Read the following instructions carefully.

1. All questions in this paper are of objective type.
2. There are a total of 65 questions carrying 100 marks.
3. Questions 1 to 25 will carry 1 mark each and questions 26 to 55 will carry 2 marks each.
4. Questions 48 to 51 (2 pairs) are common data questions and questions 52 to 55 (2 pairs) are linked answer questions. The answer to the second question of the linked answer questions depends on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is unattempted, then the answer to the second question in the pair will not be evaluated.
5. Questions 56 to 65 belong to General Aptitude (GA). Questions 56 to 60 will carry 1 mark each and questions 61 to 65 will carry 2 marks each.
6. Unattempted questions will carry zero marks.
7. Wrong answers will carry negative marks. For Q.1–Q.25 and Q.56–Q.60, $\frac{1}{3}$ mark will be deducted for each wrong answer. For Q.26–Q.51 and Q.61–Q.65, $\frac{2}{3}$ mark will be deducted for each wrong answer. The question pairs (Q.52, Q.53), and (Q.54, Q.55) are questions with linked answers. There will be negative marks only for wrong answer to the first question of the linked answer question pair *i.e.*, for Q.52 and Q.54, $\frac{2}{3}$ mark will be deducted for each wrong answer. There is no negative marking for Q.53 and Q.55.

(1 Mark Questions)

1. An aircraft with a larger wing as compared to smaller wing will have
   (a) more static stability (b) less static stability
   (c) same (d) None of these
2. If the centre of gravity of the aircraft moves forward, the static longitudinal stability of the aircraft will
   (a) always increase
   (b) sometimes increase
   (c) remain same
   (d) None of the above
3. A tail-less aircraft can be made stable by having its centre of gravity located
   (a) behind the aerodynamic centre of the wing
   (b) ahead of the aerodynamic centre of the wing
   (c) at the landing gear
   (d) None of the above
4. If tail area is increased while the elevator to tail area ratio is kept the same, then
   (a) both static stability and control power will increase
   (b) only static stability will increase
   (c) only control power will increase
   (d) neither stability nor control power changes
5. The term angle of attack is defined as the angle
   (a) between the wing chord line and the relative wing
   (b) between the airplane's climb angle and the horizon
   (c) between the longitudinal axis of the airplane and the chord of the wing
   (d) None of the above
6. Purpose of aircraft wing dihedral angle is to
   (a) increase lateral stability
   (b) increase longitudinal stability
   (c) increase lift coefficient of the wing
   (d) None of the above
7. Satellites used for telecommunication relay are kept in a geostationary orbit. A satellite is said to be in such an orbit when
   1. the orbit is geosynchronous.
   2. the orbit is circular.
   3. the orbit lies in the plane of the earth's equator.
   4. the orbit is at an altitude of 22236 km.

   Select the correct answer using the codes given below.
   (a) 1, 2 and 3 (b) 1, 3 and 4
   (c) 2 and 4 (d) 1, 2, 3 and 4
8. Load factor in gliding flight is always
   (a) > 1 (b) < 1
   (c) $= 1$ (d) None of these

9. For compressor, what is the relation between polytropic efficiency (η_p) and overall efficiency (η_o)?
(a) $\eta_p = \eta_o$ (b) $\eta_p > \eta_o$
(c) $\eta_p < \eta_o$ (d) None of these

10. For turbine, what is the relation between polytropic efficiency (η_p) and overall efficiency (η_o)?
(a) $\eta_p = \eta_o$ (b) $\eta_p > \eta_o$
(c) $\eta_p < \eta_o$ (d) None of these

11. If the vertical tail was inverted and put below the horizontal tail of an aircraft, then its contribution to $C_{l\beta}$ will be
(a) negative (b) positive
(c) zero (d) None of these

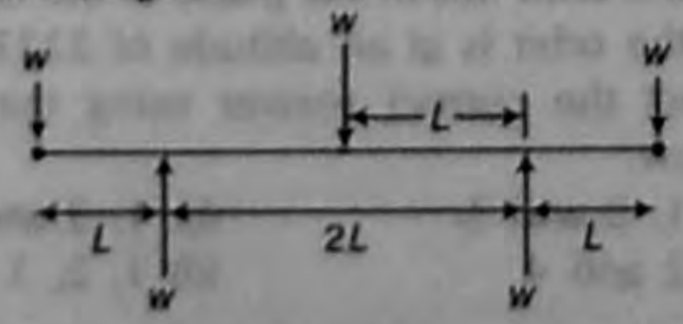
12. The state of plane stress at a point is described by $\sigma_X = \sigma_Y = \sigma$ and $\tau_{XY} = 0$. The normal stress on the plane inclines at 45° to the *X*-plane will be
(a) σ (b) $\sqrt{2\sigma}$
(c) $\sqrt{3\sigma}$ (d) 2σ

13. 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

14. The Euler's crippling load for a 2 m long slender steel rod of uniform cross-section hinged at both the ends is 1 kN. The Euler's crippling load for a 1m long steel rod of the same cross-section and hinged at both ends will be
(a) 0.25 kN (b) 0.5 kN
(c) 2 kN (d) 4 kN

15. The state of plane stress in a plate 100 mm thickness is given as
$\sigma_{XX} = 100$ N/mm^2, $\sigma_{YY} = 200$ N/mm^2
Young's modulus = 300 N/mm^2
Poisson's ratio = 0.3
The stress developed in the direction of thickness is
(a) zero (b) 90 N/mm^2
(c) 100 N/mm^2 (d) 200 N/mm^2

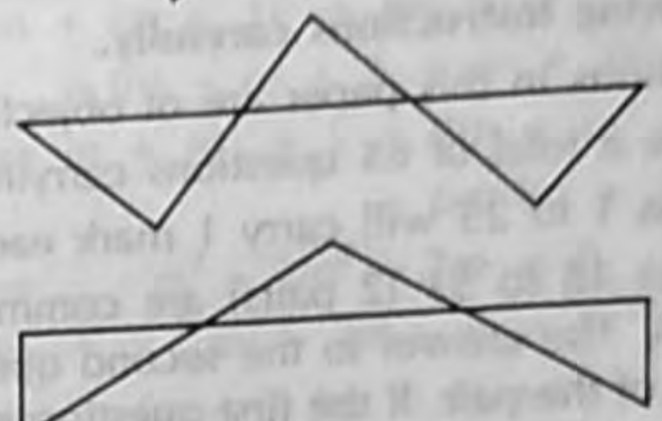
16. A loaded beam is shown in the figure. The bending moment diagram of the beam is best represented as



(a)

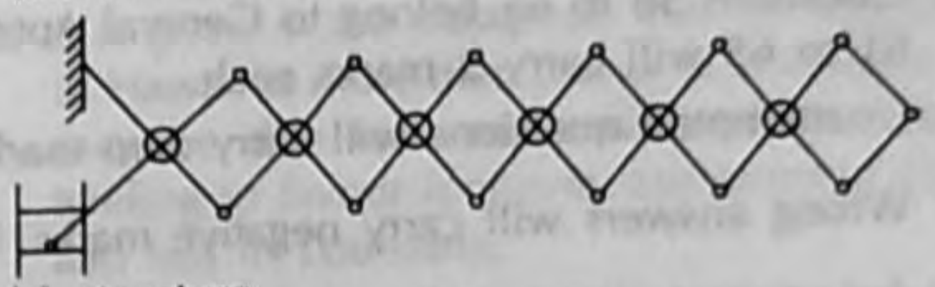
(b)

(c)



(d)

17. The kinematic chain shown in the figure is a



(a) structure
(b) mechanism with one degree of freedom
(c) mechanism with two degrees of freedom
(d) mechanism with more than two degrees of freedom

18. 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 collors 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) $w_1 + w_2 =$ constant
(c) $\frac{w_1}{A_1 E_1} = \frac{w_2}{A_2 E_2}$ (d) $\frac{w_1}{A_1 E_2} = \frac{w_2}{A_2 E_1}$

19. The ratio of pressures between two points *A* and *B* located respectively at depths 0.5 cm and 2 cm below a constant level of water in a tank is
(a) 1: $\sqrt{2}$ (b) 1 : 2
(c) 1 : 4 (d) 1 : 16

20. A ship with hull length of 100 m is to run with a speed of 10 m/s. For dynamic similarity, the velocity for a 1 : 2 model of the ship in a towing tank should be
(a) 2 m/s (b) 10 m/s
(c) 20 m/s (d) 25 m/s

21. Match List I (names) with List II (figures) and select the correct answer using the codes given below the lists.

List I
A. Subsonic nozzle
B. Supersonic nozzle
C. Subsonic diffuser
D. Centrifugal diffuser

List II

1.

2.

3.

4.

Codes

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

22. According to Blasius law, the local skin friction coefficient in the boundary layer over a flat plate is given by

(a) $\frac{0.332}{\sqrt{Re}}$ (b) $\frac{0.664}{\sqrt{Re}}$

(c) $\frac{0.647}{\sqrt{Re}}$ (d) $\frac{1.328}{\sqrt{Re}}$

23. Determine the row rank of $A = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 3 & 1 \\ 1 & 1 & 2 \end{bmatrix}$.

(a) 1 (b) 2

(c) 3 (d) 4

24. Determine the solution of the differential equation

$$y''' - 2y'' + y' = 0$$

(a) $c_1 e^x + c_2 xe^x$ (b) $c_1 xe^x$

(c) $c_1 + c_2 e^x + c_3 xe^x$ (d) None of these

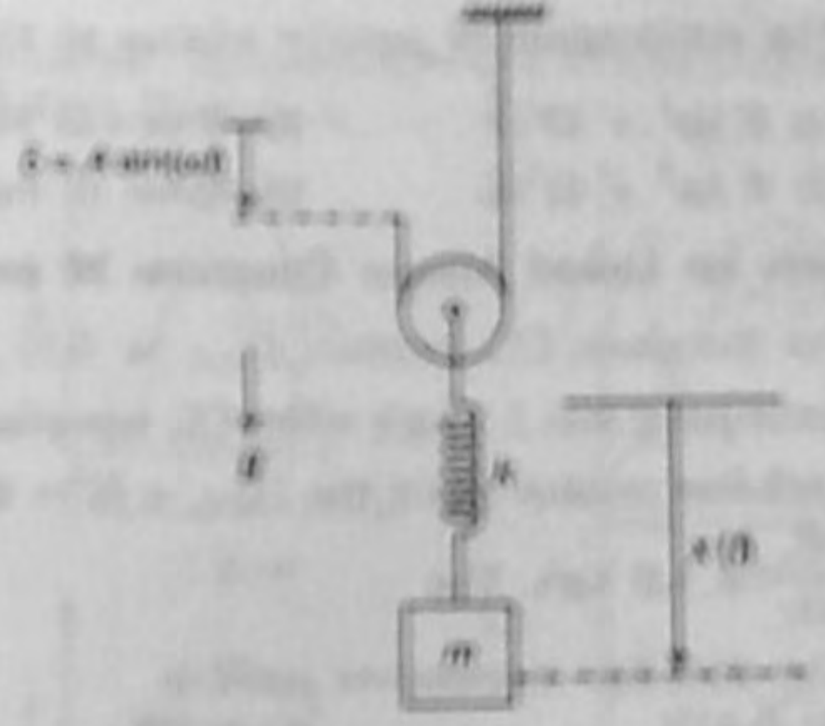
25. Particular solution of $y'' - 4y = 2e^x$ is

(a) $\frac{-2}{3}e^x$ (b) $\frac{-3}{2}e^x$

(c) $\frac{2}{3}e^x$ (d) $\frac{3}{2}e^x$

Statements for Linked Answer Questions 26 and 27

The spring-mass system shown is forced by moving the free end of the cable vertically according to $\delta(t) = A \sin \omega t$ as shown in the figure. Assuming the cable is massless and inextensible and the pulley is massless.



26. Its steady state solution is

(a) $\frac{A}{2\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]} \sin \omega t$ (b) $x = \frac{mg}{k}$

(c) $x = \frac{mg}{k}$ (d) $\frac{mg}{k}$

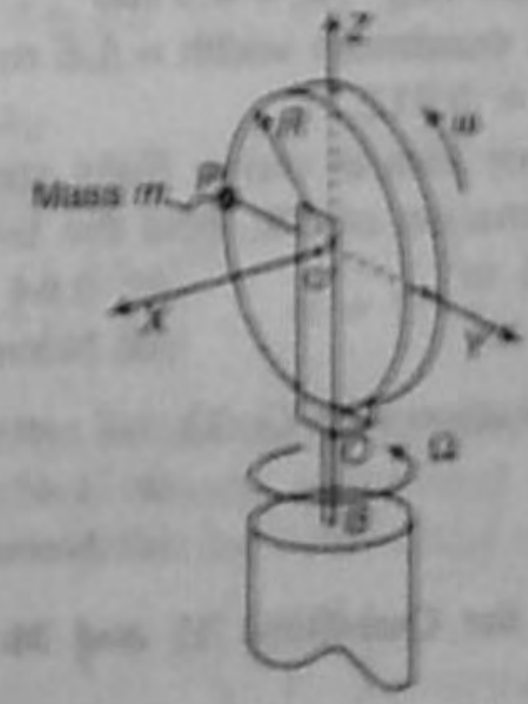
27. Calculate the smallest frequency ω at which the pulley just losses contact with the cable at any stage of its motion.

(a) $\sqrt{\frac{2g/A}{1 + 2g/(A\omega_n^2)}}$ (b) $\frac{2g/A}{1 + 2g/(A\omega_n^2)}$

(c) $\sqrt{\frac{2g/A}{1 - 2g/(A\omega_n^2)}}$ (d) None of these

Common Data for Questions 28 and 29

A particle P of mass m is attached to the edge of the disk of radius R as shown. The disk spins about its centreline with constant speed ω relative to the shaft OB. The shaft rotates with constant angular speed Ω. For the instant when the disk lies in the Y-Z plane and the particle is on the Y-axis.



28. The velocity of particle relative to XYZ is

(a) $-R(\omega\hat{k} + \Omega\hat{i})$ (b) $-R(\omega\hat{k} - \Omega\hat{i})$

(c) $+R(\omega\hat{k} - \Omega\hat{i})$ (d) None of these

29. The acceleration of particle relative to XYZ is

(a) $R(\omega^2 + \Omega^2)\vec{j}$ (b) $R(\vec{\omega} + \Omega^2)\vec{k}$

(b) $R(\omega^2 + \Omega^2)\vec{i}$ (d) None of these

Statements for Linked Answer Questions 30 and 31

For the given CG location $(\bar{x}_{CG} = 0.3)$, the stick force per g was 2.5 kg/g when CG was placed at the stick-free neutral point the $(\bar{x}_{CG} = N' = 0.3714)$ $\frac{dF_s}{dn} \geq 1.0$ kg/s. The

30. The stick-free manoeuvre point is

(a) 0.419 (b) 0.205

(c) 0.325 (d) None of these

31. In continuation with the previous Q. 30, what will be the usable CG limits if the stick force per g was to be within 1.5 and 3.5 kg/g?

(a) 0.2524 and 0.3476 (b) 0.1512 and 0.6852

(c) 1.326 and 1.562 (d) None of these

32. What is the most forward CG location permissible? Given, $\delta_{emax'}$ $\delta_{e0'}$ $C_{Lmax'}$ $C_{m\delta'}$ N_0

(a) $N_0 + (\delta_{e_0} - \delta_e)\frac{C_{m_\delta}}{C_{L\max}}$

(b) $[N_0 - (\delta_{e_0} - \delta_e)]\frac{C_{m_\delta}}{C_{L\max}}$

(c) $N_0 - (\delta_{e_0} - \delta_e)\frac{C_{m_\delta}}{C_{L\max}}$

(d) None of the above

Common Data for Questions 33 and 34

Given: $w/s = 500$ kg/m^2; $s = 50$ m^2; cruise $v = 150$ m/s; AR = 5, $\rho = 0.8$ kg/m^3, $i_\omega = 1°$, $\alpha_0 = -4°$, $C_{m,CG} = -0.03$; $\bar{x}_{CG} = 0.35$, wing airfoil $C_{L\alpha} = 0.085$ deg^{-1}; $a_t = 4.5$ rad^{-1}; $i_t = 10$ m; $\eta_t = 0.9$ Fuselage: maximum width = 1.6 m; length = 15 m; factor $K_f = 0.012$.

33. To achieve trim at cruise flight speed end to have stability margin of 8%, find the tail area.

(a) 0.396 m^2 (b) 0.64 m^2

(c) 0.59 m^2 (d) None of these

34. In continuation with Q. 33, tail setting (i_t) is required

(a) 5.2° (b) 3.4°

(c) 2.1° (d) None of these

Common Data for Questions 35 and 36

For earth

$\mu = 398600.4$ km^3/s^2

$r_e = 6378.14$ km,

1 nautical mile = 1.852 kg

150ϕ nautical mile = 277.8 km

35. Find the velocity of space shuttle orbit in a 150 nautical mile high circular orbit.

(a) 7.738 km/s (b) 5.738 km/s

(c) 10.733 km/s (d) None of these

36. In continuation with Q. 35, what is the time period of space shuttle?

(a) 90 min (b) 95 min

(c) 85 min (d) None of these

37. Match the following regimes.

A. Incompressible	1. $M < 0.3$
B. Compressible (subsonic)	2. $0.7 < M < 1.3$
C. Trisonic	3. $M > 4$
D. Supersonic	4. $0.3 < M < 0.9$
E. Hypersonic	5. $1.3 < M < 4.0$

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

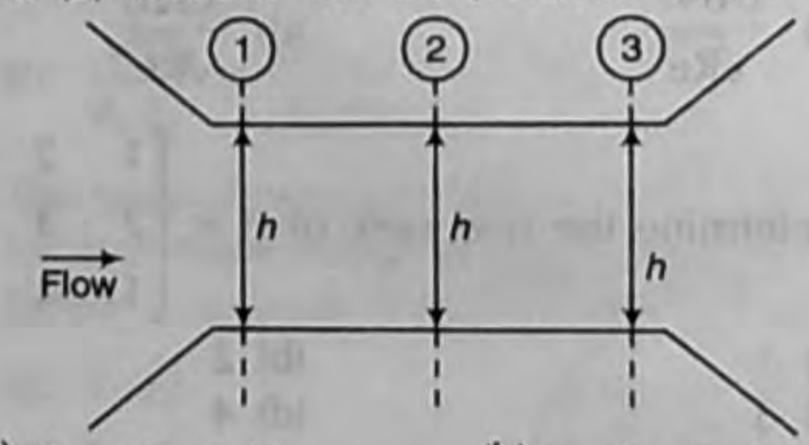
(d) None of the above

38. Root-mean-square fluctuation of velocity is measured to be 0.5, while value of free stream velocity is 10 m/s. What is turbulence level?

(a) 0.05% (b) 0.5%

(c) 5% (d) None of these

39. In real situation, for given figure, velocities at (1), (2) and (3) sections will be (consider subsonic flow)



(a) $v_1 = v_2 = v_3$ (b) $v_1 > v_2 > v_3$

(c) $v_1 < v_2 < v_3$ (d) Cannot be determined

40. In a constant area section, across fan

(a) velocity increases and static pressure increases

(b) velocity constant and static pressure constant

(c) velocity constant and static pressure increases

(d) None of the above

41. **Assertion (A)** In convergent-divergent nozzle, once sonic conditions are established at the throat, any amount of reduction of pressure at the exit will not be effective in increasing the flow rate.

Reason (R) The reduction of upstream pressure is caused by the depletion of the reservoir compensates for the acceleration of flow due to lowering of back pressure.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R in not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

42. The specific speed of a centrifugal compressor is generally
(a) higher than that of an axial compressor
(b) less than that of a reciprocating compressor
(c) independent of the type of compressor but depends only on the size of the compressor
(d) more than the specific speed of the reciprocating compressor but less than that of axial compressor

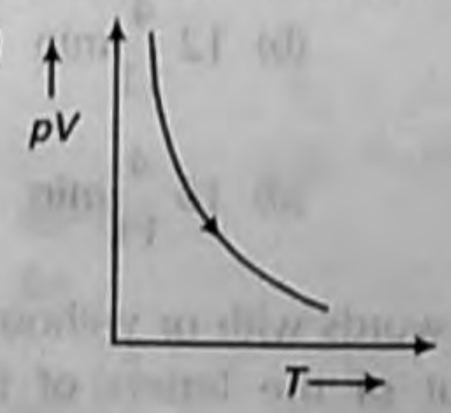
43. Consider the following statements:
1. Almost all flow losses take place in the divergent part of a nozzle.
2. Normal shocks are likely to occur in the convergent part of a nozzle.
3. Efficiency of reaction turbines is higher than that of impulse turbine.

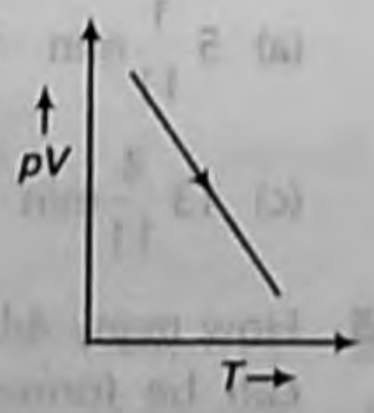
Of these statements,
(a) 1, 2 and 3 are correct
(b) 2 and 3 are correct
(c) 1 and 2 are correct
(d) 1 and 3 are correct

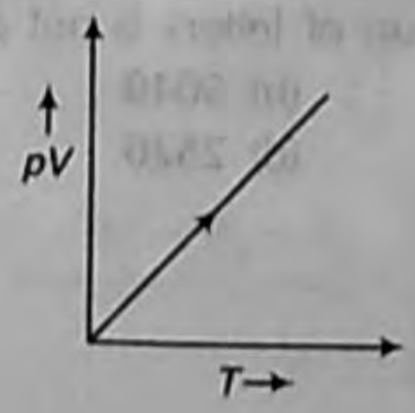
44. An air breathing aircraft flying at an altitude where the air density is half the value at ground level. With reference to the ground level, the air fuel ratio at this altitude will be

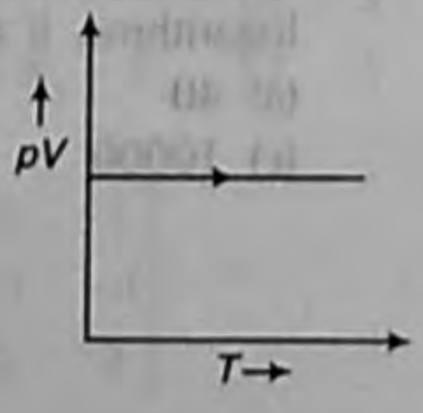
(a) $\sqrt[3]{2}$ (b) $\sqrt{2}$
(c) 2 (d) 4

45. Which one of the following *pV-T* diagrams correctly represents the ideal gas?

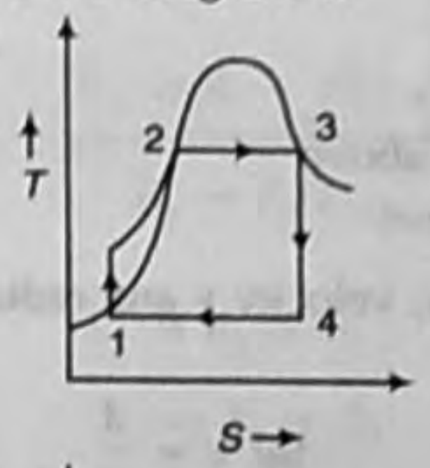
(a)


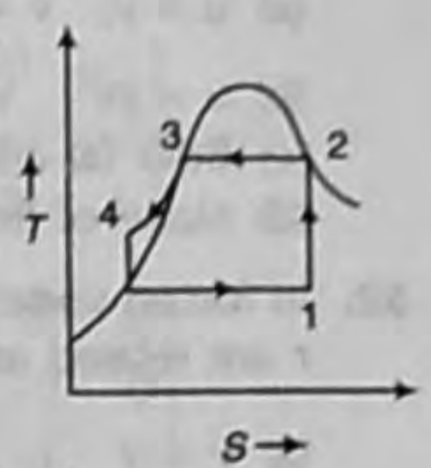
(b)


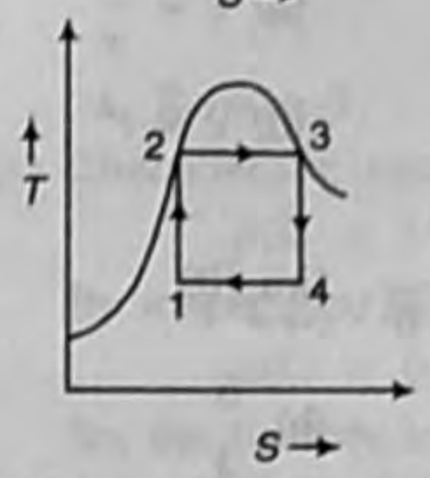
(c)


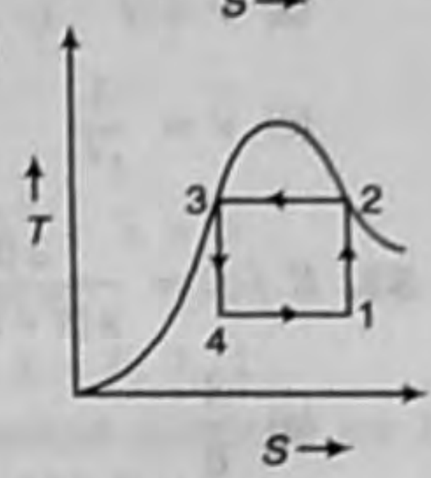
(d)


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

(a)


(b)


(c)


(d)


47. Air (C_p = 1 kJ/kg, γ = 1.4) enters a compressor at a temperature of 27°C. The compressor pressure ratio is 4. Assuming an efficiency of 80%, the compressor work required in kJ/kg is
(a) 160 (b) 172
(c) 182 (d) 225

48. If u and v are the components of velocity in the X and Y directions of a flow given by

$$u = ax + by; \quad v = cx + dy$$

Then the condition to be satisfied is
(a) $a + c = 0$
(b) $b + d = 0$
(c) $a + b + c + d = 0$
(d) $a + d = 0$

49. A Newtonian fluid is that for which

(a) $\tau = \mu\left(\frac{\partial u}{\partial y}\right)^n, \quad m \neq 1$

(b) $\tau = \tau\theta - \alpha\frac{\partial u}{\partial y}$

(c) $\tau = \mu\frac{\partial u}{\partial y}$

(d) $\tau_C = \tau + \mu\left(\frac{\partial u}{\partial y}\right)^m, \quad m \neq 1$

50. The velocity potential ϕ at any point for a two-dimensional steady irrotational flow in polar coordinates is given by (with usual notations)

$$\phi = m\left(\frac{\cos\theta}{r}\right)$$

The equation represents a
(a) vortex (b) sink
(c) source (d) doublet

51. Which of the following flow is irrotational?

(a) $u = y; \quad v = \frac{3}{2}x$

(b) $u = xv^2; \quad v = x^2y$

(c) Both (a) and (b) above

(d) None of the above

52. In forced vortex flow, velocity v and radial distance r are related as

(a) $v \propto r$ (b) $v \propto \frac{1}{r}$

(c) $v \propto \frac{1}{r^2}$ (d) $v \propto r^2$

53. If $F(s) = \frac{2(s+3)}{s(s+2)(s+8)}$, $\lim_{t \to \infty} f(t)$

(a) $\frac{3}{8}$ (b) $\frac{8}{3}$

(c) 2 (d) Cannot be determined

54. Using trapezoidal rule compute the integral $\int_0^1 e^{x^2}\,dx$, where, the table for the values of $y = e^{x^2}$ is given below.

x	0.0	0.1	0.2	0.3	0.4
y	1.00000	1.01005	1.04081	1.09417	1.17357

0.5	0.6	0.7	0.8	0.9	1.0
1.28402	1.4332	1.63231	1.89648	2.2479	2.71828

(a) 1.27 (b) 1.47

(c) 2.27 (d) None of these

55. Given that $y_1 = \frac{1}{x}$, $x \geq 1$ is a solution of

$$x^2y'' + 4xy' + 2y = 0,$$

Another solution y_2 of this equation, such that the solutions y_1, y_2 for $x \geq 1$ are linearly independent, is

(a) $\frac{1}{x^2}$ (b) $\frac{1}{x}$

(c) x^2 (d) None of these

General Aptitude

Directions (Q. Nos. 56 to 58) Pick out the word with opposite meaning of underlined word.

56. Though his view is correct his behaviour was impertinent.

(a) healthy (b) respectful

(c) inadequate (d) smooth

57. The chairman rebuked the accounts officer.

(a) received (b) awarded

(c) invited (d) praised

58. The manager is quite tactful and handles the workers union very effectively.

(a) disciplined (b) naive

(c) strict (d) loose

Fill in the blanks

59. Mahesh ..... me coming to his table, he smiled and ..... me a chair.

(a) looked, gave (b) welcomed, took

(c) saw, offered (d) found, signaled

60. Satyam ..... another feather ..... his cap by his performance in one day match.

(a) created, by (b) took, in

(c) added, to (d) kept, in

61. It was Sunday on Jan 1, 2006. What was the day of the week Jan 1, 2010?

(a) Sunday (b) Saturday

(c) Friday (d) Wednesday

62. The calendar for the year 2007 will be the same for the year

(a) 2014 (b) 2016

(c) 2017 (d) 2018

63. How much does a watch looses everyday, if its hands coincide every 64 min?

(a) $32\frac{8}{11}$ min (b) $32\frac{11}{8}$ min

(c) $32\frac{9}{13}$ min (d) None of these

64. At what time, in minute, between 3 O'clock and 4 O'clock, both the needles will coincide each other?

(a) $5\frac{1}{11}$ min (b) $12\frac{4}{11}$ min

(c) $13\frac{4}{11}$ min (d) $16\frac{4}{11}$ min

65. How many 4-letter words with or without meaning can be formed out of the letters of the word, logarithms, if repetition of letters is not allowed?

(a) 40 (b) 5040

(c) 10000 (d) 2520