Mock Test 2

Number of Questions: 65 **Total Marks: 100**

Wrong answer for MCQ will result in negative marks, (-1/3) for 1 Mark Questions and (-2/3) for 2 Marks Question.

General Aptitude

Number of Questions: 10 **Section Marks: 15**

Questions 1 to 5 carry One Mark each.

Directions for question 1: Select the word most similar in meaning to the given word:

1. Risque
(A) Risky (B) Lascivious
(C) Queasy (D) Pompous

***Directions for questions 2 and 3*:** Select the correct alternative from the given choices.

2. In a certain code language, GOOGLE is coded as HNPFMD. How is the word APPLE coded in that language?
(A) BOGKE (B) BQOKF
(C) BOQKF (D) None of these

3. The numbers a, b, c, d and e form a geometric progression. Which of the following also form a geometric progression?
(i) a^2, b^2, c^2, d^2, e^2
(ii) $a-1, b+2, c-3, d+4, e-5$
(iii) $3a, 3b, 3c, 3d, 3e$
(A) Only (i) (B) Only (i) and (ii)
(C) Only (iii) and (i) (D) None of these

***Directions for question 4*:** Select the most suitable one word substitute for the following expression:

4. A place where everything is perfect
(A) Heaven (B) Cosmos
(C) Synagogue (D) Utopia

***Direction for question 5*:** Select the appropriate word/phrase out of the given options to complete the following sentence:

5. Neither the teacher nor the students _____ any clue as to who could have stolen the keys to the office treasury.
(A) was (B) has
(C) have (D) were

Questions 6 to 10 carry Two Marks each.

***Directions for question 6*:** Select the correct alternative from the given choices.

6. Consider a function $f(x) = 3 - |x|$, where $-2 \le x \le 2$. The minimum and maximum values of $f(x)$ are:
(A) 0, 2 (B) 0, –2
(C) 1, 3 (D) 0, –4

***Directions for question 7*:** In the following sentence certain parts are underlined and marked P, Q, and R. One of the parts may contain a certain error or may not be acceptable in standard written communication. Select the part containing the error. Choose D as your answer if there is no error.

7. There are no machineries (P) for resolving these disputes and this has, (Q) in no small measure, compounded the present situation. (R)
(A) P (B) Q
(C) R (D) No error

***Directions for question 8*:** Which one of the statements given below the passage is logically valid and can be inferred from the passage below?

8. Napoleon Bonaparte was one of the world's youngest generals. At the age of 24 he was master of the art of war, a military general and a cruel dictator at heart. He had the magnetism of the great and he won devoted friendship from many. His glance, like Akbar's, was magnetic. He often said that he had won many battles with his eyes, not the sword. A strange statement for a man who had plunged Europe into war. And it appears, during his last years when he was imprisoned at St. Helena, he had a change of heart. Good thoughts came to him during the fading years of life, his painful period of exile. He was much chastened, and perhaps wrote to influence posterity in his favour. He wrote that the conquest of the spirit is greater than the conquest of the sword.
(A) Napoleon Bonaparte was not the world's youngest general.
(B) Napoleon Bonaparte was not the world's youngest dictator.
(C) Napoleon Bonaparte believed that some day victories would be won without cannons and bayonets.
(D) Napoleon Bonaparte was thoroughly irreligious but he encouraged religion.

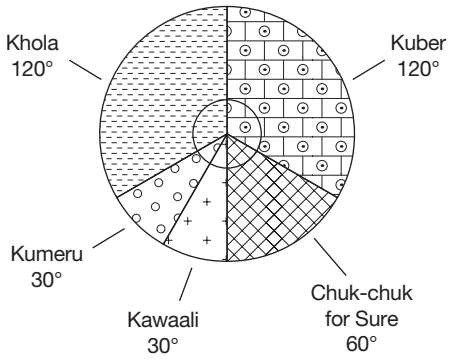
***Directions for questions 9 and 10*:** Select the correct the alternative from the given choices.

9. The chairman of a multinational corporation desires to appoint four of the five selected persons A, B, C, D and

E to lead the four different domains of the organization, which are Operations, Marketing, Finance and R&D. *C* doesn't want to get hitched to one specific domain as he desires to have an exposure to all the four domains.
B is given the designation of Operations head. Neither *D* nor *A* is posted as Marketing heads.
Which of the following can be a valid assignment of heads to the domains?

(A) *A* – Marketing, *B* – Operations, *C* – Finance, *D* – R&D
(B) *A* – Finance, *B* – Operations, *D* – R&D, *E* – Marketing
(C) *A* – Operations, *B* – Finance, *C* – R&D, *D* – Marketing
(D) None of these

10. The pie chart below gives the breakup of market share by volume of five different fleet management companies in the year 2015. The proportion of male to female customers of each company is 5 : 1. If the total number of customers of the five companies in 2015 is 216000. The Number of customers of Chuk-chuk for Sure are females is _____.



MECHANICAL ENGINEERING

Directions for questions 1 to 55: Select the correct alternative from the given choices.

Questions 1 to 25 carry One Mark each.

11. The third term in the Taylor's series expansion of the function $f(x) = 5x^2 + \cos x$ about $x = \pi$ is _____.

(A) 0 (B) $\frac{9}{2}(x-\pi)^2$
(C) $\frac{11}{2}(x-\pi)^2$ (D) $\frac{13}{6}(x-\pi)^3$

12. If *A* and *B* are two square matrices of same order such that $AB = A$, $BA = B$, then

(A) both *A* and *B* are idempotent
(B) both *A* and *B* are involutory
(C) *A* is idempotent and *B* is involutory
(D) *A* is involutory and *B* is idempotent

13. The value of the contour integral $\oint_C \left(\frac{z^2+5}{z^2+4}\right)dz$ where *C* is the circle $|z-i| = 2$ traversed in counter clockwise direction is _____.

14. The directional derivative of $f(x, y, z) = 4xz^3 - 3x^2yz^2$ at the point $P(2, -1, 2)$ in the direction of x -axis is _____.

(A) 80 (B) –48
(C) 48 (D) 144

15. The value of the definite integral $\int_0^\infty \frac{\left(e^{-3t} - e^{-2t}\right)}{t}dt$ is _____.

(A) $\ln\left(\frac{2}{3}\right)$ (B) $\ln\left(\frac{3}{2}\right)$
(C) $\frac{1}{2}\ln\left(\frac{2}{3}\right)$ (D) $\frac{1}{2}\ln\left(\frac{3}{2}\right)$

16. A rotating steel shaft is supported at the ends. It is subjected to a point load at the centre. The maximum bending stress developed is 80 MPa. If the yield, ultimate and corrected endurance strength of the material are 320 MPa, 450 MPa and 200 MPa respectively, then the factor of safety for the shaft is .

17. A hollow circular shaft of 60 mm outside diameter 40 mm inside diameter transmits a torque of 1500 N m. Value of maximum shear stress developed (in MPa) is.

18. A single degree of freedom system with viscous damping, having a natural frequency of vibration of 25 Hz, is excited by a harmonic force of frequency 30 Hz. The magnitude of phase angle (in degree) of displacement with respect to the exciting force is

(A) 0 (B) 90
(C) less than 90 (D) more than 90

19. A particle of mass 50 kg, travelling with a uniform velocity of 20 m/s, makes a perfectly inelastic collision with a stationary particle of mass 25 kg. The kinetic energy lost in the collision(in J) is

(A) 2222.22 J (B) 3333.33 J
(C) 4444.44 J (D) 6666.67 J

20. Consider the following statements.

(i) As per maximum distortion energy theory, failure occurs when the distortion energy per unit volume exceeds a critical value.
(ii) Intermediate principal stress is ignored when applying the maximum principal stress theory.
(iii) The maximum shear stress theory gives the most accurate results amongst all the failure theories.
(iv) As per maximum strain energy theory, failure occurs when the strain energy per unit volume exceeds a critical value.

The correct statements are
(A) (i), (ii), (iii) and (iv)
(B) (i), (ii) and (iv) only
(C) (i), (iii) and (iv) only
(D) (ii), (iii) and (iv) only

21. If there is no displacement of follower when the cam has turned through certain angle, then this angle turned by the cam is called
(A) Angle of dwell (B) Cam angle
(C) Pressure angle (D) Angle of return

22. Consider a long cylindrical tube of inner and outer radii, a and b, respectively, length L_0 and thermal conductivity k. Its inner and outer surface are maintained at temperatures T_i and T_0 respectively ($T_i > T_0$). Assuming one-dimensional steady state heat conduction in the radial direction, the thermal conductance in the wall of the tube is

(A) $\frac{1}{4\pi kL_0}\ell n\left(\frac{b}{a}\right)$ (B) $\frac{1}{2\pi kL_0}\ell n\left(\frac{b}{a}\right)$

(C) $\frac{2\pi kL_0}{\ell n\left(\frac{b}{a}\right)}$ (D) $2\pi kL_0\ell n\left(\frac{b}{a}\right)$

23. Which one of the following pairs of equations describes a reversible heat engine?

(A) $\oint \delta Q = 0, \oint \frac{dQ}{T} = 0$ (B) $\oint \delta Q < 0, \oint \frac{dQ}{T} = 0$

(C) $\oint \delta Q > 0, \oint \frac{\delta Q}{T} = 0$ (D) $\oint \delta Q > 0, \oint \frac{\delta Q}{T} < 0$

24. Consider a viscous flow through a pipe of circular cross section. Identify the correct statements
I. Flow is well mixed
II. Flow is laminar.
III. Reynolds number less than 2300.
IV. Reynolds number greater than 2300.
(A) I, II (B) II, IV
(C) II, III (D) I, IV

25. For a single stage impulse turbine with rotor diameter 1.8 m and speed 3000 rpm, nozzle angle is 18°. Optimum velocity of steam (in m/s) is
(A) 134.45 (B) 268.91
(C) 297.29 (D) 594.58

26. A source at a temperature of 750 K provides 1200 kJ of heat. The temperature of environment is 27°C. The maximum useful work (in kJ) that can be obtained from the heat source is .

27. Specific humidity of a sample of air was found to be 20 gm/kg of dry air. Values of dry bulb temperature, barometric pressure and saturation temperature of water were 30°C, 85 kPa and 4.24 kPa respectively. Relative humidity (in percentage) of the air is-

28. In ultrasonic machining process, the material removal rate will be higher if the material has
(A) Higher toughness
(B) Higher ductility
(C) Lower toughness
(D) Higher fracture strain

29. Actual sales of a product for different months are shown below.
April: 285
May: 245
June: 195
July: 235
Aug: 185
Forecast of the sales for the month September, based on 4 months moving average is-

30. In a straight turning operation using a single point cutting tool feed is 0.2 mm/ revolution and depth of cut is 0.5 mm. If the side cutting edge angle of the tool is 50°, the uncut chip thickness (in mm) is-

31. In PERT, the distributions of activity times is assumed to be
(A) Normal (B) Gamma
(C) Beta (D) Exponential

32. Match items in Group A to items in Group B
Group A (Casting defects)
P. Misrun
Q. Pinholes
R. Shrinkage cavity
S. Hot tear
Group B (Probable causes)
1. Restriction in shrinking freely
2. Improperly designed gates.
3. Presence of hydrogen in molten metal.
4. Improper design of riser.

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

33. Even though cutting tool is harder compared to the work material, it wears out during tool work interaction, because
(A) due to the action of coolant, extra hardness is imparted to the work piece.
(B) extra hardness is imparted to the work piece due to severe rate of strain.
(C) oxide layers formed on the surface imparts extra hardness to the work piece.
(D) vibration is induced in the cutting tool.

34. Match the ferrous materials (Group A) with carbon percentage (Group B)
Group A
P – Grey cast iron
Q – White cast iron

R – Malleable cast iron.
S – Pig iron
T – High carbon steel

Group B

(1) 3.00 to 4.00
(2) 2.50 to 3.75
(3) 2.20 to 3.60
(4) 1.75 to 2.30
(5) 0.60 to 1.50
(6) 0.30 to 0.60

(A) *P*-4, *Q*-2, *R*- 3, *S*-6, *T*-1
(B) *P*-2, *Q*-3, *R*-4, *S*-6, *T*-1
(C) *P*-3, *Q*-2, *R*-4, *S*-1, *T*-6
(D) *P*-2, *Q*-4, *R*-3, *S*-1, *T*-5

35. Cold shut in a metal casting is due to
(A) absorption of gases by the liquid metal
(B) improper fusion of two streams of the molten metal
(C) improper alignment of cope and drag
(D) very high pouring temperature of molten metal

Questions 26 to 55 carry Two Marks each.

36. If 1, 4 and 5 are the eigen values of 3×3 matrix A, then the matrix $A^2 - 5A + 6I_3$ has _____.
(A) three distinct eigen values
(B) two distinct eigen values
(C) all the three eigen values which are equal
(D) zero which is an eigen value.

37. The value of the double integral $\iint_R (4xy - y^2)dx\,dy$ where R is the region bounded by the lines $y = x$, $y = 2x$ and $x = 1$ in the first quadrant is _____

(A) $\frac{11}{12}$ (B) $\frac{14}{15}$
(C) $\frac{17}{18}$ (D) $\frac{20}{21}$

38. If a fair die is rolled thrice, then the expected value of the product of the numbers that appear on the die in the three rolls is _____.

(A) $\frac{7}{2}$ (B) $\frac{21}{2}$
(C) $\frac{343}{8}$ (D) $\frac{1}{2}$

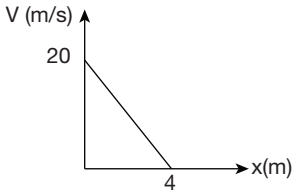
39. The maximum value of the function $f(x) = (x-1)^2 e^{-x}$ is _____.

40. The value of the definite integral $\int_1^4 \frac{1}{x^3} dx$ when evaluated by Simpson's Rule by taking 6 sub intervals is _____.

(A) 0.479 (B) 0.596
(C) 0.672 (D) 0.713

41. A slider-crank mechanism has a crank of radius 75 mm and a long connecting rod. The crank rotates at a constant angular speed of 20 rad/s in the counter clockwise direction. At an instant when the crank and connecting rod make an angle of 90°, the crank has rotated by an angle of 80° from the inner dead centre position. The speed (in m/s) of the slider is _____.

42.



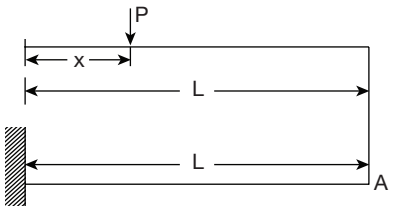
The velocity of a particle is $20\hat{i}\,(\text{m/s})$ when its position x is 0 and its velocity is zero when its position is $4\hat{i}\,(\text{m})$ and the velocity varies linearly with position as shown in figure. The acceleration of the particle, when its position is $x = 3\hat{i}\,(\text{m})$ is

(A) $+25\hat{i}\,(\text{m/s}^2)$ (B) $-75\hat{i}\,(\text{m/s}^2)$
(C) $-45\hat{i}\,(\text{m/s}^2)$ (D) $-25\hat{i}\,(\text{m/s}^2)$

43. A simply supported beam carries a vertical load P at its centre. The beam has a uniform rectangular cross section of width b and depth 2b. If the length of the beam is 50b, ratio of maximum shear stress to maximum bending stress is
(A) 0.05 (B) 0.03
(C) 0.02 (D) 0.01

44. A single degree of freedom spring mass system has a mass of 1 kg, spring of stiffness 100 N/m and a damping ratio (ξ) of 1.25. If the maximum velocity of the mass relative to the damper is 2 m/s, the magnitude of the maximum damping force (in N) is .

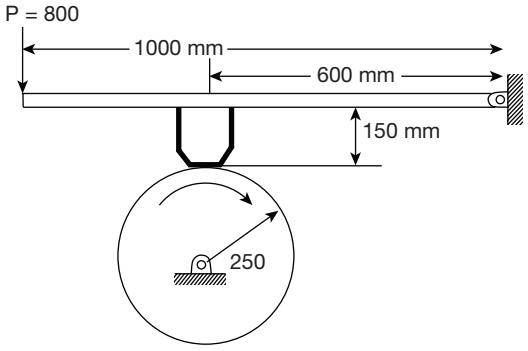
45.



A beam is loaded with a force P as shown in the figure. The value of distance x such that the deflection at A is zero, is

(A) $\frac{L}{2}$ (B) $\frac{L}{4}$
(C) $\frac{L}{3}$ (D) $\frac{2L}{3}$

46.



A drum brake of 250 mm radius is rotating in the clockwise direction as shown in the figure. The coefficient of friction between drum and shoe is 0.25. The braking torque (in N m) on the brake drum when an effort $P = 800$ N is applied at the end of lever is .

47. A flywheel connected to a punching machine has to supply an energy of 600 Nm while running at a mean angular speed of 25 rad/s. If the total fluctuation in speed is not to exceed ± 1%, the mass moment of inertia of the flywheel (in kg m^2) is .

48. If h is the height of a Porter governor (i.e the height of the pin point from the sleeve) and N is its rpm, then the sensitivity $\frac{dh}{dN}$ of a Porter governor is proportional to

(A) $\frac{1}{N^3}$ (B) $\frac{1}{N^2}$

(C) $\frac{1}{N}$ (D) N^2

49. In a Linear programming problem, the objective function is $Z = 3x + 8y$

Constraints are,

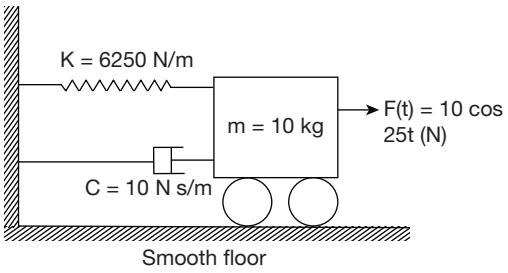
$x + y \le 7$

$x + 2y \le 4$

$x \ge 0, y \ge 0$

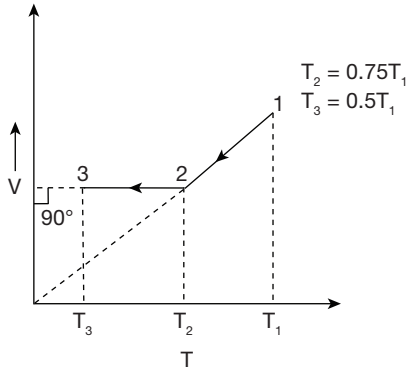
Maximum value of objective function is _____.

50.



For the spring-mass-dashpot system shown in figure, the mass m = 10 kg, stiffness of spring k = 6250 N/m and damping coefficient of damper, C = 10 N s/m. It is subjected to a harmonic force $F(t)$ = 10 cos25t (N). The amplitude of forced vibration in the steady state, expressed in millimeter, is _____.

51. An ideal gas at initial state 1 (pressure P_1, Volume V_1 and temperature T_1) undergoes a process 1-2 such that its temperature at the end of process 1-2 is $T_2 = \frac{3}{4}T_1$. Now the gas undergoes a process 2-3 such that its temperature T_3 at the end of process is $\frac{T_1}{2}$. The *V-T* diagram for process 1 – 2 and 2 – 3 is shown below.



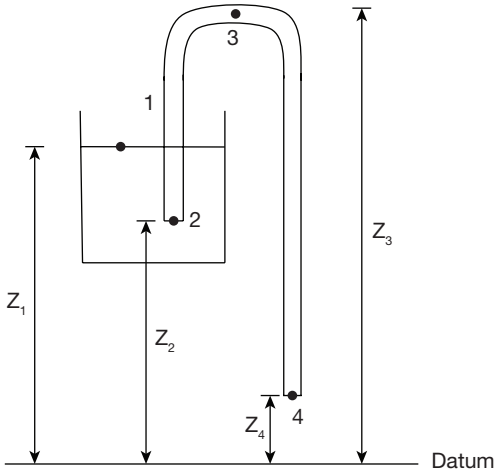
The ratio of final pressure p_3 to initial pressure p_1 of the gas $\left(ie\ \frac{p_3}{p_1}\right)$ is

(A) $\frac{3}{4}$ (B) $\frac{3}{8}$

(C) $\frac{5}{8}$ (D) $\frac{2}{3}$

52. An amount of 125 kW of heat is transferred through a wall in steady state. One side of the wall is maintained at 227°C and other side at 27°C. The entropy generated (in W/K) due to the heat transfer through the wall is_.

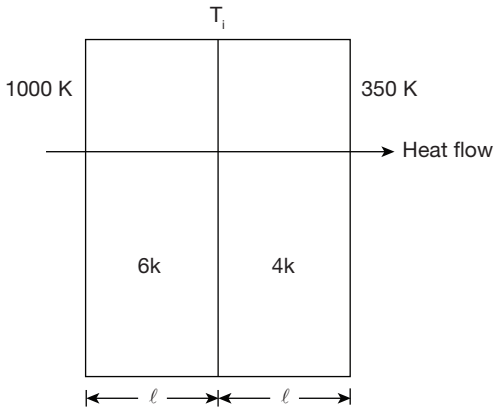
53. In a syphon arrangement as shown in the figure, water is drained from a large tank to atmosphere. Elevation of water level at 1 is held constant. Ignoring frictional head loss and losses at entry and exit, pressure at the top most point(3) is



(A) $\rho g(z_1 - z_3) - \frac{\rho V_4^2}{2g}$ (B) $\rho g(z_1 - z_3) - \frac{\rho V_4^2}{2}$

(C) $\rho g(z_2 - z_4) - \frac{\rho V_3^2}{2g}$ (D) $\rho g(z_2 - z_4) - \frac{\rho V_3^2}{2}$

54.

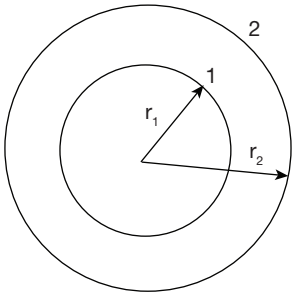


Heat transfer through a composite wall of two sections, each having same thickness (ℓ), is shown in figure. The thermal conductivity of one section is 6*k* and that of the other is 4k respectively. The left face of wall is at 1000 K and right face at 350 K. The temperature T_i(in K) of the interface of the composite wall is .

55. A fluid of dynamic viscosity 3×10^{-5} N s/m^2 and density 1.5 kg/m^3 flows through a long duct of rectangular cross section 30 mm × 20 mm with an average velocity of 1 m/s. If coefficient of friction is 0.018, pressure drop in metre of the fluid per metre length of the duct is.
(Laminar flow may be assumed)

56. In an axial impulse turbine, blade linear speed is 30 m/s and absolute velocity of steam at inlet is 120 m/s. The relative velocity and axial component of absolute velocity remain same between inlet and outlet of the blades. The steam jet angle at inlet is 25°. From velocity triangles it is found that relative velocity at inlet is 93.6 m/s and absolute velocity at outlet is 70.3 m/s. Assuming no losses, the specific work in (J/kg) is_.

57.

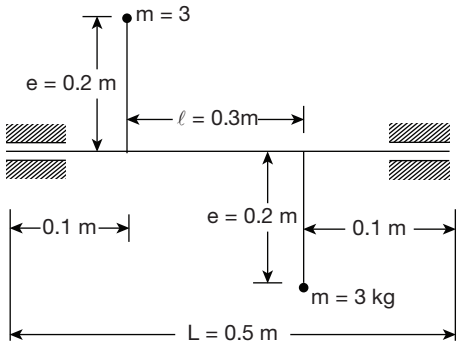


A solid sphere of radius r_1 = 15 mm is placed concentrically inside a hollow sphere 2 of radius r_2 = 75 mm as shown in the figure. The view factor F_{22} for radiation heat transfer is

(A) $\frac{1}{5}$ (B) $\frac{1}{25}$

(C) $\frac{24}{25}$ (D) $\frac{4}{5}$

58.



A strictly balanced system is shown in figure. Two equal masses, each equal to 3 kg, each with an eccentricity *e* = 0.2 m, are placed on opposite sides of the axis in the same axial plane. The shaft rotates now at a constant angular speed ω = 10 rad/s. The dynamic reaction at each support (in N) will be .

59. A diesel engine has a compression ratio of 20 and cut-off takes place at 15% of the stroke. Assuming ratio of specific heats (γ) as 1.4, the air standard efficiency (in percent) is .

60. Activities and duration of activities of a project network are as follows.

Activities	**Duration(days)**
1 – 2	2
1 – 3	3
2 – 4	1
2 – 5	3
3 – 4	2
3 – 6	8
4 – 5	2
4 – 6	7
5 – 6	4

Critical path of the project network is

(A) 1 – 3 – 4 – 5 – 6 (B) 1 – 2 – 4 – 5 – 6

(C) 1 – 3 – 4 – 6 (D) 1 – 3 – 6

61. Production rate of a product is 10,000 units per day. An order for 8000 units per day was received from a customer. Carrying cost of the item per unit per month is ₹0.15. Set up cost per production run is ₹400. Assuming 350 working days in a year economic production quantity is

(A) 49, 564 (B) 57, 686

(C) 66, 742 (D) 78, 881

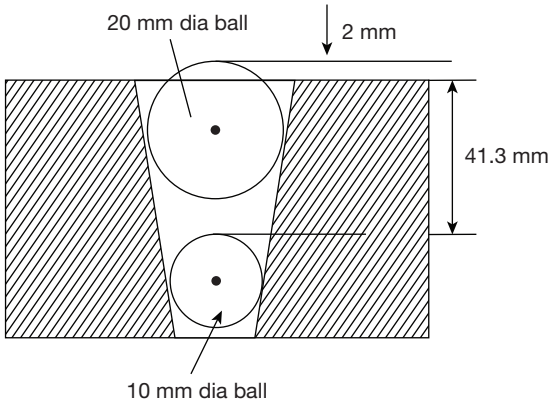
62. A top cylindrical riser of diameter *d* and height *h* is provided over a mould cavity for a casting. For constant

volume of the riser, the rate of solidification in the riser will be maximum when the ratio h/d is

(A) $\frac{1}{4}$ (B) $\frac{1}{3}$

(C) $\frac{1}{2}$ (D) 2

63. Balls of diameter 20 mm and 10 mm were used for measuring taper of a ring gauge. During measurement, the 20 mm diameter ball was protruding by 2 mm above the top surface of the ring. Top surface of the 10 mm diameter ball was at a depth of 41.3 mm from the top surface of the ring. Taper angle of the ring is



(A) 7.5° (B) 12°

(C) 15° (D) 17°

64. For orthogonal cutting using a single point cutting tool, choose the correct pair of statements from the statements given below.

P. Reduction in shear plane angle increases chip thickness

Q. Reduction in shear plane angle decreases chip thickness.

R. Reduction in friction angle increases chip thickness.

S. Reduction in friction angle decreases chip thickness.

(A) P and R (B) P and S

(C) Q and R (D) Q and S

65. Two steel sheets of 1.5 mm thickness are spot welded in a lap joint with a current of 10,000 A for 0.15 second. Effective resistance of the joint is 150 micro ohm. The joint can be considered as a cylinder of 6 mm diameter and 2 mm height. If heat required for melting of 1 mm^3 of steel is 10 J, heat loss (in percentage) to the surroundings is

(A) 60 (B) 65

(C) 70 (D) 75

Answer Keys

1. B	**2.** C	**3.** C	**4.** D	**5.** C	**6.** C	**7.** A	**8.** A	**9.** B	**10.** 6000
11. C	**12.** A	**13.** 1.55 to 1.59		**14.** A	**15.** A	**16.** 2.45 to 2.55		**17.** 43.95 to 44.35	
18. D	**19.** B	**20.** B	**21.** A	**22.** C	**23.** C	**24.** C	**25.** D	**26.** 719.50 to 720.50	
27. 62 to 63		**28.** C	**29.** 215	**30.** 0.12 to 0.13		**31.** C	**32.** B	**33.** B	**34.** D
35. B	**36.** B	**37.** A	**38.** C	**39.** 0.18 to 0.20		**40.** A	**41.** 1.45 to 1.55		**42.** D
43. C	**44.** 50	**45.** C	**46.** 88 to 89		**47.** 48	**48.** A	**49.** 16	**50.** 40	**51.** D
52. 166.0 to 167.0		**53.** B	**54.** 739 to 741		**55.** 0.113 to 0.114		**56.** 4720 to 4726		**57.** C
58. 36	**59.** 56.5 to 58.7		**60.** C	**61.** D	**62.** C	**63.** C	**64.** B	**65.** D	

Hints and Explanations

1. The synonym of risque is lascivious or vulgar. Queasy means sickening and pompous means overdone or affected and have little to do with the headword.

Choice (B)

2.

G	O	O	G	L	E
+1	–1	+1	–1	+1	–1
H	N	P	F	M	D

Similarly,

A	P	P	L	E
+1	–1	+1	–1	+1
B	O	Q	K	F

Choice (C)

3. The numbers a, b, c, d, e are in geometric progression.

$\therefore \quad \frac{b}{a} = \frac{c}{b} = \frac{d}{c} = \frac{e}{d}$ let each of these be k.

(i) $\frac{b^2}{a^2} = \frac{c^2}{b^2} = \frac{d^2}{c^2} = \frac{e^2}{d^2} = k^2$

$\therefore$ a^2, b^2, c^2, d^2, e^2 are in geometric progression.

(ii) The given terms need not be in geometric progression.

(iii) $\frac{3b}{3a} = \frac{3c}{3b} = \frac{3d}{3c} = \frac{3e}{3d} = k$

$3a$, $3b$, $3c$, $3d$, $3e$ are in geometric progression.

Only (i) and (iii) are in geometric progression.

Choice (C)

4. Utopia is a place where everything is perfect. Synagogue is a place of worship for Jews.

Choice (D)

5. The pair conjunction "neither . . . . . nor" always takes a plural verb with the plural subject being placed second. So "have" is apt. Choice (C)

6. $f(x) = 3 - |x|$ where $-2 \le x \le 2$,
$|a| = a$ when $a \ge 0$,
$= -a$ when $a < 0$,
$|x|$ ranges from 0 to 2.
$f(x)$ has the minimum and the maximum values when x has the maximum and the minimum values respectively.
Min $(f(x)) = 3 - 2 = 1$.
Max $(f(x)) = 3 - 0 = 3$. Choice (C)

7. The noun "machinery" is correct and it cannot be used in the plural with an "s". So the entire structure accompanying it has to be in the singular. Thus "There is no machinery for . . . ." is apt Choice (A)

8. Statement (B) is not true. The passage only states that he was a dictator "at heart", not a crowned and dreaded despotic ruler. Towards the end of the passage we are told of his beliefs regarding war. He came to believe that the conquest of the self was the greatest conquest. This DOES NOT mean he believed that men would shun violence and live peacefully. So (C) too is ruled out. (D) is ruled out as it is out of the text. Choice (A) is correct as per the first line of the passage. ". . . one of the . . ." means not the only. Choice (A)

9.

Person	Designation
A	Head of R&D / Finance
B	Head of operations
C	Posted to work in all departments
D	Head of Finance / R&D
E	Head of Marketing

A valid assignment of heads to the domains can be.
A – Finance B – Operations D – R&D E – Marketing.
Choice (B)

10. Total number of people using "Chuk–chuk for sure"
$= \frac{60}{360}(216000) = 36000$

Number of female customers of this company
$= \frac{1}{6}(36000) = 6000$ Ans: 6000

11. Given $f(x) = 5x^2 + \cos x$
The Taylor's series expansion of $f(x)$ about $x = a$ is

$$f(x) = f(a) + (x-a)f^1(a) + \frac{(x-a)^2}{2!}f^{11}(a) + \ldots\ldots\infty$$

$\therefore$ The third term is $\frac{(x-a)^2}{2!}f^{11}(a)$

Here $f(x) = 5x^2 + \cos x$ and $x = \pi$

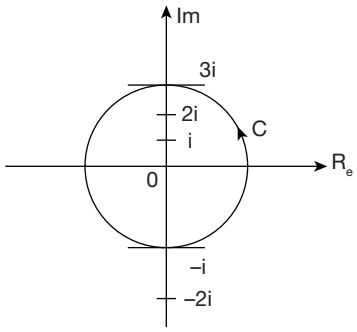
$\Rightarrow f^{11}(x) = 10 - \cos x$
$\therefore f^{11}(a) = f^{11}(\pi) = 10 - \cos\pi = 11$
$\therefore$ The third term in the Taylor's series expansion of $f(x)$ about $x = \pi$ is $\frac{(x-\pi)^2}{2!} \times 11 = \frac{11}{2}(x-\pi)^2$

Choice (C)

12. Given, $AB = A$ $\rightarrow (1)$
and $BA = B$ $\rightarrow (2)$
From (1) $AB = A$
$\Rightarrow (AB)A = A \times A$
$\Rightarrow A(BA) = A^2$
$\Rightarrow A(B) = A^2$ (from (2))
$\Rightarrow A = A^2$ (from (1))
$\Rightarrow A^2 = A \Rightarrow A$ is an idempotent matrix.
From (2), $BA = B$
$(BA)B = B \times B$
$\Rightarrow B(AB) = B^2$
$\Rightarrow B(A) = B^2$ (from (1))
$\Rightarrow B = B^2$ (from (2))
$\Rightarrow B^2 = B$
$\Rightarrow B$ is an idempotent matrix. Choice (A)

13. We have to evaluate $\oint_C \left(\frac{z^2+5}{z^2+4}\right)dz$,

where C is $|Z - i| = 2$



$z = \pm 2i$ are the singularities of $\frac{z^2+5}{z^2+4}$ and of these $z = +2i$ lies inside and $z = -2i$ lies outside C.

$$\therefore \oint_C \left(\frac{z^2+5}{z^2+4}\right)dz = \oint_C \left(\frac{z^2+5}{(z+2i)(z-2i)}\right)dz$$

$$= \oint_C \frac{\left(\frac{z^2+5}{z+2i}\right)}{(z-2i)}dz$$

$= 2\pi i f(a)$, where $f(z) = \frac{z^2+5}{z+2i}$ and $a = 2i$

(By Cauchy's Integral Formula)

$$= 2\pi i \times \left(\frac{(2i)^2+5}{2i+2i}\right) = \frac{\pi}{2} = 1.57$$

Ans: 1.55 to 1.59

14. Given $f(x, y, z) = 4xz^3 - 3x^2yz^2$

$\therefore \quad \nabla f = \left(4z^3 - 6xyz^2\right)\bar{i} - 3x^2z^2\bar{j} + \left(12xz^2 - 6x^2yz\right)\bar{k}$

$\nabla f_{at\,(2,-1,2)} = 80\bar{i} - 48\bar{j} + 144\bar{k}$

$\therefore$ The directional derivative of f in the direction of x – axis

= The directional derivative of f in the direction of $\bar{i}$ $= \nabla f . \bar{i} = \left(80\bar{i} - 48\bar{j} + 144\bar{k}\right).\bar{i} = 80$

Choice (A)

15. We have to evaluate $\int_0^\infty \left(\frac{e^{-3t} - e^{-2t}}{t}\right) dt$

Consider, $L\left[\frac{e^{-3t} - e^{-2t}}{t}\right] = \int_s^\infty L\left[e^{-3t} - e^{-2t}\right] ds$

$\left(\because L\left[\frac{f(t)}{t}\right]\right) = \int_s^\infty L\left[f(t)\,ds\right]$

$= \int_s^\infty \left[\frac{1}{s+3} - \frac{1}{s+2}\right] ds = \ln(s+3) - \ln(s+2)\Big]_s^\infty$

$= \ln\left(\frac{s+3}{s+2}\right)\Big]_s^\infty = \ln\left(\frac{1+3/s}{1+2/s}\right)\Big]_s^\infty$

$= \ln\left(\frac{1+0}{1+0}\right) - \ln\left(\frac{1+3/s}{1+2/s}\right)$

$= \ln 1 - \ln\left(\frac{s+3}{s+2}\right) = \ln\left(\frac{s+3}{s+2}\right)^{-1}$

$L\left[\frac{e^{-3t} - e^{-2t}}{t}\right] = \ln\left(\frac{s+2}{s+3}\right)$

i.e., $\int_0^\infty e^{-st}\left(\frac{e^{-3t} - e^{-2t}}{t}\right) dt = \ln\left(\frac{s+2}{s+3}\right)$

Put $s = 0$ on both sides,

$\int_0^\infty \left(\frac{e^{-3t} - e^{-2t}}{t}\right) dt = \ln\left(\frac{2}{3}\right)$ Choice (A)

16. $\sigma_{max} = 80$ MPa

Bending stress is completely reversible stress and for bending stress, mean stress, $\sigma_m = 0$

$\Rightarrow$ stress amplitude $\sigma_a = 80$ MPa

$S_{yt} = 320$ MPa, $S_{ut} = 450$ MPa, $S_e = 200$ MPa

$F.S = ?$

From Soderberg's equation, $\frac{\sigma_a}{S_e} + \frac{\sigma_m}{S_{yt}} = \frac{1}{FS}$

$\Rightarrow \quad \frac{80}{200} + 0 = \frac{1}{FS} \Rightarrow FS = \frac{200}{80} = 2.5$ Ans: 2.5

17. $\frac{T}{J} = \frac{\tau}{R}$

$\Rightarrow \quad \tau = \frac{16T}{\pi D^3\left(1 - k^4\right)}$

where $k = \frac{I\,D}{OD}$

$T = 1500$ N m

$D = 60$ mm, d = 40 mm

$k = \frac{40}{60} = \frac{2}{3}$

Maximum shear stress $\tau = \frac{16 \times 1500 \times 10^3}{\pi 60^3\left[1 - \left(\frac{2}{3}\right)^4\right]}$

= 44.074 MPa Ans: 43.95 to 44.35

18. $\phi = \tan^{-1}\frac{2\xi\left(\frac{\omega}{\omega_n}\right)}{\left[1 - \left(\frac{\omega}{\omega n}\right)^2\right]}$

$\omega = 2\pi \times 30$ rad/s

$\omega_n = 2\pi \times 25$ rad/s

$\therefore \quad \omega > \omega_n \Rightarrow 1 - \left(\frac{\omega}{\omega_n}\right)^2$ is negative.

$\therefore$ $\tan\phi$ is negative $\Rightarrow \phi > 90°$ Choice (D)

19. $m_1 = 50$ kg, $u_1 = 20$ m/s

$m_2 = 25$ kg, $u_2 = 0$

$e = 0$ ($\because$ perfectly inelastic)

$\Delta KE = \frac{1}{2}\frac{m_1 m_2}{(m_1 + m_2)}\left(u_1 - u_2\right)^2\left(1 - e^2\right)$

$= \frac{1}{2} \times \frac{50 \times 25}{(50 + 25)}(20 - 0)^2\left(1 - 0^2\right)$

$= \frac{25 \times 25}{75} \times 400 = 3333.33\,\text{J}$ Choice (B)

20. (iii) is wrong. Distortion energy theory gives more accurate value. Choice (B)

21. The angle of rotation of cam for a definite displacement of follower is termed as cam angle.

Hence (B) is not correct

When follower lifts from base circle upto its maximum rise, the angle turned by the cam is known as angle of rise. If there is no displacement of follower when the cam has turned through certain angle, then the angle turned by cam is called angle of dwell. The angle turned during the fall of follower is known as angle of return. The angle at any point on the pitch curve between the line of motion of follower and normal to point on cam profile is called pressure angle. Choice (A)

22. Thermal conductance $= \frac{1}{Thermal\ resis\tan ce}$

And thermal resistance $= \frac{\ell n\left(\frac{b}{a}\right)}{2\pi k L_0}$

$\therefore$ Thermal conductance $= \frac{2\pi k L_0}{\ell n\left(\frac{b}{a}\right)}$ Choice(C)

23. For reversible heat engine $\oint \delta Q > 0$ as some work is done by the engine and $\oint \delta Q = \oint \delta W$ for closed system as per first law of thermodynamics. Also, for reversible cycles, $\oint \frac{\delta Q}{T} = 0$ as per Claussius inequality. Choice(C)

24. Choice (C)

25. For optimum velocity v,

$\frac{u}{v} = \frac{\cos\alpha}{2}$. Where α = nozzle angle.

$u = \frac{\pi DN}{60} = \frac{\pi \times 1.8 \times 3000}{60}$

$\therefore \quad v = \frac{2u}{\cos\alpha} = \frac{2 \times \pi \times 1.8 \times 3000}{60 \times \cos 18°} = 594.58$ m/s

Choice (D)

26. Work done will be maximum when a reversible heat engine is used to convert heat into work.

$\therefore$ $T_1 = 750$ K, $T_2 = 27 + 273 = 300$ K

$\therefore$ Work done by reversible engine = $\eta_{rev} Q$

$= \left(1 - \frac{T_2}{T_1}\right) \times 1200$ kJ

$= \left(1 - \frac{300}{750}\right) \times 1200 = 0.6 \times 1200$

= 720 kJ Ans: 719.50 to 720.50

27. $p_b = 85$ kPa

$p_s = 4.24$ kPa

Specific humidity = $\frac{0.622\ p_v}{p_b - p_v}$

$\frac{20}{1000} = \frac{0.622 \times p_v}{85 - p_v}$

$\Rightarrow \quad 1.7 - 0.02 p_v = 0.622\ p_v$

$\Rightarrow \quad p_v = 2.648$ kPa.

Relative humidity

$\phi = \frac{p_v}{p_s} = \frac{2.648}{4.24} = 0.6245 = 62.45\%$

Answer 62 to 63

28. In ultrasonic machining material removal takes place due to brittle fracture.

If toughness is less, brittleness is more. Choice(C)

29. 4 months moving average for the month September

= Average of the sales of 4 months just before September

$= \frac{245 + 195 + 235 + 185}{4} = \frac{860}{4}$

= 215 units Ans: 215

30. Feed $f = 0.2$ mm/rev

Depth of cut $d = 0.5$ mm

Side cutting edge angle $C_s = 50°$

Uncut chip thickness $t = f \sin\lambda$

Where λ = plan approach angle = $(90° - C_s)$

$\therefore \quad t = 0.2 \sin(90° - 50°)$

= 0.1286 mm Ans: 0.12 to 0.13

31. Choice (C)

32. Choice (B)

33. Choice (B)

34. Choice (D)

35. Choice (B)

36. Given, 1, 4 and 5 are the eigen values of A.

$\therefore$ The eigen values of $A^2 - 5A + 6I_3$ are $1^2 - 5 \times 1 + 6 = 2$, $4^2 - 5 \times 4 + 6 = 2$ and $5^2 - 5 \times 5 + 6 = 6$.

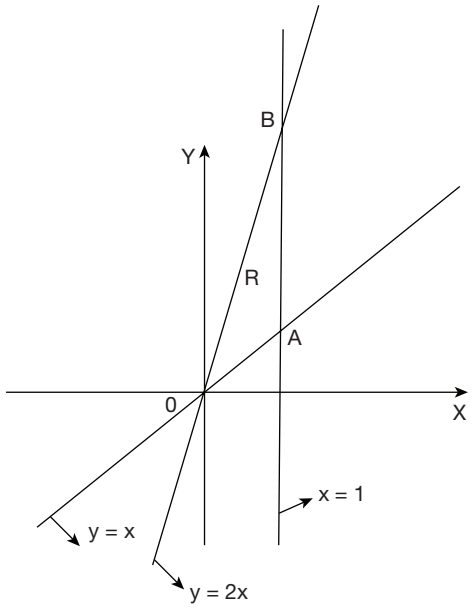
Hence, the eigen value of $A^2 - 5A + 6I_3$ are 2, 2 and 6

$\therefore$ $A^2 - 5A + 6I_3$ has two distinct eigen values.

Choice (B)

37. We have to evaluate the double integral

$\iint_R (4xy - y^2) dx\ dy$



where R is the triangular region OAB as shown in the figure.

In R, y varies form $y = x$ to $y = 2x$

and x varies form $x = 0$ to $x = 1$.

$\therefore \quad \iint_R [4xy - y^2] dxdy = \int_{x=0}^{1} \left(\int_{y=x}^{2x} (4xy - y^2) dy \right) dx$

$= \int_{x=0}^{1} \left[2xy^2 - \frac{y^3}{3} \right]_{y=x}^{2x} dx$

$$= \int_{x=0}^{1}\left[\left(2x(2x)^2 - \frac{(2x)^3}{3}\right) - \left(2x(x)^2 - \frac{x^3}{3}\right)\right]dx$$

$$= \int_{x=0}^{1}\left[\frac{11}{3}x^3\right]dx = \frac{11}{3}\times\frac{x^4}{4}\Big]_0^1 = \frac{11}{12}$$ Choice (A)

38. Let X_1, X_2 and X_3 denote the number appeared on the die in the first, second and third rolls respectively.

$\therefore$ X_1, X_2 and X_3 take the values 1, 2, 3, 4, 5 and 6 with equal probability $\frac{1}{6}$.

$\therefore$ $E(X_1) = E(X_2) = E(X_3)$

$$= 1\times\frac{1}{6} + 2\times\frac{1}{6} + 3\times\frac{1}{6} + 4\times\frac{1}{6} + 5\times\frac{1}{6} + 6\times\frac{1}{6} = \frac{7}{2}$$

$\therefore$ The expected value of the product of numbers that appear on the die when rolled thrice

$= E(X_1 X_2 X_3) = E(X_1) \cdot E(X_2) \cdot E(X_3)$

$$= \frac{7}{2}\times\frac{7}{2}\times\frac{7}{2} = \frac{343}{8}$$ Choice (C)

39. Given $f(x) = (x-1)^2 e^{-x}$

$f^1(x) = 2(x-1)e^{-x} - (x-1)^2 e^{-x}$

$f^1(x) = (x-1)(3-x)e^{-x} = (4x - x^2 - 3)e^{-x}$

$f^1(x) = 0 \Rightarrow (x-1)(3-x)e^{-x} = 0$

$\Rightarrow$ $(x-1)(3-x) = 0$

$\Rightarrow$ $x = 1; x = 3$

And $f^{11}(x) = (4-2x)e^{-x} - (4x - x^2 - 3)e^{-x}$

$= (x^2 - 6x + 7)e^{-x}$

At $x = 1, f^{11}(x) = 2e^{-1} = \frac{2}{e} > 0$

At $x = 3; f^{11}(x) = -2e^{-3} = \frac{-2}{e^3} < 0$

$\therefore$ $f(x)$ has a local maximum at $x = 3$

$\therefore$ The maximum value of $f(x)$ is

$f(x)$ at $x = 3$ is $f(3) = (3-1)^2 e^{-3} = \frac{4}{e^3}$

$= 0.1991$ Ans: 0.18 to 0.20

40. Let $y = f(x) = \frac{1}{x^3}$

Here $a = 1$, $b = 4$ and $n = 6$

$\therefore$ $h = \frac{b-a}{n} = \frac{4-1}{6} = 0.5$

$x = x_i$	1.0	1.5	2.0	2.5	3.0	3.5	4.0
$y = y_i$	1	0.2963	0.125	0.064	0.0370	0.0233	0.0156

$\therefore$ By Simpson's Rule, we have

$$\int_1^4 \frac{1}{x^3}dx = \int_a^b y\,dx$$

$$= \frac{0.5}{3}\left[\begin{matrix}(1+0.0156)+4(0.2963+0.064+0.0233)\\+2(0.125+0.0370)\end{matrix}\right]$$

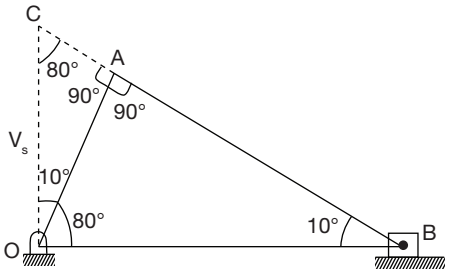
$= 0.479$ Choice (A)

41. OAC is the velocity triangle.

$OA = r\omega = 0.075 \times 20 = 1.5$ m/s

OC = speed of slider = V_s

$\therefore$ $\frac{V_s}{\sin 90^\circ} = \frac{r\omega}{\sin 80^\circ}$ $\left[\because \frac{OA}{\sin 80^\circ} = \frac{OC}{\sin 90^\circ}\right]$



$\Rightarrow$ $V_s = \frac{r\omega\times 1}{\sin 80^\circ} = \frac{1.5}{0.9848}$

$= 1.5231$ m/s Ans: 1.45 to 1.55

42. Slope of $v - x$ graph is $\frac{20-0}{(0-4)} = -5/s$

$\therefore$ $\bar{V} = -5\bar{x} + 20$ is the relation between v and x

($\because$ equation of straight line)

$\therefore$ $\frac{dv}{dx} = -5$

$$a = \frac{dv}{dt} = \left(\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right) = v\frac{dv}{dx}$$

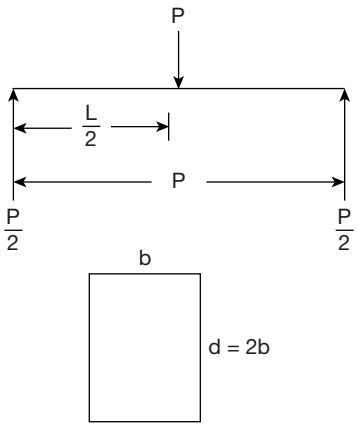
$= (-5x + 20)(-5) = 25x - 100$

$\therefore$ $\bar{a} = 25\bar{x} - 100$

When $x = 3$ m, $a = 25 \times 3 - 100 = -25$ m/s^2

$\therefore$ $\bar{a} = -25\hat{i}\ (\text{m/s}^2)$ when $x = 3\hat{i}\ (\text{m})$ Choice (D)

43.



Shear force = $\frac{P}{2}$

Average shear stress = $\tau_{av} = \frac{P}{2A} = \frac{P}{2\times 2b^2} = \frac{P}{4b^2}$

Maximum shear stress

$$\tau_{max} = \tau_{av} \times 1.5 = 1.5\times\frac{P}{4b^2} = 0.375\frac{P}{b^2}$$

Maximum bending stress $\sigma_{max} = \frac{M}{Z}$

Where M = maximum bending moment = $\frac{PL}{4}$

And Z = section modulus = $\frac{bd^2}{6}$

$\therefore \quad \sigma_{max} = \frac{P \times 50b}{4} \times \frac{6}{b \times (2b)^2} = \frac{18.75P}{b^2}$

$$\frac{\tau_{max}}{\sigma_{max}} = \frac{0.375P}{b^2} \times \frac{b^2}{18.75P} = 0.02$$ Choice(C)

44. $m = 1$ kg, $k = 100$ N/m, $\xi = 1.25$

$\therefore \quad C = \xi C_c = 2\xi\sqrt{km} = 2 \times 1.25 \times \sqrt{1 \times 100}$

$= 25$ N s/m

$V_{max} = 2$ m/s

$\therefore \quad (Fd)_{max} = CV_{max} = 25 \times 2 = 50$ N Ans: 50

45.

Equivalent loading is as shown in the figure.

Moment $M = P(L - x)$

For zero deflection at A,

Deflection due to P =

Deflection due to M.

i.e., $\frac{PL^3}{3EI} = \frac{ML^2}{2EI} = \frac{P(L-x)L^2}{2EI}$

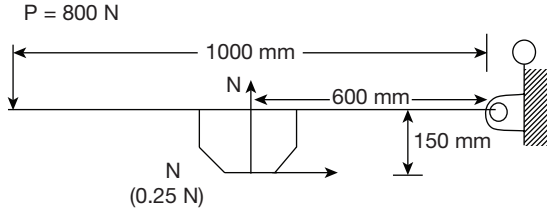
$\Rightarrow \quad \frac{L}{3} = \frac{(L-x)}{2}$

$\Rightarrow \quad 2L = 3L - 3x$

$\Rightarrow \quad L = 3x$

$\Rightarrow \quad x = \frac{L}{3}$ Choice(C)

46.



Taking moments about hinge 0,

$800 \times 1 = N \times 0.6 - 0.25\text{ N} \times 0.15$

$\Rightarrow \quad N = \frac{800}{0.5625} = 1422.22$ N

$\therefore$ Frictional force $f = \mu N = 0.25 \times 1422.22$

$= 355.55$ N

Frictional torque, $T = fr$

$= 355.55 \times 0.25$

$= 88.8$ Nm Ans:88.0 to 89.0

47. $\Delta E = I\omega\Delta\omega \Rightarrow 600 = I \times 25 \times (0.02 \times 25)$

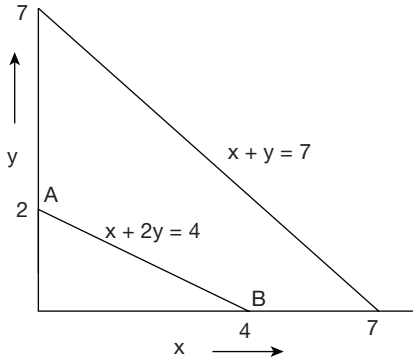
$\Rightarrow \quad I = 48$ kg m^2 Ans:48

48. For a Porter governor (which is a modification of Watt's governor),

$h \propto \frac{1}{N^2}$ ie, $h = kN^{-2}$

$\therefore \quad \frac{dh}{dN} = -2kN^{-3} \propto \frac{1}{N^3}$ Choice (A)

49.



On plotting the constraints, feasible solutions are $A(0, 2)$ and $B(4, 0)$.

Value of objective function

at A, $z = 0 + 8 \times 2 = 16$

at B, $z = 3 \times 4 + 0 = 12$

So maximum value of objective function is 16.

Ans:16

50. $\omega = 25$ rad/s; $F = 10$ N

$$A = \frac{F}{\sqrt{\left[k - m\omega^2\right]^2 + (c\omega)^2}}$$

$$= \frac{10}{\sqrt{\left[6250 - 10 \times 25^2\right]^2 + (10 \times 25)^2}} = \frac{10}{250}\text{ m}$$

$$= \frac{10 \times 1000}{250}\text{ mm} = 40\text{ mm}$$ Ans:40

51. Process 1 – 2 is isobaric ($\because$ straight line, passing through origin of V-T diagram).

$\therefore \quad p_1 = p_2$

Process 2 – 3 is isochoric. $\therefore \quad V_2 = V_3$

For ideal gas,

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2} = \frac{p_1V_2}{T_2} \left(\because p_1 = p_2\right)$$

Also $\frac{p_2V_2}{T_2} = \frac{p_3V_3}{T_3}$

$$\therefore \quad \frac{p_3}{p_2} = \frac{T_3}{T_2} \left(\because V_2 = V_3\right)$$

$$\text{i.e.,} \quad \frac{p_3}{p_1} = \frac{T_3}{T_2} \left(\because p_2 = p_1\right)$$

$$= \frac{0.5T_1}{0.75T_1} = \frac{1}{2} \times \frac{4}{3} = \frac{2}{3}$$ Choice (D)

52. $T_1 = 227 + 273 = 500$ K

$T_2 = 27 + 273 = 300$ K

$$\Delta S_1 = \frac{-Q_1}{T_1} = \frac{-125 \times 10^3}{500} = -250 \text{ W/K}$$

$$\Delta S_2 = \frac{+Q_1}{T_2} = \frac{+125 \times 10^3}{300} = +416.67 \text{ W/K}$$

$\Delta S = \Delta S_2 + \Delta S_1 = 416.67 - 250$

$= 166.67$ W/K Ans:166.0 to 167.0

53. Applying Bernoulli's theorem between points 1 and 4.

$$0 + 0 + z_1 = 0 + \frac{v_4^2}{2g} + z_4$$

$$\Rightarrow \quad \frac{v_4^2}{2g} = z_1 - z_4$$

Applying Bernoulli's theorem between points 1 and 3

$$0 + 0 + z_1 = \frac{p_3}{\rho g} + \frac{v_3^2}{2g} + z_3$$

$$\Rightarrow \quad \frac{p_3}{\rho g} = \left(z_1 - z_3\right) - \frac{v_3^2}{2g}$$

$$\Rightarrow \quad P_3 = \rho\tau g(z_1 - z_3) - \frac{\rho v_4^2}{2} \left[\because V_3 = V_4\right]$$ Choice (B)

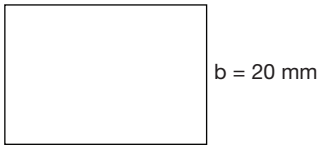
54. $$Q = \frac{6k\,A\left(1000 - T_i\right)}{\ell} = \frac{4k\,A\left(T_i - 350\right)}{\ell}$$

$\Rightarrow 6(1000 - T_i) = 4(T_i - 350)$

$\Rightarrow 6000 + 4 \times 350 = 10T_i$

$$\Rightarrow T_i = \frac{6000 + 4 \times 350}{10} = \frac{7400}{10} = 740 \text{ K}$$ Ans:739 to 741

55.



Diameter equivalent

$$d = \frac{2ab}{(a+b)} = \frac{2 \times 30 \times 20}{(30+20)} = 24 \text{ mm} = 0.024 \text{ m}$$

$\rho = 1.5$ kg/m^3

$V = 1$ m/s

$\mu = 3 \times 10^{-5}$ N s/m^2

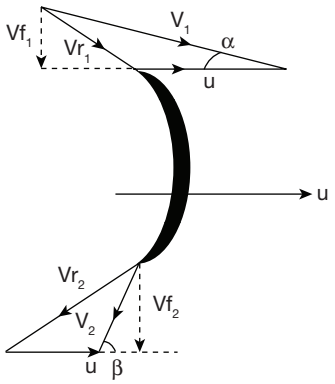
For laminar flow, pressure drop in metre of the fluid

$$\frac{p_2 - p_1}{\rho g} = \frac{32\mu VL}{\rho g d^2}$$

$$= \frac{32 \times 3 \times 10^{-5} \times 1 \times 1}{1.5 \times 9.81 (0.024)^2} = 0.1133 \text{ m}$$

Ans:0.113 to to 0.114

56.



$u = 30$ m/s

$V_1 = 120$ m/s

$\alpha = 25°$

$Vr_1 = Vr_2 = 93.6$ m/s

$V_2 = 70.3$ m/s

Axial component of velocity (velocity of flow)

$V_{f_1} = V_{f_2}$

$$V_{f_1} = V_1 \sin\alpha = 120 \times \sin 25° = 50.714$$

$= V_2 \sin\beta = 70.3 \sin\beta$

$\Rightarrow \sin\beta = 0.7214$

$\Rightarrow \cos\beta = 0.6925$

$$V_{w_2} = V_2 \cos\beta = 70.3 \times 0.6925 = 48.68 \text{ m/s.}$$

$$V_{w_1} = V_1 \cos\alpha = 120 \cos 25 = 108.76 \text{ m/s}$$

Specific work $= \left(V_{w_1} + V_{w_2}\right) u$

$= (108.76 + 48.68) \times 30 = 4723.2$ J/kg

Ans:4720 to 4726

57. $F_{11} + F_{12} = 1$ ($\because$ Enclosure)

$F_{11} = 0$ ($\because$ convex surface)

$\therefore \quad F_{12} = 1$

$A_1F_{12} = A_2F_{21}$ (Reciprocity theorem)

$$\therefore \quad F_{21} = \frac{A_1}{A_2} F_{12} = \frac{A_1}{A_2} = \frac{4\pi r_1^2}{4\pi r_2^2} = \frac{15^2}{75^2} = \frac{1}{25}$$

$F_{22} + F_{21} = 1$ ($\because$ Enclosure)

$$\therefore \quad F_{22} = 1 - F_{21} = 1 - \frac{1}{25} = \frac{24}{25}$$ Choice (C)

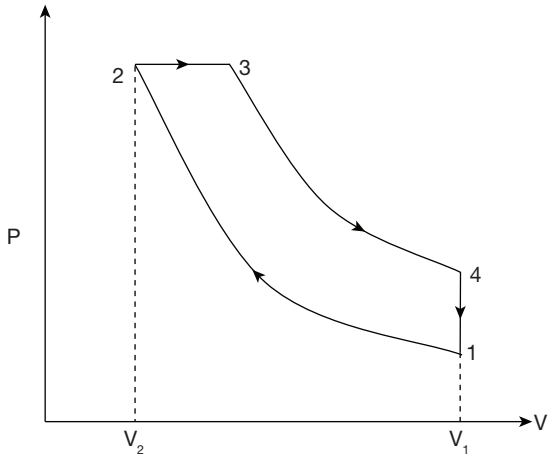
58. T = couple on shaft due to centrifugal forces on masses
$= (me\omega^2)\ell$ N m
$= 3 \times 0.2 \times 10^2 \times 0.3 = 18$ N m (clockwise)
This has to be balanced by the anticlockwise couple of support reactions.

$\therefore$ Support reaction $= \dfrac{T}{L} = \dfrac{18\text{ N m}}{0.5\text{ m}} = 36\text{ N}$

$\therefore$ Dynamic reaction at each support, R_D =36 N

Ans:36

59.



Compression ratio, $r_k = \dfrac{V_1}{V_2} = 20 \Rightarrow V_1 = 20V_2$

$V_3 - V_2 = 0.15\ (V_1 - V_2)$
$= 0.15[20V_2 - V_2] = 0.15 \times 19V_2$
$= 2.85V_2$

$\therefore$ $V_3 = 3.85\ V_2$

Cut off ratio, $r_c = \dfrac{V_3}{V_2} = 3.85$

$$\eta_{th} = \left[1 - \frac{1}{\gamma r_k^{\gamma-1}}\left(\frac{r_c^{\gamma} - 1}{r_c - 1}\right)\right] \times 100$$

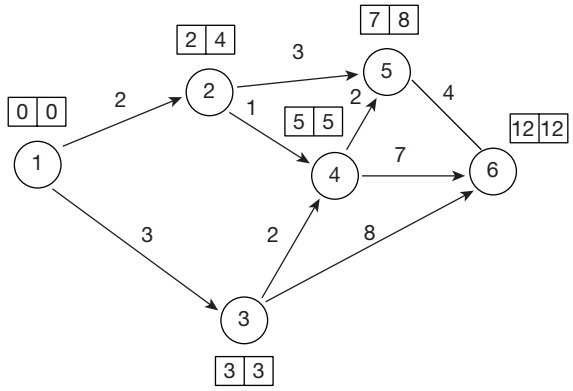
$$= \left[1 - \frac{1}{1.4 \times 20^{0.4}}\left[\frac{3.85^{1.4} - 1}{3.85 - 1}\right]\right] \times 100$$

$$= \left[1 - \frac{1}{1.4 \times 20^{0.4}}\left\{\frac{6.6015 - 1}{3.85 - 1}\right\}\right] \times 100$$

$$= \left[1 - \frac{1}{1.4 \times 3.3145}\left\{\frac{5.6015}{2.85}\right\}\right] \times 100$$

$= [1 - 0.4236] \times 100$
$= 57.57.64\%$ Ans:56.5 to 58.7

60.



By forward and backward pass calculation, it is found that events 1, 3, 4 and 6 are having zero slack.
So the critical path is 1 – 3 – 4 – 6

Choice(C)

61. Production rate p = 10,000/day
Demand rate d = 8000/day
Carrying cost C_c = ₹0.15/unit/month
= ₹0.15 × 12/unit/year
= ₹1.8/unit per year
Set up cost C_s = ₹400

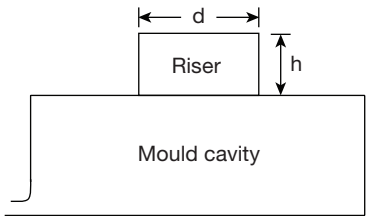
Economic production quantity $EPQ = \sqrt{\dfrac{2C_sD}{C_c\left(1 - \dfrac{d}{p}\right)}}$

where D = annual demand

$\therefore$ $EPQ = \sqrt{\dfrac{2 \times 400 \times 8000 \times 350}{1.8\left(1 - \dfrac{8000}{10000}\right)}}$

= 78,881 units Choice(D)

62.



Solidification time $T = C\left(\dfrac{V}{A}\right)^2$

As V is constant, $T \propto \dfrac{1}{A^2}$

Rate of solidification is least when T is maximum or A is least.

$A = \pi dh + \dfrac{\pi d^2}{4}$ for a top riser.

$$V = \frac{\pi}{4} d^2 h \Rightarrow h = \frac{4V}{\pi d^2}$$

$$\Rightarrow \quad A = \pi d \times \frac{4V}{\pi d^2} + \frac{\pi d^2}{4}$$

$$= \frac{4V}{d} + \frac{\pi d^2}{4}$$

For minimum area, $\frac{\partial A}{\partial d} = 0$

i.e. $\frac{-4V}{d^2} + \frac{\pi d}{2} = 0$

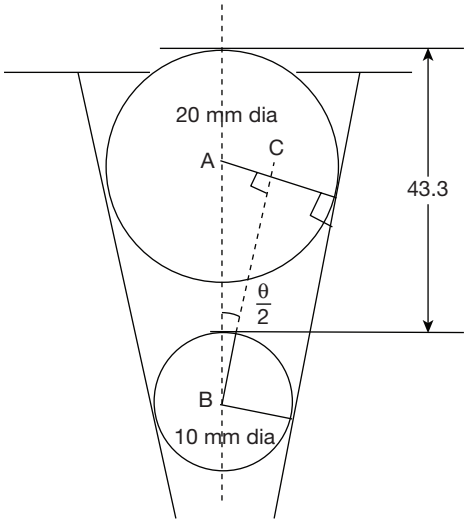
$$\Rightarrow \quad d^3 = \frac{8V}{\pi} = \frac{8}{\pi}\frac{\pi d^2}{4} h$$

$$\Rightarrow \quad d = 2h$$

$$\Rightarrow \quad \frac{h}{d} = \frac{1}{2}$$

Choice(C)

63.



$AB = 43.3 - 10 + 5 = 38.3$ mm

$AC = 10 - 5 = 5$ mm

$$\sin\frac{\theta}{2} = \frac{AC}{AB} = \frac{5}{38.3} = 0.1305$$

$$\Rightarrow \quad \frac{\theta}{2} = 7.5°$$

$$\Rightarrow \quad \theta = 15°$$

Choice(C)

64. Chip thickness ratio

$$r = \frac{t_1}{t_2} = \frac{\sin\varphi}{\cos(\varphi - \alpha)}$$

where t_2 = chip thickness.

and ϕ = shear plane angle.

So reduction in shear plane angle causes increase in chip thickness. So statement P is correct. For minimum cutting force

$2\phi + \beta - \alpha = 90°$

where β = friction angle.

So with reduction in friction angle, there is increase in shear plane angle and hence decrease in chip thickness.

So statement S is correct

Choice (B)

65. Heat supplied = I^2Rt

$= (10000)^2 \times 150 \times 10^{-6} \times 0.15 = 2250$ J

Volume of the joint = $\frac{\pi \times (6)^2}{4} \times 2 = 56.549$ mm^3

Heat required for melting = $56.549 \times 10 = 565.49$ J

Heat lost to surroundings = $2250 - 565.49 = 1684.51$ J

Percentage heat lost = $\frac{1684.51}{2250} \times 100 = 75\%$

Choice (D)