to open chamber engines because
(*a*) pintle nozzles cannot withstand high injection pressures
(*b*) high air swirl does not require high injection pressures for atomisation

(c) high injection pressures may cause over-penetration
(d) high injection pressure causes leakage of the fuel at the pintle

Ans. (b) In divided combustion chamber, the restrictions or throat between chambers results in high velocities which helps in rapid mixing of fuel with air. Thus high injection pressure is not required for atomisation.

Q.4. In a variable speed S.I. engine, the maximum torque occurs at the maximum
(a) speed (b) brake power
(c) indicated power (d) volumetric efficiency

Ans. (c) The torque developed by an engine is directly proportional to the indicated power. Thus maximum torque will occur corresponding to maximum indicated power.

Q.5. In a Morse test for a 2-cylinder, 2-stroke, spark ignition engine, the brake power was 9 kW whereas the brake powers of individual cylinders with spark cut off were 4.25 kW and 3.75 kW respectively. The mechanical efficiency of the engine is
(a) 90% (b) 80% (c) 45.5% (d) 52.5%

Ans. (a) Indicated power of second cylinder is $9 - 4.25 = 4.75$ kW and of first engine is $9 - 3.75 = 5.25$ kW. Thus total indicated power of engine is $4.75 + 5.25 = 10$ kW.

$$\therefore \text{Mechanical efficiency of engine} = \frac{9}{10} \times 100 = 90\%$$

Q.6. An aircraft flying horizontally at a speed of 900 km/h is propelled by a jet leaving the nozzle at a speed of 500 m/s. The propulsive efficiency is
(a) 0.334 (b) 0.426 (c) 0.556 (d) 0.667

Ans. (d) Propulsive efficiency $\eta_p = \dfrac{2 \times \text{Velocity of approach of air } (V_a)}{\text{Velocity of jet relative to air plane } (V_j) + V_a}$

$$V_a = 900 \text{ km/hr} = \frac{900 \times 1000}{3600} = 250 \text{ m/s}, \; V_j = 500 \text{ m/s}$$

$$\eta_p = \frac{2 \times 250}{500 + 250} = \frac{500}{750} = 0.607$$

Q.7. Match List-I (Name of boiler) with List-II (Special features) and select the correct answer using the codes given below the lists :

List-I
A. Lancashire
B. Cornish
C. La Mont
D. Cochran

List-II
1. High pressure water tube
2. Horizontal double fire tube
3. Vertical multiple fire tube
4. Low pressure inclined water tube
5. Horizontal single fire tube

Codes :

	A	B	C	D
(a)	2	5	1	3
(c)	1	5	2	3

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

Ans. (a) Lancashire boiler is horizontal double fire tube type, Cornish boiler is horizontal single fire tube type, La Mont boiler is high pressure water type, and Cochran boiler is vertical multiple fire tube type.

Q.8. The amount of CO_2 produced by 1 kg of carbon on complete combustion is

(*a*) $\frac{3}{11}$ kg (*b*) $\frac{3}{8}$ kg (*c*) $\frac{8}{3}$ kg (*d*) $\frac{11}{3}$ kg

Ans. (*d*) 12 kg of C + 32 kg of $O_2 \rightarrow$ 44 kg of CO_2 or 1 kg of C + $\frac{8}{3}$ kg of $O_2 \rightarrow \frac{11}{3}$ kg of CO_2

Q.9. Methane burns with stoichiometric quantity of air. The air/fuel ratio by weight is

(*a*) 4 (*b*) 14.7 (*c*) 15 (*d*) 17.16

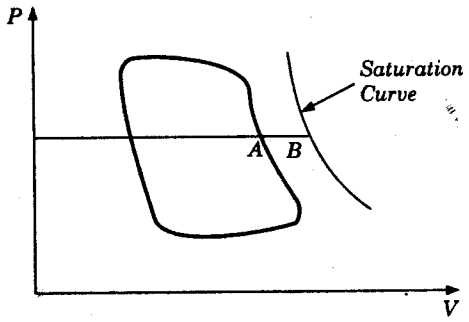
Ans. (*d*) 16 kg of methane (CH_4) + 64 kg of $O_2 \rightarrow$ 44 kg of CO_2 + 36 kg of water

1 kg of methane (CH_4) + 4 kg of $O_2 \rightarrow \frac{11}{4}$ kg of $CO_2 + \frac{9}{4}$ kg of water

Thus O_2 requirement for burning 1 kg of methane is 4 kg. Since air contains 23% of oxygen by weight,

air/fuel ratio = $\frac{4/0.23}{1} = 17.16\%$.

Q.10. The p-V diagram for the reciprocating steam engine is shown in the figure. The length A-B represents the



(*a*) condensation loss (*b*) friction loss (*c*) missing quantity (*d*) dryness fraction

Ans. (*c*) The length AB in the figure represents the missing quantity.

Q.11. Benson boiler is one of the high pressure boilers having

(*a*) one drum (*b*) one water drum and one steam drum
(*c*) three drums (*d*) no drum

Ans. (*d*) Benson boiler is drumless, once-through boiler.

Q.12. The compounding of steam turbines is done to

(*a*) improve efficiency (*b*) reduce turbine speed
(*c*) increase blade speed ratio (*d*) reduce axial thrust

Ans. (*b*) The compounding of steam turbine is done to reduce turbine speed.

Q.13. Consider the following statements :

1. De Laval nozzle is a subsonic nozzle. 2. Supersonic nozzle is a converging passage.
3. Subsonic diffuser is a diverging passage.

Which of these statements is/are correct ?

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

Ans. (*d*) Only third statement is correct, i.e. subsonic diffuser is a diverging passage.

Q.14. In a steam nozzle, inlet pressure of superheated steam is 10 bar. The exit pressure is decreased from 3 bar to 1 bar. The discharge rate will

(*a*) remain constant (*b*) decrease (*c*) increase slightly
(*d*) increase or decrease depending on whether the nozzle is convergent or convergent-divergent.

Ans. (*a*) Since exit pressure is less than that corresponding to critical pressure, discharge rate remains

unchanged with further decrease in exit pressure. Statement at (*d*) is also not correct.

Q.15. Match List-I (Different turbine stages) with List-II (Turbines) and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. 50% reaction stage	1. Rateau
B. Two-stage velocity compounded turbine	2. Parson
C. Single-stage impulse	3. Curtis
D. Two-stage pressure compounded turbine	4. De-Lavel
	5. Hero

Codes :

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

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

Ans. (*a*) 50% reaction turbine is Parson, 2-stage velocity compounded turbine is Curtis, single stage impulse turbine is De-Lavel, and 2-stage pressure compounded turbine is Rateau.

Q.16. The expression for the maximum efficiency of a Parson's turbine is (α is the angle made by absolute velocity at inlet)

(*a*) $\dfrac{\cos^2\alpha}{2\left(1+\cos^2\alpha\right)}$ (*b*) $\dfrac{2+\cos^2\alpha}{2\cos^2\alpha}$ (*c*) $\dfrac{2\cos\alpha}{1+\cos^2\alpha}$ (*d*) $\dfrac{2\cos^2\alpha}{1+\cos^2\alpha}$

Ans. (*d*) The maximum efficiency of a Parson's turbine is $\dfrac{2\cos^2\alpha}{1+\cos^2\alpha}$.

Q.17. Which one of the following safety devices is used to protect the boiler when the water level falls below a minimum level ?

(*a*) Water level indicator (*b*) Fusible plug (*c*) Blow off cock (*d*) Safety valve

Ans. (*b*) When water level falls below a minimum level, fusible plug melts and extinguishes fire to protect the boiler from overheating.

Q.18. Consider the following statements regarding effects of heating of steam in a steam turbine :

1. It increases the specific output of the turbine
2. It decreases the cycle efficiency
3. It increases blade erosion.
4. It improves the quality of exit steam ?

Which of these statements are correct ?

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

Ans. (*d*) Heating of steam increases specific output of turbine and improves the quality of exit steam.

Q.19. A 3-stage reciprocating compressor has suction pressure of 1 bar and delivery pressure of 27 bar. For minimum work of compression, the delivery pressure of 1st stage is

(*a*) 14 bar (*b*) 9 bar (*c*) 5.196 bar (*d*) 3 bar

Ans. (*d*) For minimum work of compression in 3 stage compressor the delivery pressure of 1st stage is

$\sqrt[3]{27/1} = 3$ bar

Q.20. Consider the following factors :

1. Cylinder size.
2. Clearance ratio.
3. Delivery pressure.
4. Compressor shaft power.

The factors which affect the volumetric efficiency of a single-stage reciprocating air compressor would include

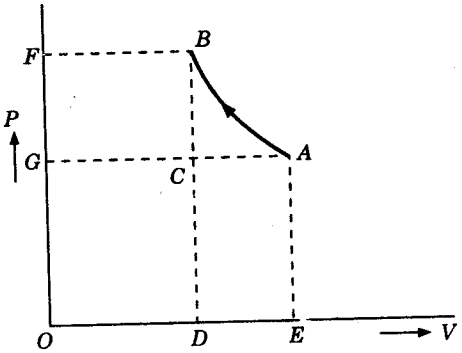
(*a*) 1 and 2 (*b*) 3 and 4 (*c*) 2 and 3 (*d*) 1 and 4

Ans. (*a*) Volumetric efficiency of a single stage reciprocating air compressor is dependent on clearance

ratio and cylinder size.

Q.21. The diagram shown in the figure represents reversible compression of air on the p-V co-ordinates. The work of compression needed by a centrifugal compressor is equal to the area

(*a*) *ABDE-ABC*
(*b*) *ABDE*
(*c*) *ABFG*
(*d*) *ABFG-ABC*



Ans. (*b*) Work of compression is area below the compression curve *AB, i.e. ABDE.*

Q.22. In centrifugal compressor terminology, vaneless space refers to the space between

(*a*) the inlet and blade inlet edge
(*b*) blades in the impeller
(*c*) diffuser exit and volute casing
(*d*) impeller tip and diffuser inlet edge

Ans. (*d*) The vaneless shape refers to space between impeller tip and diffuser inlet edge.

Q.23. If the static temperature rise in the rotor and stator respectively are ΔT_A and ΔT_B, the degree of reaction in an axial flow compressor is given by

(*a*) $\dfrac{\Delta T_A}{\Delta T_B}$ (*b*) $\dfrac{\Delta T_A}{\Delta T_A + \Delta T_B}$ (*c*) $\dfrac{\Delta T_B}{\Delta T_A + \Delta T_B}$ (*d*) $\dfrac{\Delta T_B}{\Delta T_A}$

Ans. (*b*) Degree of reaction of axial flow compressor $= \dfrac{\text{static temperature rise in rotor}}{\text{static temperature rise in stage}} = \dfrac{\Delta T_A}{\Delta T_A + \Delta T_B}$

Q.24. Consider the following statements relating to a closed gas turbine cycle :

1. The cycle can employ monatomic gas like helium instead of air to increase the cycle efficiency if other conditions are the same.
2. The efficiency of heat exchanger increases with the use of helium.
3. The turbine blades suffer higher corrosion damages.
4. Higher output can be obtained for the same size.

Which of these statements are correct ?

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

Ans. (*b*) Item 3 is not correct and other items are correct.

Q.25. Forced draught fans of a large steam generator have

(*a*) backward curved blades
(*b*) forward curved blades
(*c*) straight or radial blades
(*d*) double curved blades

Ans. (*a*) Forced draught fans of a large steam generator have backward curved blades because these have steep head characteristics, good efficiency, high speed and ability to operate in parallel.

Q.26. Air from a reservoir is to be passed through a supersonic nozzle so that the jet will have a Mach number of 2. If the static temperature of the jet is not to be less than 27°C, the minimum temperature of air in the reservoir should be

(*a*) 48.6°C (*b*) 167°C (*c*) 267°C (*d*) 367°C

Ans. (*a*) $\dfrac{T_R\ (\text{temperature of air in reservoir})}{T_J\ (\text{static temperature of jet})} = 1 + \left(\dfrac{\gamma - 1}{2}\right) M_N^2 = 1 + \left(\dfrac{1.4 - 1}{2}\right) \times 2^2 = 1.8$

$\therefore \quad T_R = 27 \times 1.8 = 48.6°C$

Q.27. Which one of the following is the correct statement ?

(*a*) The Mach number is less than 1 at a point where the entropy is maximum whether it is Rayleigh

or Fannoline

(*b*) A normal shock can appear in subsonic flow

(*c*) The downstream Mach number across a normal shock is more than one

(*d*) The stagnation pressure across a normal shock decreases

Ans. (*a*)

Q.28. Consider the following statements :

1. A draft tube may be fitted to the tail end of a Pelton turbine to increase the available head.
2. Kaplan turbine is an axial flow reaction turbine with adjustable vanes on the hub.
3. Modern Francis turbine is a mixed flow reaction turbine.

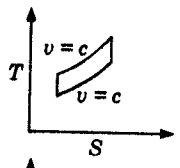
Which of these statements are correct ?

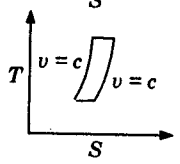
(*a*) 1, 2 and 3 (*b*) 1 and 2 (*c*) 2 and 3 (*d*) 1 and 3

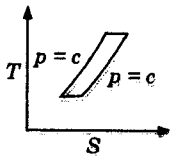
Ans. (*c*) In a Pelton turbine, draft tube can't help to increase the available head since the jet from nozzle gets exposed to atmospheric air.

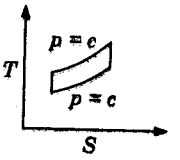
Q.29. Match List-I (The T-S diagram of thermodynamic cycles) with List-II (Names of cycles) and select the correct answer using the codes given below the lists :

List-I

A. 

B. 

C. 

D. 

List-II

1. Brayton cycle
2. Otto cycle
3. Stirling cycle
4. Ericsson cycle
5. Diesel cycle

Codes :

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

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

Ans. (*d*) The correct matching is A–2, B–3, C–4, D–1.

Q.30. Consider the following data for the performance of a centrifugal pump :
Speed : 1200 rpm, flow rate : 30 *l/s*, head : 20 m, Power : 5 kW
If the speed is increased to 1500 rpm, the power will be nearly equal to

(*a*) 6.5 kW (*b*) 8.7 kW (*c*) 9.8 kW (*d*) 10.9 kW

Ans. (*c*) Power is proportional to cube of speed, $\therefore\ P = 5\times\left(\frac{1500}{1200}\right)^3 = 9.8$ kW

Q.31. Consider the following pumps :

1. Centrifugal pump, single-stage.
2. Centrifugal pump, multi-stage
3. Reciprocating pump.
4. Jet pump.

The pump (*s*) which can be used to lift water through a suction head of 12 m from a well would include

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

Ans. (*c*) Since suction head is 12 m, i.e. more than atmospheric pressure, only jet pump can be used to lift water under such a situation.

Q.32. If ω_s and ω_p represent the angular velocities of driver and driving members of a fluid coupling respectively, then the slip is equal to

(*a*) $1-\frac{\omega_s}{\omega_p}$ (*b*) $\frac{\omega_s}{\omega_p}$ (*c*) $\frac{\omega_p}{\omega_s}$ (*d*) $1-\frac{\omega_p}{\omega_s}$

Ans. (*d*) $\text{Slip} = 1-\frac{\text{angular velocity of driving member}}{\text{angular velocity of driver}}$

Q.33. Hydraulic ram is a pump which works on the principle of

(*a*) water hammer (*b*) centrifugal action (*c*) reciprocating action (*d*) hydraulic press

Ans. (*a*) Hydraulic ram utilises effect of water hammer to lift water.

Q.34. The correct sequence of the given hydraulic turbines in *decreasing* order of their specific speeds is :

(*a*) Pelton wheel, Francis turbine, Kaplan turbine
(*b*) Propeller turbine, Francis turbinee, Pelton wheel
(*c*) Kaplan turbine, Pelton wheel, Francis turbine
(*d*) Francis turbine, Kaplan turbine, Pelton wheel

Ans. (*b*) Specific speed of propeller is around 225–850, Francis 50–225, and Pelton 10–50.

Directions :

The following 15 (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 of A
(*c*) A is true but R is false
(*d*) A is false but R is true

Q.35. *Assertion* (*A*) : The change in heat and work cannot be expressed as difference between the end states.
Reason (*R*) : Heat and work are both exact differentials.

Ans. (*c*) *A* is true because change in heat and work are path functions and thus can't be expressed simply as difference between the end states. *C* is false because both work and heat are inexact differentials.

Q.36. *Assertion* (*A*) : Heat cannot spontaneously pass from a colder system to a hotter system without simultaneously producing other effects in the surroundings.
Reason (*R*) : External work must be put into heat pump so that heat can be transferred from a cold to a hot body.

Ans. (*a*) *A* and *R* are true. *A* is the Clausius statement of second law of thermodynamics. Spontaneously means without change in surroundings. Statement at *R* provides the correct reasoning for *A*, i.e. the work must be done by surroundings on the system for heat to flow from lower temperature to higher temperature.

Q.37. *Assertion* (*A*) : Second law of thermodynamics is called the law of degradation of energy.
Reason (*R*) : Energy does not degrade each time it flows through a finite temperature difference.
Ans. (*b*) Both *A* and *R* are true but *R* does not give correct reasoning for *A*.

Q.38. *Assertion* (*A*) : Water is not a pure substance.
Reason (*R*) : The term pure substance designates a substance which is homogeneous and has the same chemical composition in all phases.
Ans. (*d*) Water for all practical purpose can be considered as pure substance because it is homogeneous and has same chemical composition under all phases.

Q.39. *Assertion* (*A*) : Depth of centre of pressure of any immersed surface is independent of the density of liquid.
Reason (*R*) : Centre of area of immersed surface lies below the centre of pressure.
Ans. (*c*) Depth of centre of pressure is proportional to second moment of area about the water surface, area of surface, and depth of centre of gravity.
However centre of area of immersed surface lies above the centre of pressure. Thus A is true but R is false.

Q.40. *Assertion* (*A*) : If a boat, built with sheet metal on wooden frame, has an average density which is greater than that of water, then the boat can float in water with its hollow face upward but will sink once it overturns.
Reason (*R*) : Buoyant force always acts in the upward direction.
Ans. (*b*) Both A and R are true, but R does not give sufficient explanation for phenomenon at A. Location of Metacentre and centre of buoyancy decide about floating of a body.

Q.41. *Assertion* (*A*) : A cylinder, partly filled with a liquid, is rotated about its vertical axis. The rise of liquid level at the ends is equal to the fall of liquid level at the axis.
Reason (*R*) : Rotation creates forced vortex motion.
Ans. (*b*) Both *A* and *R* are true, but *R* is not satisfactory explanation for *A*. The liquid rise up the wall is same as liquid fall at centre because the volume of a paraboloid of revolution is equal to half the volume of the cylinder circumscribing the paraboloid.

Q.42. *Assertion* (*A*) : To have maximum hydraulic efficiency, the trapezoidal section of an open channel should be a half-hexagon.
Reason (*R*) : For any cross-section, a hexagon has the least perimeter.
Ans. (*a*) Both *A* and *R* are true. For maximum hydraulic efficiency the wetted perimeter should be least and this is provided by half-hexagon section.

Q.43. A viscous fluid flows over a flat plate placed at zero angle of attack.
Assertion (*A*) : The thickness of boundary layer is an ever increasing one as its distance from the leading edge of the plate increases.
Reason (*R*) : In practice, 99 per cent of the depth of the boundary layer is attained within a short distance of the leading edge.
Ans. (*b*) *A* is true but *R* is not true. The thickness of boundary layer varies from zero at a stationary boundary to the free stream velocity asymptotically. The thickness corresponding to 99% velocity is defined as boundary layer thickness.

Q.44. *Assertion* (*A*) : The thermal efficiency of Brayton cycle with regeneration decreases as the compressor ratio increases.
Reason (*R*) : As the compression ratio of compressor increases, the range of temperature in the regenerator decreases and the amount of heat recovered reduces.
Ans. (*a*) Both *A* and *R* are true and *R* is correct explanation for *A*.

Q.45. *Assertion* (*A*) : Parsons turbine has a degree of reaction equal to 50%.
Reason (*R*) : It is a reaction turbine with symmetrical fixed and moving blades.

Ans. (*a*) Because fixed and moving blades are symmetrical, the enthalpy drop in both becomes equal and this results in degree of reaction as 50%.

Q.46. *Assertion* (*A*) : The thermal efficiency of a nuclear power plant using a boiling water reactor is higher than of a plant using a pressurised water reactor.
Reason (*R*) : In a boiling water reactor, steam is directly allowed to be generated in the reactor itself, whereas in a pressurised water reactor, steam is generated in a separate boiler by heat exchanger device using water of the primary circuit which absorbs the fission energy.

Ans. (*a*) Both *A* and *R* are true and *R* provides reason for thermal efficiency of boiling water reactor to be high compared to pressurised water reactor.

Q.47. *Assertion* (*A*) : In Infrared gas analyser, the amount of absorption is the function of concentration of the gas and the length of the absorption path.
Reason (*R*) : Different gases are characterised by distinctive absorption bands within the infrared range.

Ans. (*a*)

Q.48. *Assertion* (*A*) : The use of turboprop engine is limited to medium speed applications.
Reason (*R*) : The efficiency of a turboprop engine decreases at higher speed.

Ans. (*c*) *A* is true and *R* is false. In fact the efficiency increases with speed but thrust keeps on decreasing.

Q.49. *Assertion* (*A*) : In a three-way catalytic converter for emission control in S.I. engines, conversion of NO_x has to precede the oxidation of HC and CO.
Reason (*R*) : A reducing atmosphere is essential for the conversion of NO_x.

Ans. (*a*)

Q.50. Which one of the following is the extensive property of a thermodynamic system ?
(*a*) Volume (*b*) Pressure (*c*) Temperature (*d*) Density

Ans. (*a*) Extensive property is dependent on mass of system. Thus volume is extensive property.

Q.51. A closed thermodynamic system is one in which
(*a*) there is no energy or mass transfer across the boundary
(*b*) there is no mass transfer, but energy transfer exists
(*c*) there is no energy transfer, but mass transfer exists
(*d*) both energy and mass transfer take place across the boundary, but the mass transfer is controlled by valves

Ans. (*b*) In closed thermodynamic system, there is no mass transfer but energy transfer exists.

Q.52. Match List-I (Process) with List-II (Index n in pV^n = const) and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. Adiabatic	1. n = Infinity
B. Isothermal	2. $n = \frac{C_p}{C_v}$
C. Constant pressure	3. $n = 1$
D. Constant volume	4. $n = \frac{C_p}{C_v} - 1$
	5. n = zero

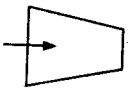
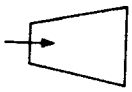
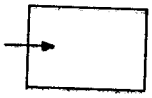
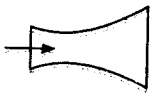
Codes :

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

	A	B	C	D
(b)	2	3	5	1
(d)	2	5	3	1

Ans. (b) Correct choice is : n for adiabatic is C_p/C_v, for isothermal $n = 1$, for constant pressure $n = 0$, and for constant volume $n = \alpha$.

Q.53. Which one of the following diagrams depicts correctly the shape of a supersonic diffuser ?

(a)  (b)  (c)  (d) 

Ans. (d) Supersonic diffuser has converging and diverging section.

Q.54. Joule-Thomson coefficient is the ratio of

(a) pressure change to temperature change occurring when a gas undergoes the process of adiabatic throttling

(b) temperature change to pressure change occurring when a gas undergoes the process of adiabatic throttling

(c) temperature change to pressure change occurring when a gas undergoes the process of adiabatic compression

(d) pressure change to temperature change occurring when a gas undergoes the process of adiabatic compression

Ans. (b) Joule Thomson coefficient is the ratio of temperature change to pressure change when a gas undergoes adiabatic throttling.

Q.55. Gibb's free energy 'G' is defined as

(a) $G = H - TS$ (b) $G = U - TS$ (c) $G = U + pV$ (d) $G = H + TS$

Ans. (a) Gibb's free energy 'G' is defined as $G = H - TS$.

Q.56. The device used to heat feed-water by utilizing the heat of the exhaust flue gases before leaving through the chimney, is called

(a) superheater (b) economizer (c) air preheater (d) ID fan

Ans. (b) Economiser is used to heat feed water by utilising the heat of the exhaust flue gases before leaving through the chimney.

Q.57. A tank containing air is stirred by a paddle wheel. The work input to the paddle wheel is 9000 kJ and the heat transferred to the surroundings from the tank is 3000 kJ. The external work done by the system is

(a) zero (b) 3000 kJ (c) 6000 kJ (d) 9000 kJ

Ans. (c)

Q.58. The p–v–T surface of a pure substance is shown in the given figure. The two-phase regions are labelled as

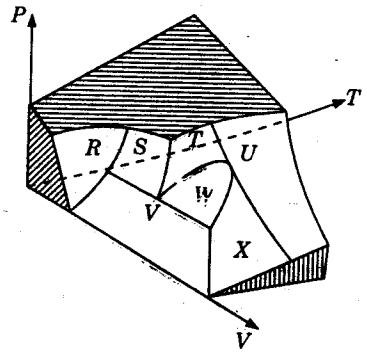
(a) R, T and X

(b) S, U and W

(c) S, W and V

(d) R, T and V

Ans. (a)



Q.59. Clausius-Clapeyron equation gives the 'slope' of a curve in

(a) p–v diagram (b) p–h diagram (c) $p - T$ diagram (d) T–S diagram

Ans. (c)

Q.60. Match List-I (name of cycles) with List-II (pv diagrams) and select the correct answer using the codes given below the lists :

List-I

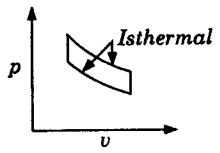
A. Stirling cycle

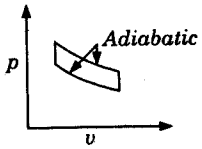
B. Diesel cycle

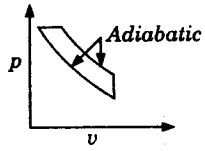
C. Otto cycle

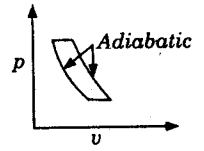
D. Atkinson cycle

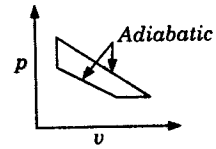
List-II

1.


2.


3.


4.


5.


Codes :

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

Ans. (*b*) Correct matching is A – 1, B – 3, C – 2, D – 5.

Q.61. The reheat cycle in steam power plant is mainly adopted to

(*a*) improve thermal efficiency

(*b*) decrease the moisture content in low pressure stages to a safe value

(*c*) decrease the capacity of condenser (*d*) recover the waste heat of boiler

Ans. (*a*) Though answers at (*a*) and (*b*) are correct, still the reheat cycle in steam power plant is mainly adopted to improve thermal efficiency.

Q.62. Consider the following statements :

The efficiency of the vapour power Rankine cycle can be increased by

1. increasing the temperature of the working fluid at which heat is added.
2. increasing the pressure of the working fluid at which heat is added.
3. decreasing the temperature of the working fluid at which heat is rejected.

Which of these statements is/are correct ?

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

Ans. (*d*) All statements are correct.

Q.63. Consider the following processes :

1. Constant pressure heat addition.
2. Adiabatic compression.
3. Adiabatic expansion.
4. Constant pressure heat rejection.

The correct sequence of these processes in Rankine cycle is :
(*a*) 1, 2, 3, 4 (*b*) 2, 1, 4, 3 (*c*) 2, 1, 3, 4 (*d*) 1, 2, 4, 3

Ans. (*c*) Correct sequence in Rankine cycle is compression, heating, expansion and heat rejection.

Q.64. Consider the following statements :
1. Pulverised fuel gives high and controlled burning rate.
2. Insufficient air casuses excessive smoking of exhaust.
3. Excess air is provided to control the flue gas temperature.
4. Effect of sulphur in fuel is to give high heat transfer rate.

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

Ans. (*c*) Statements 1 and 2 are correct.

Q.65. Which one of the following gaseous fuels does not have different higher and lower calorific values ?
(*a*) Methane (*b*) Ethane (*c*) Carbon monoxide (*d*) Hydrogen

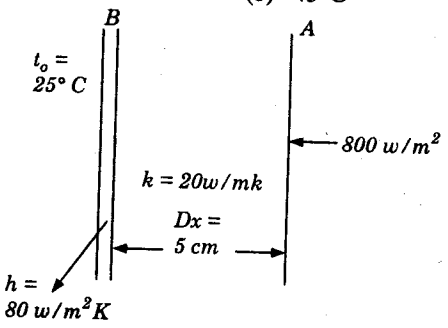
Ans. (*c*) Since CO does not have hydrogen content, the HCV and LCV are same.

Q.66. The heat flow equation through a cylinder of inner radius 'r_1' and outer radius 'r_2' is desired in the same form as that for heat flow through a plane wall. The equivalent area A_m is given by;

(*a*) $\dfrac{A_1+A_2}{\log_e\left(\dfrac{A_2}{A_1}\right)}$ (*b*) $\dfrac{A_1+A_2}{2\log_e\left(\dfrac{A_2}{A_1}\right)}$ (*c*) $\dfrac{A_2-A_1}{2\log_e\left(\dfrac{A_2}{A_1}\right)}$ (*d*) $\dfrac{A_2-A_1}{\log_e\left(\dfrac{A_2}{A_1}\right)}$

Ans. (*d*)

Q.67. A steel plate of thickness 5 cm and thermal conductivity 20 W/mK is subjected to a uniform heat flux of 800 W/m^2 on one surface 'A' and transfers heat by convection with a heat transfer co-efficient of 80 W/m^{2}K from the other surface 'B' into ambient air T_α of 25°C. The temperature of the surface 'B' transferring heat by convection is
(*a*) 25°C (*b*) 35°C (*c*) 45°C (*d*) 55°C



Ans. (*b*) $800=\dfrac{t_B-t_o}{1/h}=\dfrac{t_B-25}{1/80}$, $10=t_B-25$ and $t_B=35°C$

Q.68. The hydrodynamic boundary layer thickness is defined as the distance from the surface where the
(*a*) velocity equals the local external velocity (*b*) velocity equals the approach velocity
(*c*) momentum equals 99% of the momentum of the free stream
(*d*) velocity equals 99% of the local external velocity

Ans. (*d*)

Q.69. Heat is lost from a 100 mm diameter steam pipe placed horizontally in ambient at 30°C. If the Nusselt number is 25 and thermal conductivity of air is 0.03 W/mK, then the heat transfer co-efficient will be
(*a*) 7.5 W/m^{2}K (*b*) 16.2 W/m^{2}K (*c*) 25.2 W/m^2 K (*d*) 30 W/m^{2}K

Ans. (*a*) $\dfrac{hl}{k}=N_u$, or $h=\dfrac{25\times0.03}{0.1}=7.5$ W/m^{2}K

Q.70. If the temperature of a solid surface changes from 27°C to 627°C, then its emissive power will increase in the ratio of

(*a*) 3 (*b*) 9 (*c*) 27 (*d*) 81

Ans. (*d*) Emissive power is proportional to T^4 *i.e.* $\alpha \left(\frac{627+273}{27+273}\right)^4 \alpha\, 3^4\, \alpha\, 81$

Q.71. A spherical aluminium shell of inside diameter 2 m is evacuated and used as a radiation test chamber. If the inner surface is coated with carbon black and maintained at 600 K, the irradiation on a small test surface placed inside the chamber is (Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/m^{2}K^4)

(*a*) 1000 W/m^2 (*b*) 3400 W/m^2 (*c*) 5680 W/m^2 (*d*) 7348 W/m^2

Ans. (*d*) Irradiation on a small test surface placed inside a hollow black spherical chamber = σT^4
$= 5.67 \times 10^{-8} \times 600^4 = 7348$ W/m^2

Q.72. Match List-I with List-II and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. Stefan-Boltzmann law	1. $q = hA\,(T_1 - T_2)$
B. Newton's law of cooling	2. $E = \alpha E_b$
C. Fourier's law	3. $q = \frac{kA}{L}(T_1 - T_2)$
D. Kirchoff's law	4. $q = \sigma A\left(T_1^4 - T_2^4\right)$
	5. $q = kA\left(T_1 - T_2\right)$

Codes :

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

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

Ans. (*c*) Correct matching is A–2, B–1, C–3, D–4.

Q.73. A cross-flow type air-heater has an area of 50 m^2. The overall heat transfer coefficient is 100 W/m^{2}K and heat capacity of both hot and cold stream is 1000 W/K. The value of NTU is

(*a*) 1000 (*b*) 500 (*c*) 5 (*d*) 0.2

Ans. (*c*) $\text{NTU} = \frac{AU}{C_{min}}$, A = area = 50 m^2, U = overall heat transfer coefficient = 100 W/m^{2}K

C_{min} = heat capacity = 1000 W/K $\therefore$ NTU = $\frac{50 \times 100}{1000} = 5.$

Q.74. Saturated steam is allowed to condense over a vertical flat surface and the condensate film flows down the surface. The local heat transfer coefficient for condensation

(*a*) remains constant at all locations of the surface

(*b*) decreases with increasing distance from the top of the surface

(*c*) increases with increasing thickness of condensate film

(*d*) increases with decreasing temperature differential between the surface and vapour.

Ans. (*a*)

Q.75. A fin of length 'l' protrudes from a surface held at temperature t_0 greater than the ambient temperature t_a. The heat dissipation from the free end of the fin is assumed to be negligible. The temperature gradient at the fin tip $\left(\frac{dt}{dx}\right)_{x=l}$ is

(*a*) zero (*b*) $\frac{t_i - t_a}{t_o - t_a}$ (*c*) $h(t_o - t_i)$ (*d*) $\frac{t_o - t_i}{l}$

Ans. (*a*)

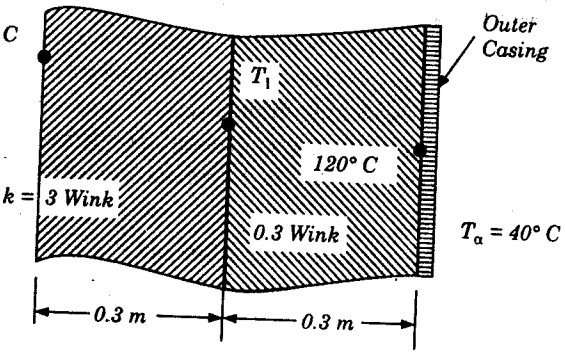
Q.76. A furnace wall is constructed as shown in the given figure. The heat transfer coefficient across the outer casing will be

(*a*) 80 W/m²K

(*b*) 40 W/m²K

(*c*) 20 W/m²K

(*d*) 10 W/m²K



Ans. (*d*) For two insulating layers,

$$\frac{Q}{A} = \frac{t_1 - t_2}{\frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2}} = \frac{1000 - 120}{\frac{0.3}{3} + \frac{0.3}{0.3}} = \frac{880}{1.1} = 800$$

For outer casing, $\frac{Q}{A} = \frac{120 - 40}{1/h}$, or $800 \times \frac{1}{h} = 80$, and $h = \frac{800}{80} = 10$ W/m²K

Q.77. For laminar flow over a flat plate, the local heat transfer coefficient 'h_x' varies as $x^{-1/2}$, where x is the distance from the leading edge ($x = 0$) of the plate. The ratio of the average coefficient 'h_a' between the leading edge and some location 'A' at $x = x$ on the plate to the local heat transfer coefficient 'h_x' at A is

(*a*) 1 (*b*) 2 (*c*) 4 (*d*) 8

Ans. (*b*) Say at $x = 0$, $h_0 = h$, at $x = x$, $h_x = \frac{h}{\sqrt{x}}$

$$\text{Average} = \frac{1}{x}\int_0^x \frac{h}{\sqrt{x}}\,dx = 2h\sqrt{x} \quad \therefore \text{Ratio} = \frac{1}{x} \cdot \frac{2h\sqrt{x}\sqrt{x}}{h} = 2.$$

Q.78. A heat pump operating on Carnot cycle pumps heat from a reservoir at 300 K to a reservoir at 600 K. The coefficient of performance is

(*a*) 1.5 (*b*) 0.5 (*c*) 2 (*d*) 1

Ans. (*c*) COP of heat pump = $\frac{T_2}{T_2 - T_1} = \frac{600}{600 - 300} = 2$

Q.79. In a vapour compression plant, if certain temperature differences are to be maintained in the evaporator and condenser in order to obtain the necessary heat transfer, then the evaporator saturation temperature must be

(*a*) higher than the derived cold-region temperature and the condenser saturation temperature must be lower than the available cooling water temperature by sufficient amounts

(*b*) lower than the derived cold-region temperature and the condenser saturation temperature must be lower than the available cooling water temperature by sufficient amounts

(*c*) lower than the derived cold-region temperature and the condenser saturation temperature must be higher than the available cooling water temperature by sufficient amounts

(*d*) higher than the derived cold-region temperature and the condenser saturation temperature must be higher than the available cooling water temperature by sufficient amounts

Ans. (*c*)

Q.80. One ton refrigeration is equivalent to
(*a*) 3.5 kW (*b*) 50 kJ/s (*c*) 1000 J/min (*d*) 1000 kJ/min

Ans. (*a*) 1 ton refrigeration = 3.5 kW

Q.81. The correct sequence of the given components of a vapour compression refrigerator is
(*a*) evaporator, compressor, condenser and throttle valve
(*b*) condenser, throttle valve, evaporator and compressor
(*c*) compressor, condenser, throttle valve and evaporator
(*d*) throttle valve, evaporator, compressor and condenser

Ans. (*c*)

Q.82. The coefficient of performance of a refrigerator working on a reversed Carnot cycle is 4. The ratio of the highest absolute temperature to the lowest absolute temperature is
(*a*) 1.2 (*b*) 1.25 (*c*) 3.33 (*d*) 4

Ans. (*b*) COP of reversed Carnot cycle $= \dfrac{T_1}{T_2 - T_1} = \dfrac{1}{\dfrac{T_2}{T_1} - 1} = 4$, or $\left(\dfrac{T_2}{T_1} - 1\right) = 0.25$, $\dfrac{T_2}{T_1} = 1.25$

Q.83. When a burnt out hermetic compressor is replaced by a new one, it is desirable to include in the system a large drier-cum-strainer also. This is to be placed in
(*a*) liquid line (*b*) suction line (*c*) hot gas line (*d*) discharge line

Ans. (*d*)

Q.84. A good refrigerant should have
(*a*) large latent heat of vaporisation and low operating pressures
(*b*) small latent heat of vaporisation and high operating pressures
(*c*) large latent heat of vaporisation and large operating pressures
(*d*) small latent heat of vaporisation and low operating pressures

Ans. (*a*) (*a*) is correct statement for good refrigerant.

Q.85. The most common type of absorption system in use in industrial applications is based on the refrigerant-absorbent combination of
(*a*) air-water (*b*) lithium bromide-air
(*c*) carbon dioxide-water (*d*) ammonia-water

Ans. (*b*) Industrial applications use lithium bromide-water combination for absorption refrigeration units.

Q.86. Solar energy can be directly used in
(*a*) vapour compression refrigeration system (*b*) vapour absorption refrigeration system
(*c*) air refrigeration system (*d*) jet refrigeration system

Ans. (*b*)

Q.87. The equation $\phi = \dfrac{p_v}{p_s}$ is used to calculate the (p_v = partial pressure of water vapour in moist air at a given temperature, p_s = saturation pressure of water vapour at the same temperature)
(*a*) relative humidity (*b*) degree of saturation (*c*) specific humidity (*d*) absolute humidity

Ans. (*a*)

Q.88. During adiabatic saturation process of air, wet bulb temperature
(*a*) increases and dry bulb temperature remains constant
(*b*) remains constant and dry bulb temperature increases
(*c*) remains constant and dry bulb temperature decreases
(*d*) decreases and dry bulb temperature remains constant

Ans. (*b*)

Q.89. In a chilled-water spray pond, the temperature of water is lower than dew point temperature of entering air. The air passing through the spray undergoes
(*a*) cooling and humidification (*b*) cooling and dehumidification
(*c*) sensible cooling (*d*) dehumidification

Ans. (*b*) In this case condensation of moisture takes place which results in fall in specific humidity ratio. Cooling and dehumidification take place.

Q.90. The sensible heat factor of a room is given by (S.H.L. = Sensible heat load and L.H.L. = Latent heat load)

(*a*) $\frac{\text{S.H.L.} - \text{L.H.L.}}{\text{S.H.L.}}$ (*b*) $\frac{\text{S.H.L.}}{\text{S.H.L.} + \text{L.H.L.}}$ (*c*) $\frac{\text{S.H.L.} + \text{L.H.L.}}{\text{S.H.L.}}$ (*d*) $\frac{\text{S.H.L.}}{\text{S.H.L.} + \text{L.H.L.}}$

Ans. (*d*) $\text{SHF} = \frac{\text{SHL}}{\text{SHL} + \text{LHL}}$

Q.91. A human body feels comfortable when the heat produced due to metabolism of human body is equal to the
(*a*) heat dissipated to the surroundings (*b*) heat stored in human body
(*c*) difference between heat dissipated to the surroundings and heat stored in human body
(*d*) sum of heat dissipated to the surroundings and heat stored in human body

Ans. (*a*) A human body feels comfortable when heat produced due to metabolism of human body gets equal to the heat dissipated to the surroundings.

Q.92. The reason for a person feeling more comfortable on a warm day if seated in front of an electric fan is that the
(*a*) metabolic heat production is reduced
(*b*) body loses more heat by convection and evaporation
(*c*) body loses more heat by radiation
(*d*) body loses more heat by evaporation and radiation

Ans. (*b*)

Q.93. Air at state 1 (dpt 1°C, W = 0.0040 kg/kg$_{air}$) mixes with air at state 2 (dpt 18°C, W = 0.0051 kg/kg$_{air}$) in the ratio 1 to 3 by weight. The degree of saturation (%) of the mixture is (the specific humidity of saturated air at 13.6°C, W = 0.01 kg/kg$_{air}$)
(*a*) 25 (*b*) 30 (*c*) 48 (*d*) 62

Ans. (*c*) kg of moisture actually contained in mixture $= \frac{.004 + 3 \times .0051}{4} = .0048$

kg of moisture in saturated air of mixture = 0.01 kg/kg air

$\therefore$ Degree of saturation $= \frac{.0048}{.01} = 48\%$

Q.94. Air is 20°C dry bulb temperature and 40% relative humidity is heated upon 40°C using an electric heater, whose surface temperature is maintained uniformly at 45°C. The bypass factor of the heater is
(*a*) 0.20 (*b*) 0.25 (*c*) 0.88 (*d*) 1

Ans. (*a*) Bypass factor $= \frac{t_3 - t_2}{t_3 - t_1} = \frac{45 - 40}{45 - 20} = \frac{5}{25} = 0.2$

Q.95. The performance of an evaporator condenser largely depends on
(*a*) dry bulb temperature of air (*b*) wet bulb temperature of air
(*c*) hot water temperature (*d*) air-conditioned room temperature

Ans. (*a*)

Q.96. Match angle α and Mach number M are related as :

(*a*) $M = \sin^{-1}\left(\frac{1}{\alpha}\right)$ (*b*) $\alpha = \cos^{-1}\left(\sqrt{\frac{M^2-1}{M}}\right)$

(*c*) $\tan\alpha = \left(\sqrt{M^2-1}\right)$ (*d*) $\alpha = \cos ec^{-1}\left(\frac{1}{M}\right)$

Ans. (*a*)

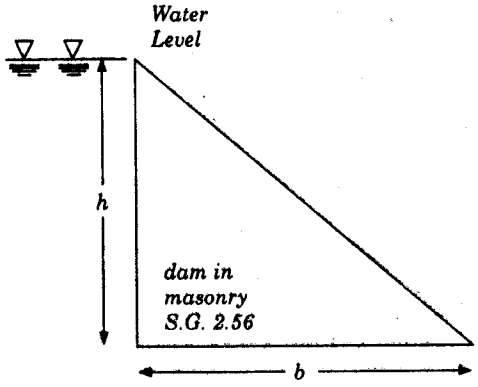
Q.97. A triangular dam of height *h* and base width *b* is filled to its top with water as shown in the given figure. The condition of stability is

(*a*) $b = h$

(*b*) $b = 2.6\,h$

(*c*) $b = \sqrt{3}\,h$

(*d*) $b = 0.625\,h$



Ans. (*b*)

Q.98. Stability of a freely falling object is assured if its centre of

(*a*) buoyancy lies below its centre of gravity

(*b*) gravity coincides with its centre of buoyancy

(*c*) gravity lies below its metacenter (*d*) buoyancy lies below its metacenter

Ans. (*c*) For freely falling object to be stable, its gravity must be below its metacentre.

Q.99. A vertical sluice gate, 2.5 m wide and weighing 500 kg is held in position due to horizontal force of water on one side and associated friction force. When the water level drops down to 2 m above the bottom of the gate, the gate just starts sliding down. The coefficient of friction between the gate and the supporting structure is

(*a*) 0.20 (*b*) 0.10 (*c*) 0.05 (*d*) 0.02

Ans. (*b*) Area of gate at sliding $= 2 \times 2.5 = 5\ m^2$

Pressure on upstream of gate $P = \rho g \times 5 \times \frac{2}{2}$

Friction force $= \mu P = W = 500\ kg = 500\ g N$

$$\therefore \qquad \mu = \frac{500 \times 9.81}{1000 \times 9.81 \times 5} = 0.1$$

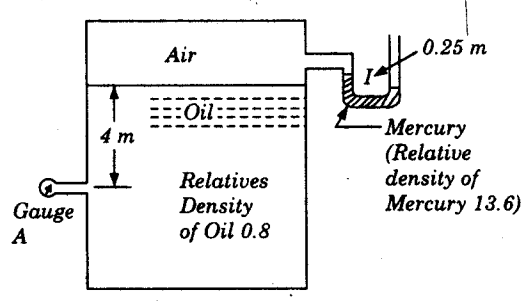
Q.100. The reading of gauge 'A' shown in the given figure is

(*a*) –31.392 kPa

(*b*) –1.962 kPa

(*c*) 31.392 kPa

(*d*) +19.62 kPa



Ans. (*b*) Air pressure from manometer reading is

$= -\rho g \times 0.25 = -1000 \times 9.81 \times 0.25\ N/m^2$

$= 3.4 \times 9.81$ kPa

Pressure of oil

$= 0.8 \times 1000 \times 9.81 \times 4 = 3.2 \times 9.81$ kPa

Resultant pressure read by gauge $= 3.2 - 3.4 \times 9.81$ kPa $= -1.962$ kPa.

Q.101. Match List-I with List-II regarding a body partly submerged in a liquid and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. Centre of pressure	1. Point of application of the weight of displaced liquid
B. Centre of gravity	2. Point about which the body starts oscillating when tilted by a small angle
C. Centre of buoyancy	3. Point of application of hydrostatic
D. Metacentre	4. Point of application of the weight of the body

Codes :

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

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

Ans. (*c*) Correct matching is A–3, B–4, C–1, D–2.

Q.102. If a piece of metal having a specific gravity of 13.6 is placed in mercury of specific gravity 13.6, then
(*a*) the metal piece will sink to the bottom
(*b*) the metal piece will simply float over the mercury with no immersion
(*c*) the metal piece will be immersed in mercury by half
(*d*) the whole of the metal piece will be immersed with its top surface just at mercury level

Ans. (*d*)

Q.103. A bucket of water hangs with a spring balance. If an iron piece is suspended into water from another support without touching the sides of the bucket, the spring balance will show
(*a*) an increased reading (*b*) a decreased reading (*c*) no change in reading
(*d*) increased or decreased reading depending on the depth of immersion

Ans. (*c*) Whatever is the weight of iron piece buoyancy force to same extent acts upward and thus spring balance on which water bucket is hanging will show no change in reading.

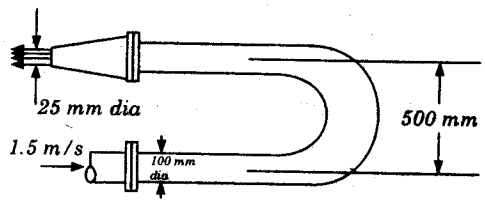
Q.104. The least radius of gyration of a ship is 9 *m* and the metacentric height is 750 mm. The time period of oscillation of the ship is
(*a*) 42.41 *s* (*b*) 75.4 *s* (*c*) 20.85 *s* (*d*) 85 *s*

Ans. (*c*) $T = 2\pi\sqrt{\dfrac{(\text{radiation of gyration})^2}{\text{Metacentric height}\times g}} = 2\times 3.14\sqrt{\dfrac{9^2}{0.75\times 9.81}} = \dfrac{6.28\times 9}{2.71} = 20.85 \text{ sec.}$

Q.105. If the surface tension of water-air interface is 0.073 *N/m*, the gauge pressure inside a rain drop of 1 mm diameter will be
(*a*) 0.146 N/m^2 (*b*) 73 N/m^2 (*c*) 146 N/m^2 (*d*) 292 N/m^2

Ans. (*d*) Pressure inside rain drop $= \dfrac{4T}{d} = \dfrac{4\times 0.073}{0.001} = 292$ N/m^2

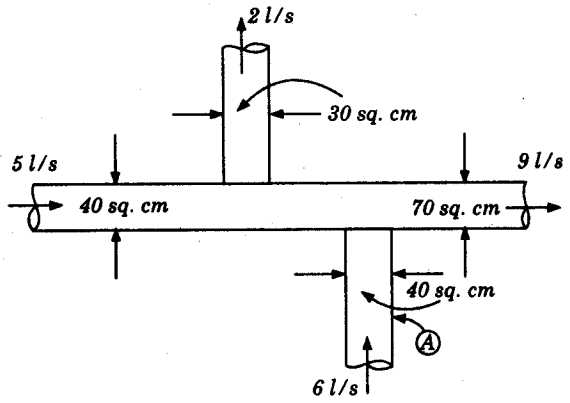
Q.106. The elbow nozzle assembly, shown in the given figure is in a horizontal plane. The velocity of jet issuing from the nozzle is
(*a*) 4 m/s
(*b*) 16 m/s
(*c*) 24 m/s
(*d*) 30 m/s



Ans. (*c*) $Q = A_1 v_1 = A_2 v_2$ or $\frac{\pi}{4} d_1^2 \times 1.5 = \frac{\pi}{4} d_2^2 \times v_2$,

or $v_2 = 1.5\left(\frac{d_1}{d_2}\right)^2 = 1.5 \times \left(\frac{100}{25}\right)^2 = 1.5 \times 16 = 24$ m/s.

Q.107. The pipe cross-sections and fluid flow rates are shown in the given figure. The velocity in the pipe labelled as is



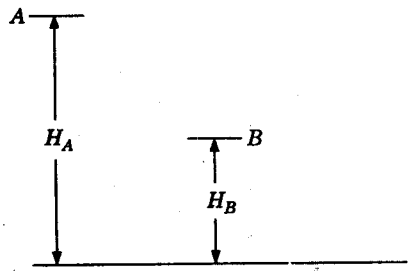
(*a*) 1.5 m/s (*b*) 3 m/s (*c*) 15 m/s (*d*) 30 m/s

Ans. (*a*) $Q = av$ or $6 \times 1000 = 40 \times v$, and $v = 150$ cm/s = 1.5 m/s

Q.108. Point *A* of head 'H_A' is at a higher elevation than point B of head 'H_B'. The head loss between these points is H_L. The flow will take place

(*a*) always from *A* to *B* (*b*) from *A* to *B* if $H_A + H_L = H_B$

(*c*) from *B* to *A* if $H_A + H_L = H_B$ (*d*) from *B* to *A* if $H_B + H_L = H_A$



Ans. (*c*) *A* is at higher level than *B*. If pressure at *B* is H_L more than H_A, then water will flow from *B* to *A*.

Q.109. Consider the following statements regarding a hydraulic jump :

1. There occurs a transformation of supercritical flow to sub-critical flow.
2. The flow is uniform and pressure distribution is due to hydrostatic force before and after the jump.
3. There occurs a loss of energy due to eddy formation and turbulence.

Which of these statements are correct ?

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

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

Q.110. Match List-I (Pipe flow) with List-II (Types of acceleration) and select the correct answer using the codes given below the lists :

List-I	*List-II*
A. Flow at constant rate passing through a bend	1. zero acceleration
B. Flow at constant rate passing through a straight uniform diameter pipe	2. Local and convective acceleration
C. Gradually changing flow through a bend	3. Convective acceleration
D. Gradually changing flow through a straight pipe	4. Local acceleration

Codes :

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

Ans. (*a*)

Q.111. The value of friction factor is misjudged by +25% in using Darcy-Weisbach equation. The resulting error in the discharge will be

(*a*) +25% (*b*) −18.25% (*c*) −12.5% (*d*) +12.5%

Ans. (*c*) As per Darcy – Weisbach equation $h_f = \frac{4fl}{2gd} \cdot \frac{16Q^2}{\pi^2 d^4}$ *i.e.* $Q \propto \sqrt{\frac{l}{f}}$

If f is misjudged by +25%, new Q will be proportional to $\sqrt{\frac{1}{1.25}}$, *i.e.* 89%

i.e. it is reduced by about 11%.

Q.112. For turbulent boundary layer flow, the thickness of laminar sublayer 'δ' is given by

(*a*) $\frac{\upsilon}{u^*}$ (*b*) $\frac{5\upsilon}{u^*}$ (*c*) $575 \log \frac{\upsilon}{u^*}$ (*d*) $2300 \frac{\upsilon}{u^*}$

Ans. (*b*)

Q.113. The correct sequence in ascending order of the magnitude of the given parameters is :

(*a*) Boundary layer thickness, momentum thickness, displacement thickness

(*b*) Displacement thickness, boundary layer thickness, momentum thickness

(*c*) Momentum thickness, displacement thickness, boundary layer thickness

(*d*) Momentum thickness, boundary layer thickness, displacement thickness

Ans. (*c*)

Q.114. Consider the following statements :

1. The cause of stalling of an aerofoil is the boundary layer separation and formation of increased zone of wake.
2. An aerofoil should have a rounded nose in supersonic flow to prevent formation of new shock.
3. When an aerofoil operates at an angle of incidence greater than that of stalling, the lift decreases and drag increases.
4. A rough ball when at certain speeds can attain longer range due to reduction of lift as the roughness induces early separation.

Which of these statements are correct ?

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

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

Q.115. A parachutist has a mass of 90 kg and a projected frontal area of 0.30 m^2 in free fall. The drag coefficient based on frontal area is found to be 0.75. If the air density is 1.28 kg/m^3, the terminal velocity of the parachutist will be

(*a*) 104.4 m/s (*b*) 78.3 m/s (*c*) 25 m/s (*d*) 18.5 m/s

Ans. (*b*) Weight of parachutist = $C_d \times \frac{1}{2}\rho V^2 A$, or $90\times 9.81 = 0.75\times\frac{1}{2}\times 1.28\times V^2\times 0.3$

or $$V = \sqrt{\frac{90\times 9.81\times 2}{0.75\times 0.3\times 1.28}} = \sqrt{6131.25} = 78.3 \text{ m/s}.$$

Q.116. If the number of fundamental dimensions equals 'm', then the repeating variables shall be equal to
(*a*) m and none of the repeating variables shall represent the dependent variable
(*b*) m + 1 and one of the repeating variables shall represent the dependent variable
(*c*) m + 1 and none of the repeating variables shall represent the dependent variable
(*d*) m and one of the repeating variables shall represent the dependent variable

Ans. (*c*)

Q.117. A sphere is moving in water with a velocity of 1.6 m/s. Another sphere of twice the diameter is placed in a wind tunnel and tested with air which is 750 times less dense and 60 times less viscous than water. The velocity of air that will give dynamically similar conditions is
(*a*) 5 m/s (*b*) 10 m/s (*c*) 20 m/s (*d*) 40 m/s

Ans. (*b*) $$\frac{\rho_1 v_1 d_1}{\mu_1} = \frac{\rho_2 v_2 d_2}{\mu_2}, \quad \frac{v_2}{v_1} = \frac{\rho_1}{\rho_2}\times\frac{\mu_2}{\mu_1}\times\frac{d_1}{d_2} = 750\times\frac{1}{60}\times\frac{1}{2}$$

$$\therefore \quad v_2 = \frac{750}{120}\times 1.6 = 10 \text{ m/s}$$

Q.118. A ship model 1/60 scale with negligible friction is tested in a towing tank at a speed of 0.6 m/s. If a force of 0.5 kg is required to tow the model, the propulsive force required to tow the prototype ship will be
(*a*) 5 MN (*b*) 3 MN (*c*) 1 MN (*d*) 0.5 MN

Ans. (*c*) For dynamic sinularity, as per Froude law, $\left(\frac{V}{\sqrt{gL}}\right)_m = \left[\frac{V}{\sqrt{gL}}\right]_p$, $\therefore \frac{V_m}{V_p} = \sqrt{\frac{L_m}{L_p}} = \sqrt{60}$

Propulsive force of protoptype $F_p = F_m\left(\frac{V_m}{V_p}\right)^2\times\left(\frac{L_m}{L_p}\right)^2 = F_m\left(\sqrt{\frac{L_m}{L_p}}\right)^2\times\left(\frac{L_m}{L_p}\right)^2$

$$= 0.5\times 10(60)\times 60^2 = 1080000 \text{ N} \cong 1 \text{ MN}.$$

Q.119. A 1 : 256 scale model of a reservoir is drained in 4 minutes by opening the sluice gate. The time required to empty the prototype will be
(*a*) 128 min. (*b*) 64 min. (*c*) 32 min. (*d*) 25.4 min.

Ans. (*b*) $T = 4\times\sqrt{256} = 4\times 16 = 64$ min.

Q.120. Air at 2 bar and 60°C enters a constant area pipe of 60 mm diameter with a velocity of 40 m/s. During the flow through the pipe, heat is added to the air stream. Frictional effects are negligible and the values of C_p and C_v are that of standard air. The Mach number of the flow corresponding to the maximum entropy will be
(*a*) 0.845 (*b*) 1 (*c*) 0.1212 (*d*) 1.183

Ans. (c)

I.E.S. (Objective)

MECHANICAL ENGINEERING–1999

PAPER–II

Time Allowed : Two Hours *Maximum Marks : 200*

Instructions : See Paper-I, 1999.

Q.1. Consider the following statements :
The strength of the fibre reinforced plastic product
1. depends upon the strength of the fibre alone
2. depends upon the fibre and plastic
3. is isotropic
4. is anisotropic

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

Ans. (*b*) Fibre Reinforced plastics are composite materials possessing additional and/or superior properties to individual components.

Q.2. Match List-I (Crystal structure) with List-II (Atomic packing factor) and select the correct answer using the codes given below the Lists :

List-I	*List-II*
A. Simple cubic	1. 94%
B. Body-centered cubic	2. 74%
C. Face-centered cubic	3. 52%
D. Hexagonal close packed	4. 68%

Codes :

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

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

Ans. (*a*) Maximum packing of atoms is in hexagonal closed packed arrangement followed by face-centred cubic, body-centered cubic, and least in simple cubic.

Q.3. Consider the following pairs of plastics and their distinct characteristics :
1. Acrylics ... Very good transparency to light
2. Polycarbonate ... Poor impact resistance
3. PTFE ... Low coefficient of friction.
4. Polypropylene ... Excellent fatigue strength

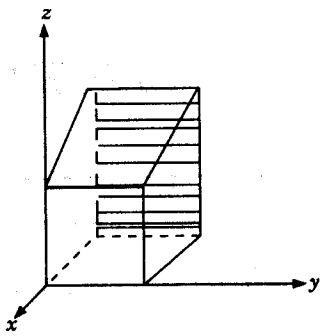
Which of these pairs are correctly matched ?
(*a*) 2 and 3 (*b*) 1 and 3 (*c*) 1 and 4 (*d*) 2 and 4

Ans. (*c*) PTFE is used for high temperature applications. Polycarbon has good impact resistance.

Q.4. Gibb's phase rule is given by
(F = number of degrees of freedom.
C = number of components.
P = number of phases)
(*a*) $F = C + P$
(*b*) $F = C + P - 2$
(*c*) $F = C - P - 2$
(*d*) $F = C - P + 2$

Ans. (*d*) $F = C - P + 2$

Q.5. The set of Miller indices of the plane shown in the given figure is



(*a*) $(\bar{1}\ 0\ 0)$

(*b*) (1 0 0)

(*c*) (1 0 1)

(*d*) (1 1 0)

Ans. (*d*) Intercepts on *x*, *y* and *z* axes are – 1, ∞, ∞. Their reciprocals are $\bar{1}$, 0, 0.

Q.6. Match List-I with List-II and select the correct answer using the codes given below the Lists :

List-I *(Materials)*	***List-II*** *(Applications)*
A. Tungsten carbide	1. Abrasive wheels
B. Silicon nitride	2. Heating elements
C. Aluminium oxide	3. Pipes for conveying liquid metals
D. Silicon carbide	4. Drawing dies

Codes :

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

Ans. (*d*) WC is used for drawing dies, silicone nitride for pipes to carry liquid metal, Al_2O_3 for abrasive wheels, and silicon carbide for heating elements.

Q.7. Heating the hypoeutectoid steels to 30°C above the upper critical temperature line, soaking at that temperature and then cooling slowly to room temperature to form a pearlite and ferrite structure, is known as

(*a*) hardening (*b*) normalising (*c*) tempering (*d*) annealing

Ans. (*d*) The process described is annealing.

Q.8. In a eutectic system, two elements are completely

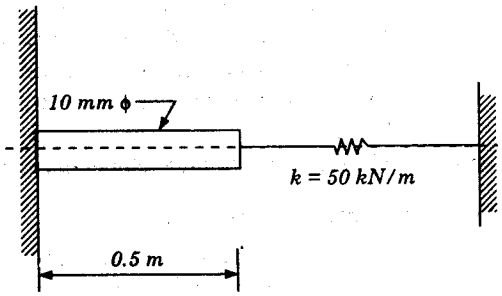
(*a*) insoluble in solid and liquid states (*b*) soluble in liquid state

(*c*) soluble in solid state (*d*) insoluble in liquid state

Ans. (*b*) In eutectic system, two elements are completely soluble in liquid state.

Q.9. $\alpha = 12.5 \times 10^{-6}/°C$, $E = 200$ GPa

If the rod fitted snugly between the supports as shown in the figure, is heated, the stress induced in it due to 20°C rise in temperature will be



(*a*) 0.07945 MPa

(*b*) –0.07945 MPa

(*c*) –0.03972 MPa

(*d*) 0.03972 MPa

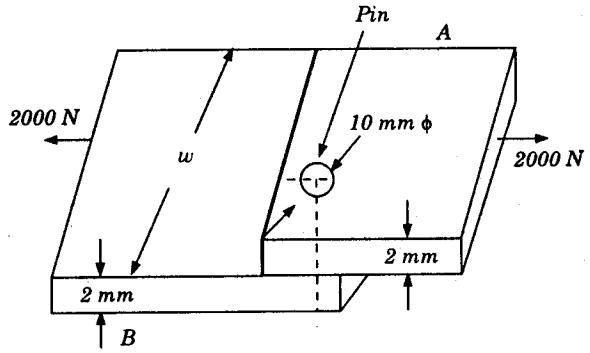
Ans. (*a*) Expansion of rod

$= l \alpha \Delta t = 0.5 \times 12.5 \times 10^{-6} \times 20 = 0.125 \times 10^{-3}$ m

Force will be induced due to spring and same $= 0.125 \times 10^{-3} \times 50 \times 10^3$ N = 6.25 N

$$\text{Stress} = \frac{F}{A} = \frac{6.25}{(\pi/4) \times 0.01^2} = 0.07945 \text{ MPa}$$

Q.10.



If permissible stress in plates of joint through a pin as shown in the given figure is 200 *MPa*, then the width *w* will be

(*a*) 15 mm (*b*) 18 mm (*c*) 20 mm (*d*) 25 mm

Ans. (*a*) $(w - 10)\, 2 \times 10^{-6} \times 200 \times 10^{6} = 2000$ N ; or $w - 10 = 5$, and $w = 15$ mm.

Q.11. Circumferential stress in a cylindrical steel boiler shell under internal pressure is 80 *MPa*. Young's modulus of elasticity and Poisson's ratio are respectively 2×10^{5} *MPa* and 0.28.

The magnitude of circumferential strain in the boiler shell will be

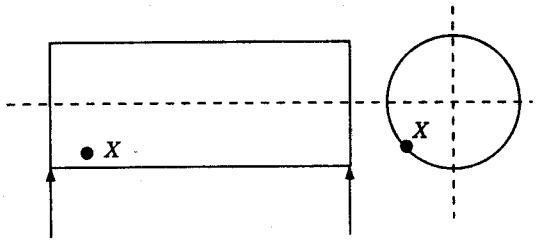
(*a*) 3.44×10^{-4} (*b*) 3.84×10^{-4} (*c*) 4×10^{-4} (*d*) 4.56×10^{-4}

Ans. (*a*) Circumferential strain $= \frac{1}{E}\left(s_1 - \frac{1}{m}s_2\right)$

Since circumferential stress $s_1 = 80$ MPa, longitudinal stress $s_2 = 40$ MPa

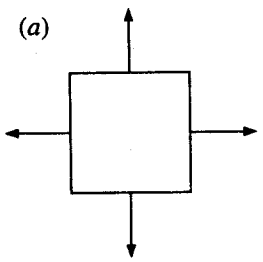
$$\therefore \text{Circumferential strain} = \frac{1}{2\times10^{5}\times10^{6}}[80 - 0.28\times40]\,10^{6} = \frac{68.8}{20}\times10^{-4} = 3.44\times10^{-4}$$

Q.12. A thin cylinder with closed lids is subjected to internal pressure and supported at the ends as shown in Figure

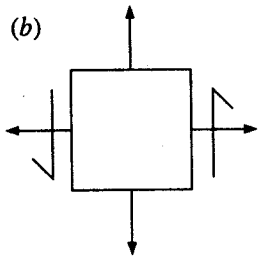


The state of stress at point X is as represented in

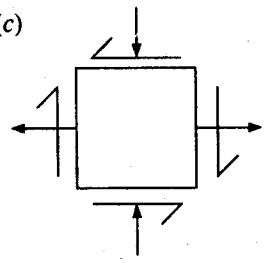
(*a*)



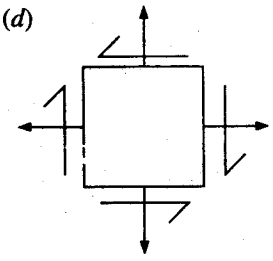
(*b*)



(*c*)



(*d*)



Ans. (*a*) Point '*X*' is subjected to circumferential and longitudinal stress, *i.e.* tension on all faces, but there is no shear stress because vessel is supported freely outside.

Q.13. The number of elastic constants for a completely anisotropic elastic material which follows Hooke's law is

(*a*) 3 (*b*) 4 (*c*) 21 (*d*) 25

Ans. (*a*) The three elastic constants for anisotropic material following Hooke's law are

Young's modulus, elastic limit stress and yield stress.

Q.14. The bending moment equation, as a function of distance x measured from the left end, for a simply supported beam of span L *m* carrying a uniformly distributed load of intensity w *N/m* will be given by

(*a*) $M = \frac{wL}{2}(L-x) - \frac{w}{2}(L-x)^2$ N-m (*b*) $M = \frac{wL}{2}x - \frac{wx^2}{2}$ - N-m

(*c*) $M = \frac{wL}{2}(L-x)^2 - \frac{w}{2}(L-x)^3$ N-m (*d*) $M = \frac{wx^2}{2} - \frac{wLx}{2}$ N-m

Ans. (*b*) $M = \frac{wL}{2} \quad x - \frac{wx^2}{2}$ Nm

Q.15. The bending moment diagram shown in Figure-I corresponds to the shear force diagram in

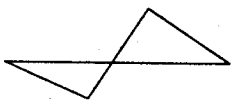
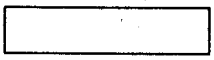
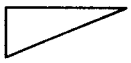
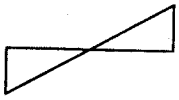


Figure-I

(*a*) (*b*)  (*c*)  (*d*) 

Ans. (*b*) If shear force is zero, B.M. will also be zero. If shear force varies linearly with length, B.M. diagram will be curved line.

Q.16. Two beams of equal cross-sectional area are subjected to equal bending moment. If one beam has square cross-section and the other has circular section, then

(*a*) both beams will be equally strong (*b*) circular section beam will be stronger

(*c*) square section beam will be stronger

(*d*) the strength of the beam will depend on the nature of loading

Ans. (*b*) If D is diameter of circle and '*a*' the side of square section, $\frac{\pi}{4}d^2 = a^2$ or $d = \sqrt{\frac{4}{\pi}}a$

Z for circular section $= \frac{\pi d^3}{32} = \frac{\pi}{32}\frac{4}{\pi}a^2 = \frac{a^2}{8}$; and Z for square section $= \frac{a^3}{6}$

Q.17. A cantilever beam of rectangular cross-section is subjected to a load W at its free end. If the depth of the beam is doubled and the load is halved, the deflection of the free end as compared to original deflection will be

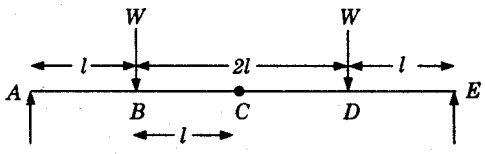
(*a*) half (*b*) one-eighth (*c*) one-sixteenth (*d*) double

Ans. (*c*) Since Z for square section is more, it is stronger.

Deflection in cantilever $= \frac{Wl^3}{3EI} = \frac{Wl^3 \times 12}{3E\ a\ h^3} = \frac{4Wl^3}{Eah^3}$

If h is doubled, and W is halved, New deflection $= \frac{4Wl^3}{2Ea\ (2h)^3} = \frac{1}{16} \times \frac{4Wl^3}{Eah^3}$

Q.18.



Which one of the following portions of the loaded beam shown in the given figure is subjected to pure bending ?

(*a*) *AB* (*b*) *DE* (*c*) *AE* (*d*) *BD*

Ans. (*d*) Pure bending takes place in the section between two weights *W*.

Q.19. A solid circular shaft is subjected to pure torsion. The ratio of maximum shear to maximum normal stress at any point would be

(*a*) 1 : 1 (*b*) 1 : 2 (*c*) 2 : 1 (*d*) 2 : 3

Ans. (*b*) Shear stress $= \frac{16T}{\pi d^3}$ and normal stress $= \frac{32T}{\pi d^3}$

$\therefore$ Ratio of shear stress and normal stress = 1 : 2.

Q.20. A short column of external diameter *D* and internal diameter *d* carries an eccentric load *W*. The greatest eccentricity which the load can have without producing tension on the cross-section of the column would be

(*a*) $\frac{D+d}{8}$ (*b*) $\frac{D^2+d^2}{8d}$ (*c*) $\frac{D^2+d^2}{8D}$ (*d*) $\sqrt{\frac{D^2+d^2}{8}}$

Ans. (*b*)

Q.21. A bar of length *L* and of uniform cross-sectional area *A* and second moment of area *I* is subjected to a pull *P*. If Young's modulus of elasticity of the bar material is E, the expression for strain energy stored in the bar will be

(*a*) $\frac{P^2L}{2AE}$ (*b*) $\frac{PL^2}{2EI}$ (*c*) $\frac{PL^2}{AE}$ (*d*) $\frac{P^2L}{AE}$

Ans. (*a*) Strain energy $= \frac{1}{2} \times$ stress $\times$ strain $\times$ volume

$$= \frac{1}{2} \times \frac{P}{A} \times \frac{P}{A} \cdot \frac{L}{E} \times AL = \frac{PL^2}{2AE}$$

Q.22. If a thick cylindrical shell is subjected to internal pressure, then hoop stress, radial stress and longitudinal stress at a point in the thickness will be

(*a*) tensile, compressive and compressive respectively

(*b*) all compressive (*c*) all tensile

(*d*) tensile, compressive and tensile respectively

Ans. (*d*) Hoop stress – tensile, radial stress – compressive, and longitudinal stress – tensile.

Q.23. A thin cylinder with both ends closed is subjected to internal pressure *p*. The longitudinal stress at the surface has been calculated as σ_0. Maximum shear stress at the surface will be equal to

(*a*) $2\sigma_0$ (*b*) $1.5\sigma_0$ (*c*) σ_0 (*d*) $0.5\sigma_0$

Ans. (*d*) Longitudinal stress $= s_0$, hoop stress $= 2s_0$

Max. shear stress $= \frac{2\sigma_0 - \sigma_0}{2} = \frac{\sigma_0}{2}$.

Q.24. The maximum shear stress occurs on the outermost fibers of a circular shaft under torsion. In a close coiled helical spring, the maximum shear stress occurs on the

(*a*) outermost fibres (*b*) fibres at mean diameter
(*c*) innermost fibres (*d*) end coils

Ans. (*c*)

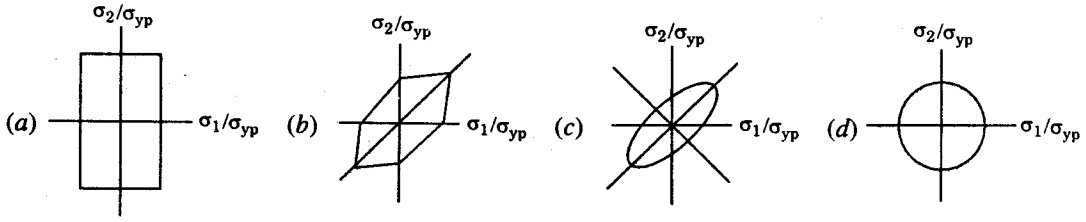
Q.25. A helical spring has N turns of coil of diameter D, and a second spring, made of same wire diameter and of same material, has $N/2$ turns of coil of diameter $2D$. If the stiffness of the first spring is k, then the stiffness of the second spring will be

(*a*) $k/4$ (*b*) $k/2$ (*c*) $2k$ (*d*) $4k$

Ans. (*a*) $$\text{Stiffness} = \frac{Cd^4}{64R^3N} = k$$

$$\text{For second spring, stiffness} = \frac{Cd^4}{64\,(2R)^3 \times \frac{N}{2}} = \frac{k}{4}$$

Q.26. Which one of the following figures represents the maximum shear stress theory or Tresea criterion ?



Ans. (*b*)

Q.27. Which one of the following sets of forces are encountered by a lathe parting tool while groove cutting?

(*a*) Tangential, radial and axial (*b*) Tangential and radial
(*c*) Tangential and axial (*d*) Radial and axial

Ans. (*a*)

Q.28. In a single-point turning operation of steel with a cemented carbide tool, Taylor's tool life exponent is 0.25. If the cutting speed is halved, the tool life will increase by

(*a*) two times (*b*) four times (*c*) eight times (*d*) sixteen times

Ans. (*d*) $VT_1^n = C$, $\frac{1}{2}VT_2^n = C$; $\left(\frac{T_2}{T_1}\right)^{0.25} = 2$, $\frac{T_2}{T_1} = 2^4 = 16$

Q.29. Consider the following approaches normally applied for the economic analysis of machining :

1. Maximum production rate 2. Maximum profit criterion 3. Minimum cost criterion

The correct sequence in ascending order of optimum cutting speed obtained by these approaches is

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

Ans. (*c*)

Q.30. Match List-I (ISO classification of carbide tools) with List-II (Applications) and select the correct answer using the codes given below the Lists :

List-I	*List-II*
A. *P*-10	1. Non-ferrous, roughing cut
B. *P*-50	2. Non-ferrous, finishing cut
C. *K*-10	3. Ferrous material, roughing cut
D. *K*-50	4. Ferrous material, finishing cut