Mock Test 5

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 most appropriate word from the options given below to complete the following sentence:

1. If I _____ you I would not have taken the help of an outsider to solve my personal problems.
(A) was (B) were
(C) am (D) will be

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

2. Ram and Shyam started simultaneously from two different stations towards each other with speeds of x kmph and y kmph respectively. To cross each other, Ram travelled y times the distance travelled by Shyam. If the speed of Ram is 4 kmph, then the speed (in kmph) of Shyam is _____.

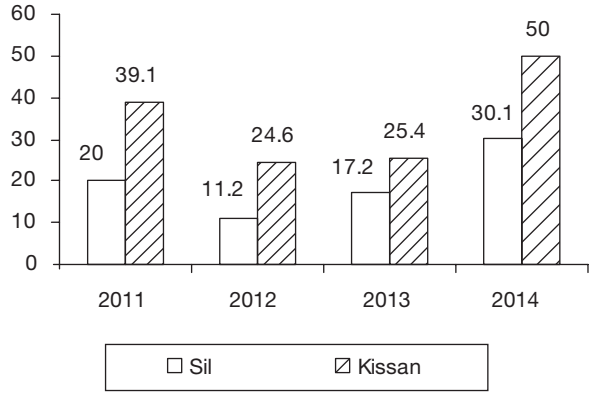
3. How is Khadar's wife's daughter's mother's daughter-in-law's husband's father related to Khadar?
(A) Grand-father (B) Father
(C) Father-in-law (D) Himself

Directions for question 4: Which one of the following combinations is incorrect?

4. (A) Beatific – Mundane
(B) Empirical – Experiential
(C) Gaunt – Emaciated
(D) Momentous – Critical

Directions for question 5: Select the correct alternative form the given choices.

5. The sales (in crores of ₹) of Kissan and Sil Mixed Fruit jams in Khaogali in each of the years from 2011 to 2014 are shown in the following bar chart.



The ratio of sales of Kissan to that of Sil is the highest in _____.
(A) 2012 (B) 2011
(C) 2013 (D) None of these

Questions 6 to 10 carry Two Marks each.

Directions for question 6: Select the alternative meaning of the underlined part of the sentence:

6. The government officials have promised the moon on the issue of regulation for industrial relations and so, have decided not to sign any new ventures.
(A) passed the buck
(B) broadened their horizons
(C) stood their ground
(D) heard something on the grapevine

Directions for question 7: The given statement is followed by some course of action. Assuming the statement to be true, decide the correct option:

7. Healthcare workers often reuse syringes or needles for multiple uses which increases the chance of infection and transmission of ailments, thus exposing people to a host of diseases from clinics, nursing homes and hospitals.
(i) Hospitals must encourage staff to incorporate smart disposal techniques.
(ii) Healthcare workers and patients must be made aware of WHO policy guidelines on safe injection practices.
(iii) Patients acquiring diseases from hospitals and nursing homes must be treated free of cost.
(iv) The government of India must make it mandatory for hospitals to switch from disposable syringes to Auto Disposable (AD) syringes.
(A) (i) and (iii) (B) (ii) and (iii)
(C) (i) and (ii) (D) (ii) and (iv)

Directions for questions 8 and 9: Select the correct alternative form the given choices.

8. Evaluate $\sqrt{5+\sqrt{5-\sqrt{5+\sqrt{5.....}}}}$.

(A) $\frac{\sqrt{13}-1}{2}$ (B) $\frac{\sqrt{17}-1}{2}$

(C) $\frac{\sqrt{17+1}}{2}$ (D) $\sqrt{17}$

9. America had entered the world war since Japan had attacked Pearl Harbour.
Which one of the statements below is logically valid and can be inferred from the above sentence?
(A) Japan was feeling restless.
(B) America would not have entered the world war, if Japan would not have attacked Pearl Harbour.
(C) Japan and America are enemies.
(D) None of these

***Directions for question* 10:** Out of the four sentences, select the most suitable sentence with respect to grammar and usage:

10. (A) Today's tip would have been sufficient to buy a full meal three years ago.
(B) Todays tip would pay for a full meal three years ago.
(C) Today's tip would be sufficient for a three-years-ago meal.
(D) A tip today would costed one a meal three years back.

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 value of the contour integral $\int_c \frac{z^2+6z+10}{(z^2+9)}$ where C is the circle $|z-i|=1$ traversed in a counterclockwise direction is _____.

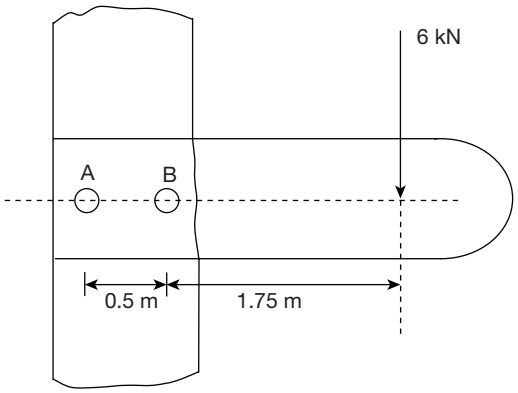
12. The magnitude of the error in evaluating the definite integral $\int_0^4 \frac{dx}{(4x+3)}$ by Trapezoidal rule with the number of subintervals as 8 is at most ____.
(A) $\frac{4}{81}$ (B) $\frac{8}{81}$
(C) $\frac{16}{81}$ (D) $\frac{32}{81}$

13. If X is a normal random variable, then which of the following is always true?
(A) Mean of X = Variance of X
(B) Mean of X = Standard Deviation of X
(C) Mean, median and mode of X is the same
(D) Variance of X = (Mean of X)^2

14. In the Taylor's series expansion of the function $f(x, y) = 2x^3 + 3y^2 + 5x^2y - 6$ in powers of $(x-2)$ and $(y+1)$, the coefficient of $(x-2)^2$ is ____

15. If the Laplace transform of f(t) is $L[f(t)] = F(s)$ then $L\left[\frac{d^2f}{dt^2}\right]$ = _____.
(A) $s^2F(s) + sf(0) + f^1(0)$
(B) $s^2F(s) + sF(0) + F^1(0)$
(C) $s^2F(s) - sf(0) - f^1(0)$
(D) $s^2F(s) - sF(0) - F^1(0)$

16. A steel bar of 15 mm × 50 mm is cantilevered with two M12 bolts (A and B) to support a static load of 6 kN as shown in figure. The ratio of magnitude of primary shear load to the magnitude of secondary shear load on bolt A is _____



17. Ultrasonic machining (USM) is best suited for
(A) soft and ductile materials
(B) hard and brittle materials
(C) non-metallic materials
(D) any of the above

18. A ball A of mass 1 kg falls from rest under gravity from a height 2 m and strikes another ball B of mass 1 kg which is supported at rest on a spring of stiffness 1 kN/m. Assume g = 9.8 m/s^2 and perfect 1 - D elastic impact between A and B. The speed of ball A immediately after impact (in m/s) is _____ .

19. In uniaxial tension test of a material, for the change in stress of 300 MPa, the change in strain was 0.0015. If modulus of rigidity of the material is 77 GPa, value of bulk modulus (in GPa) is _____ .

20. In a one dimensional incompressible, fully developed flow between two fixed parallel plates, the average velocity is 3 m/s. Value of the maximum velocity (in m/s) is
(A) 6 (B) 5
(C) 4.5 (D) 3.5

21. Ratio of lattice parameter of a unit cell of face centred cubic (FCC) structure to the radius of atom is _____ .

22. For flow of fluid over a heated plate, the following fluid properties are known. Viscosity = 0.001 Pa s, specific heat at constant pressure = 1 kJ/kgK, thermal

conductivity = 1 W/mK. If the hydrodynamic boundary layer thickness at a specified location on the plate is 0.237 mm, the thermal boundary layer thickness (in mm) at the same location is _____.

23. Gantt charts are used for
(A) forecasting sales
(B) scheduling and routing
(C) scheduling production
(D) linear programming

24. Economic order quantity of a product is 5000 units. If annual carrying cost per unit is ₹7 and annual demand is 25000, annual ordering cost (in rupees) is _____ .

25. Arrival of cars at a car service station is Poisson distributed with a mean rate of 5 per hour. Mean service time is 10 minutes and has an exponential distribution. At steady state, average number of cars waiting for service is
(A) 0.83 (B) 2.16
(C) 3.22 (D) 4.16

26. The specific heats of an ideal gas depends on its
(A) Temperature
(B) Pressure
(C) Molecular weight and structure
(D) Volume

27. Bleeding steam and reheating feed water to boiler with it (re-generative heating), in a Rankine cycle,
(A) decreases the thermal efficiency of the cycle
(B) increases the thermal efficiency of the cycle
(C) dose not affect the thermal efficiency of the cycle
(D) may increase or decrease the thermal efficiency depending up on point of extraction of steam

28. In a spring mass system, the mass is m and the spring constant is k. The critical damping coefficient of the system is 0.1 kg/s. In another spring mass system, the mass is 3m and the spring constant is 12*k*. The critical damping coefficient (in kg/s) of this system is _____ .

29. Specific enthalpy of refrigerant (in kJ/kg) at various points in a vapour compression refrigeration cycle is given below
Exit of evaporator : 230
Inlet of condenser : 282
Exit of condenser : 115
Coefficient of performance of the cycle is _____

30. A planar mechanism has 8 links and 10 revolute joints. The number of degree of freedom of mechanism, using Grubler's criterion, is _____ .

31. Brake power developed by an IC Engine was measured using a rope brake dynamo meter. Brake power was 12 kW at a speed of rotation of 420 radian /sec. Torque developed by the engine (in Nm) was _____.

32. V = axi + ayj is the velocity field equation of a fluid flow. The equation of stream line passing through a point (2, 1) is
(A) $x - 2y = 0$ (B) $2x + y = 0$
(C) $2x - y = 0$ (D) $x + 2y = 0$

33. A hole of dimension $\phi\ 12^{+0.015}_{+0}$ mm when assembled with shaft of dimension $\phi\ 12^{+0.010}_{+0.001}$ mm will result in a
(A) loose running fit (B) close running fit
(C) transition fit (D) interference fit

34. In thick film hydrodynamic journal bearings, the coefficient of friction
(A) decreases with increase in load.
(B) increases with increase in load.
(C) is independent of load.
(D) may increase or decrease with increase in load.

35. In a 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) $v \propto r^2$

Questions 26 to 55 carry Two Marks each.

36. If the system of linear equations
$2x_1 + 3x_2 + 5x_3 + 7x_4 = 0$
$-2x_2 + ax_3 = 0$
$3x_3 + 2x_4 = 0$
$6x_2 + bx_4 = 0$
Has a non-trivial solution, then 'a' and 'b' are related by ____.
(A) $a + 2b = 0$ (B) $a - 2b = 0$
(C) $2a + b = 0$ (D) $2a - b = 0$

37. The coefficient of x^3 in the Maclaurin's series expansion of $(1-x)^{\frac{5}{2}}$ is _____

38. A fair die is rolled twice. Let X denote the number on the die in the first roll and let Y denote the number on the die in the second roll. Then the value of $P\left(\frac{X+Y=6}{X-Y=2}\right)$ is _____.
(A) $\frac{1}{2}$ (B) $\frac{1}{4}$
(C) $\frac{1}{8}$ (D) $\frac{1}{16}$

39. The directional derivative of $f = 3xy^2 + yz^3$ at (2, –1, 1) in the direction of the vector $4\hat{i} + 3\hat{k}$ is _____.
(A) $\frac{3}{5}$ (B) $\frac{6}{5}$
(C) $\frac{9}{5}$ (D) $\frac{12}{5}$

40. A particular integral of the differential equation $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 2y = x^3$ is_____.

(A) $-x^3$ (B) $-e^{x^3}$

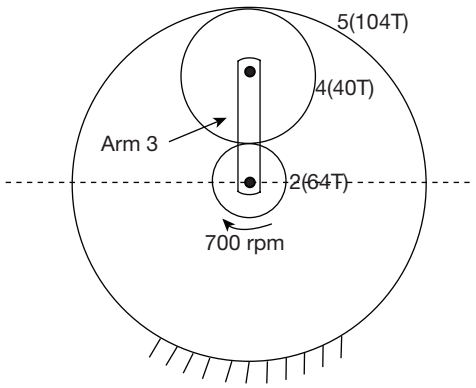
(C) x^3 (D) e^{-x^3}

41. A hollow enclosure is formed between two infinitely concentric cylinders of radii 1 m and 1.5 m respectively. Radiative heat exchange takes place between the inner surface of the larger cylinder (surface – 2) and the outer surface of smaller cylinder (surface – 1). The radiating surfaces are diffuse and medium in the enclosure is non-participating. The fraction of the thermal radiation leaving the larger surface and striking itself is

(A) $\frac{4}{5}$ (B) $\frac{2}{3}$

(C) $\frac{1}{2}$ (D) $\frac{1}{3}$

42.



A planetary gear train is shown in figure. Gears 2, 4 and 5 have 64, 40 and 104 teeth respectively. Annular gear 5 is fixed. Gear 2 is rotating clockwise at 700 rpm. The rpm of the arm 3 is _____ .

43. The inlet and outlet condition of steam of an adiabatic steam turbine are as given below.

Inlet

$h_1 = 3200$ kJ/kg

$v_1 = 160$ m/s

$z_1 = 10$ m

$p_1 = 3$ MPa

Outlet

$h_2 = 2600$ kJ/kg

$v_2 = 100$ m/s

$z_2 = 6$ m

$p_2 = 70$ kPa

Steam flow rate is 18 kg/s. Power output of the turbine (in MW) is _____ .

44. In orthogonal turning of a cylindrical work piece the following conditions are used

Cutting velocity = 180 m/min

Feed = 0.2 mm/rev

Depth of cut = 3 mm

Chip thickness ratio = 0.5

Orthogonal rake angle = 7°

If shear strength of the work piece material is 248 MPa, value of shear force (in newton) is _____ .

45. In the production of a product, fixed cost per month is ₹60,000 variable cost per unit and selling price per unit are ₹200 and ₹300 respectively. Production capacity is 2000 units per month.

If production is carried out at 90% of the production capacity, monthly profit is _____ .

46. A laminar incompressible flow is taking place in a horizontal circular pipe of length L. The head loss is h_1. For the same fluid and pipe length, when the rate of flow is doubled and diameter is halved, the head loss is h_2. Then ratio h_2/h_1 is

(A) 16 (B) 32

(C) 64 (D) 128

47. Two cubical castings of same metal and sizes 3 cm side and 5 cm side are moulded in green sand. If the smaller casting solidifies in 3 minutes, solidification time expected for the larger casting is _____

48. Nitrogen gas (molecular weight 28) is enclosed in a cylinder by a piston, at initial condition of 3 bar, 300 K and 1.5 m^3. The gas slowly expands under isothermal conditions in a particular process, until its volume becomes 3 m^3. Heat exchange occurs with the atmosphere at 300 K during this process. The entropy change for the system during the process in kJ/K is _____ .

49. A simply supported beam of span 6 m has a uniform circular cross section of diameter 80 mm. If it is loaded with a uniformly distributed load of 2 kN/m, maximum value of bending stress in Mpa is

(A) 122 (B) 179

(C) 203 (D) 256

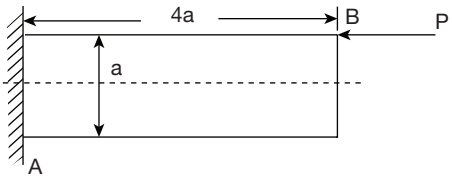
50. The pressure, temperature and velocity of air flowing in a pipe are 6 bar, 600 K and 60 m/s respectively. The specific heats of air at constant pressure and constant volume are 1.005 kJ/kg K and 0.718 kJ/kg K respectively. Neglect potential energy. If the pressure and temperature of the surroundings are 1 bar and 300 K respectively, the available energy in kJ/kg of the air stream is _____ .

51. A spur gear has a module of 4 mm, number of teeth 24, a face width of 32 mm and a pressure angle of 20°. It is transmitting a power of 5 kW at 40 rev/s. Taking a velocity factor of 1.5 and a form factor of 0.3, the stress in gear tooth (in MPa) is about

(A) 16.20 (B) 10.8

(C) 24.70 (D) 36.90

52. A rod of square cross section of side a and length 4a is subjected to a compressive force P at B, middle of top edge as shown in the figure. Magnitude of stress at point A is



(A) $\frac{P}{a^2}$ (B) $\frac{2P}{a^2}$

(C) $\frac{3P}{a^2}$ (D) $\frac{4P}{a^2}$

53. In a rolling process a 4 mm thick strip is reduced to 3 mm thick using 300 mm diameter, rolls rotating at 100 rpm. Velocity of the strip at neutral point (in m/s) is _____

54. A double pipe counter flow heat exchanger is to be designed to cool 7200 kg/hour of an oil of specific heat 1.95 kJ/kg K from 90°C to 55°C by water entering the heat exchanger at 25°C and leaving at 40°C. If the overall heat transfer coefficient of the heat exchanger is 450 W/m^{2}K, the minimum surface area required for heat exchanger (in m^2) is

(A) 14.362 (B) 11.395

(C) 7.748 (D) 4.893

55. A round billet of 60 mm diameter and length 100 mm is extruded using direct extrusion process at an extrusion ratio 4. Average flow stress of the material is 300 MPa. Assuming ideal deformation process, pressure (in MPa) on the ram is

(A) 369 (B) 416

(C) 452 (D) 497

56. A sinusoidal force of 20 N amplitude and frequency ω is applied along the axis of the spring of a single degree freedom spring-mass system. Given damping factor = 0.25, stiffness of spring = 250 N/m and undamped natural frequency is 5ω. At steady state, the amplitude of vibration (in m) is nearly

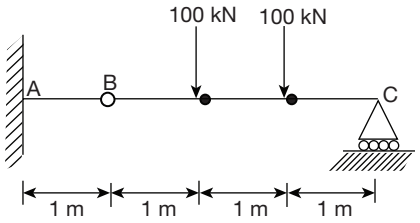
(A) 0.083 (B) 0.321

(C) 0.767 (D) 0.447

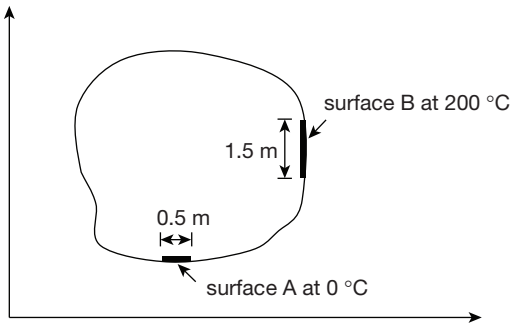
57. A cylindrical pressure vessel with vertical axis has diameter 0.24 m and length 1.48 m. It is closed at both ends and contains water upto a height of 1 m. When it is rotated at an angular velocity of 50 radian per second, the height of the paraboloid formed (in metre) is _____

58. The crank length in a slider crank mechanism is 200 mm and the length of connecting rod is 800 mm. If the crank rotates with a uniform angular speed of 10 rad/s, the magnitude of the maximum acceleration of the slider (in m/s^2) is _____.

59. Two bars *AB* and *BC* are connected by a hinge at *B* and loaded as shown in the figure. The value of bending moment (in kN m) at the mid point of bar *BC* is _____



60.



Steady two-dimensional heat conduction takes place in a body (having a constant thermal conductivity of 0.15 W/mK) as shown in figure. The normal temperature gradients over surface *A* and *B* can be considered to be uniform. The temperature gradient $\frac{\partial T}{\partial y}$ at surface *A* is equal to 18 K/m. Surface A and *B* are maintained at constant temperatures as shown in figure while the remaining part of boundary is insulated. The values of $\frac{\partial T}{\partial x}$ and $\frac{\partial T}{\partial y}$ at surface *B* are

(A) $\frac{\partial T}{\partial x} = 6$ K/m , $\frac{\partial T}{\partial y} = 0$ K/m

(B) $\frac{\partial T}{\partial x} = 54$ K/m , $\frac{\partial T}{\partial y} = 0$ K/m

(C) $\frac{\partial T}{\partial x} = 0$ K/m, $\frac{\partial T}{\partial y} = 6$ K/m

(D) $\frac{\partial T}{\partial x} = 12$ K/m, $\frac{\partial T}{\partial y} = 0$ K/m

61. A four stroke, 4 cylinder, spark ignition engine with bore 8 cm and stroke 10 cm develops 22 kW at 3000 rpm. Clearance volume of each cylinder is 55 cm^3. Brake thermal efficiency of the engine is 50% of the air standard efficiency. If calorific value of the fuel is 43 MJ/kg, fuel consumption is

(A) 4.6 kg/hr (B) 6.1 kg/hr

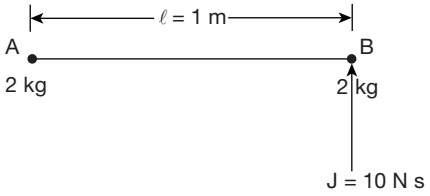
(C) 7.3 kg/hr (D) 8.2 kg/hr

62. Aluminum plates are spot welded using laser at a temperature of 30°C, focusing 0.5 J energy on an area of 0.04 mm^2. Aluminium has density 2700 kg/m^3, specific heat 896 J/kg, melting temperature 933 K and latent heat of melting 398 kJ/kg.

Assuming circular cross sectional area of weld, which is uniform through out, maximum depth of weld is

(A) 2.76 mm (B) 3.24 mm
(C) 3.65 mm (D) 4.81 mm

63.



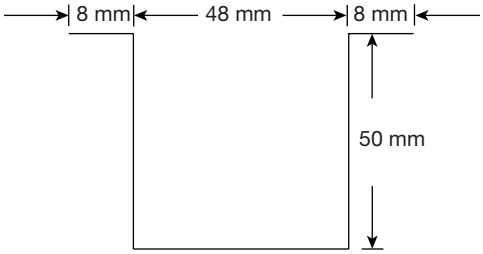
Two particles A and B, each of mass 2 kg, is connected by a light rigid rod of length $\ell = 1$ m. This arrangement is placed on a smooth horizontal floor as shown in figure and an impulse J = 10 Ns is given to particle B at right angle to rod AB. The angular velocity (is rad/s) attained by the rod is _____ .

64. The optimistic time (t_0) most likely time (t_m) and pessimistic time (t_p) of the activites (in days) in the critical path A – B – C –D of a project are as follows.

Critical Activity	t_0	t_m	t_p
A	5	6	7
B	2	4	6
C	4	5	6
D	2	3	4

Standard deviation of the critical path (in days) is _____ .

65. A cylindrical cup of 48 mm diameter and height 50 mm with 8 mm flange as shown in the figure is to be drawn from low carbon steel sheet of thickness 0.8 mm. Trimming allowance is 4 mm on radius



Neglecting effect of corner radius, size of blank required is

(A) 117 mm (B) 125 mm
(C) 133 mm (D) 140 mm

Answer Keys

1. B	**2.** 2	**3.** D	**4.** A	**5.** A	**6.** C	**7.** D	**8.** C	**9.** B	**10.** A
11. 0	**12.** B	**13.** C	**14.** 7	**15.** C	**16.** 0.12 to 0.13		**17.** B	**18.** 3.12 to 3.14	
19. 165 to 166		**20.** C	**21.** 2.8 to 2.9		**22.** 0.2 to 0.3		**23.** C	**24.** 17,500	
25. D	**26.** C	**27.** B	**28.** 0.6	**29.** 2.20 to 2.22		**30.** 1	**31.** 28 to 29		**32.** A
33. C	**34.** A	**35.** A	**36.** D	**37.** –0.32 to –0.31		**38.** B	**39.** A	**40.** A	**41.** D
42. 266 to 267		**43.** 10.92 to 10.96		**44.** 318 to 319		**45.** 120,000		**46.** B	
47. 8.3 to 8.4		**48.** 1.0397 to 1.0400		**49.** B	**50.** 248.00 to 249.00		**51.** A	**52.** B	
53. 1.56 to 1.58		**54.** C	**55.** B	**56.** A	**57.** 1.31 to 1.34		**58.** 24.90 to 25.10		**59.** 100
60. A	**61.** B	**62.** D	**63.** 4.95 to 5.15		**64.** 0.87 to 0.89		**65.** B		

Hints and Explanations

1. The given statement is a hypothetical one. An unreal situation is presented here so the verb "were" is apt.
Choice (B)

2. Let t hours be the time taken to cross each other.
Then, distance covered by Ram, to meet the other = xt km → (1)
The distance covered by Shyam, to meet the other = yt km → (2)
But, as per data, (1) is y times (2).
Hence, $xt = (y)(yt)$;
$\Rightarrow \quad x = y^2$.
It is given that $x = 4$; hence $y = 2$.

3. Khadar's wife's daughter is Khadar's daughter whose mother is Khadar's wife. Khadar's wife's daughter-in-law is Khadar's daughter-in-law. Her husband's father is Khadar himself. Choice (D)

4. Except (A) all the other combinations have a synonymous relationship. "Empirical" is that which can be practically proved while "emaciated" is lean and weak. Momentous means significant. In (A) both the words are antonyms. Beatific means sublime while mundane is common or coarse. Choice (A)

5. The ratio of sales of Kissan to Sil is the highest in the year 2012 and this highest ratio equals 2.19.
Choice (A)

6. The right idiom to fit the bill is "stood their ground", which means to stick to one's stand on one's

decision. To "pass the buck" is to shrug off responsibility, "broaden one's horizons" is to enlarge one's range of activities and world and "to hear something on the grapevine" is to get to know something via rumours. To "promise somebody the moon" is to promise somebody something that is impossible to deliver. Choice (C)

7. Statement (i) is about disposal techniques which is not the point of discussion or the source of the problem. Similarly (iii) is not the point of discussion which actually finds a solution to the problem. The possible solutions are offered in (ii) and (iv). It is necessary to create awareness among public and staff to incorporate safe injection practices and make extensive use of AD syringes. Choice (D)

8. Let $x = \sqrt{5+\sqrt{5-\sqrt{5+\sqrt{5-\text{------}}}}}$

We can see that $x > \sqrt{5}$ ($\sqrt{5} \approx 2.25$)

Choice (1): $\frac{\sqrt{13}-1}{2} \approx \frac{3.6-1}{2} \approx 1.3$

Choice (2): $\frac{\sqrt{17}-1}{7} \approx \frac{4.2-1}{2} \approx 1.6$

$\therefore \quad (x^2-5)^2 = 5 - x$ - - - (1)

Now consider $x = \frac{\sqrt{17}+1}{2}$ - - - (2)

$\therefore \quad 5 - x = \frac{9-\sqrt{17}}{2}$

$(2) \Rightarrow x^2 = \frac{18+2\sqrt{17}}{4} = \frac{9+\sqrt{17}}{2}$

$\therefore \quad x^2 - 5 = \frac{\sqrt{17}-1}{2}$

$\therefore \quad (x^2-5)^2 = \frac{18-2\sqrt{17}}{4} = \frac{9-\sqrt{17}}{2}$

$\therefore \quad x = \frac{\sqrt{17}+1}{2}$ satisfies (1) Choice (C)

9. The sentence which is logically valid and can be inferred from the given sentence is:
America would not have entered the world war if Japan would not have attacked the Pearl Harbour.
Japan's attack on pearl Harbour is cited as the reason for the America entering. Choice (B)

10. Statement (A) is grammatically correct and clearly brings out the intended meaning that a tip today would be enough to buy a meal three years ago. Choice (B) is ungrammatical as "today's" does not use an apostrophe. In (C) "three-years-ago meal" distorts the meaning. (D) uses "would costed" which is ungrammatical. Choice (A)

11. We have to evaluate $\int_c \frac{z^2+6z+10}{z^2+9}$

Where C is the circle $|z - i| = 1$

Let $f(z) = \frac{z^2+6z+10}{z^2+9}$

$z = \pm 3i$ are the singularities of $f(z)$ and $z = \pm 3i$ lie outside the circle $|z - i| = 1$

By Cauchy's integral theorem

$$\oint_c \frac{z^2+6z+10}{z^2+9}dz = \oint_c f(z)dz = 0.$$ Ans:0

12. We have $\int_0^4 \frac{dx}{(4x+3)} = \int_0^4 \frac{1}{(4x+3)}dx$

Here $a = 0$; $b = 4$ and $n = 8 \Rightarrow h = \frac{b-a}{n} = \frac{1}{2}$

$f(x) = \frac{1}{(4x+3)} \Rightarrow f^1(x) = \frac{-4}{(4x+3)^2}$ and

$f^{11}(x) = \frac{32}{(4x+3)^3}$

Magnitude of maximum error $= \frac{(b-a)h^2}{12}$ M

where $M = \underset{0\le x\le 4}{Max} |f^{11}(x)| = \underset{0\le x\le 4}{Max} \left|\frac{32}{(4x+3)^3}\right| = \frac{32}{27}$

The magnitude of maximum error

$= \frac{(4-0)\times\left(\frac{1}{2}\right)^2}{12} \times \frac{32}{27} = \frac{8}{81}$

The magnitude of error is atmost $\frac{8}{81}$. Choice (B)

13. Standard result. Choice (C)

14. We know that in the Taylor's series expansion of a function $f(x, y)$ in powers of $(x - a)$ and $(y - b)$, the coefficient of $(x-a)^2 = \frac{1}{2!} f_{xx}(a, b)$

$= \frac{1}{2!} \frac{\partial^2 f}{\partial x^2}$ at (a, b)

Here $f(x, y) = 2x^3 + 3y^2 + 5x^2y - 6$ and $(a, b) = (2, -1)$

$\Rightarrow \quad f_x(x, y) = \frac{\partial f}{\partial x} = 6x^2 + 10xy$ and

$f_{xx}(x, y) = \frac{\partial^2 f}{\partial x^2} \frac{\partial^2 f}{\partial x^2} = 12x + 10y$

$\therefore \quad f_{xx}(2, -1) = \frac{\partial^2 f}{\partial x^2}$ at $(2, -1)$

$= 12 \times 2 + 10 \times (-1) = 14$

The coefficient of $(x - 2)^2$ in the Taylor's series expansion of $f(x, y) = \frac{1}{2} \times 14 = 7$. Ans:7

15. Standard result. Choice (C)

16. Primary shear load $F_1 = \frac{P}{n} = \frac{6\,\text{kN}}{2} = 3\,\text{kN}$

Secondary shear load, $F_2 = \frac{Pe}{\left(r_1^2 + r_2^2\right)} \times r_1$

$$= \frac{6 \times (1.75 + 0.25)}{\left[0.25^2 + 0.25^2\right]} \times 0.25 = 24\ \text{kN}$$

$\therefore \frac{F_1}{F_2} = \frac{3}{24} = \frac{1}{8} = 0.125$. Ans:0.12 to 0.13

17. Choice (B)

18. Velocity of A just before impact is $U_A = \sqrt{2gh}$

Velocity of B just before impact is $U_B = 0$

After collision, both A and B move downloads together with same velocity V

$\therefore$ From conservation of linear momentum,

$$V_A = \frac{m_A u_A + m_B u_B}{(m_A + m_B)} = \frac{1 \times \sqrt{2gh} + 0}{(1+1)}$$

$$= \frac{1}{2}\sqrt{2gh} = \sqrt{\frac{2gh}{4}}$$

$$= \sqrt{\frac{gh}{2}} = \sqrt{\frac{9.8 \times 2}{2}} = 3.1305\ \text{m/s}$$

Ans 3.12 to 3.14

19. Change in stress = 300 MPa

Change in strain = 0.0015

Young's modulus $E = \frac{300}{0.0015}$

$= 2 \times 10^5$ MPa = 200 GPa

$G = 77$ GPa

$$\frac{9}{E} = \frac{3}{G} + \frac{1}{K}$$

$$\Rightarrow \frac{1}{K} = \frac{9}{E} - \frac{3}{G} = \frac{9}{200} - \frac{3}{77}$$

$\Rightarrow K = 165.6$ GPa Ans:165 to 166

20. For viscous flow between two parallel plates $\frac{V_{\max}}{V_{av}} = 1.5$

$\therefore V_{\max} = 3 \times 1.5 = 4.5$ m/s. Choice (C)

21. Lattice parameter is the side length of a unit cell expressed in terms of radius of atom

For FCC structure, $a^2 + a^2 = (4r)^2$

$2a^2 = 16r^2$

$$\Rightarrow a = \frac{4}{\sqrt{2}}r$$

$$\Rightarrow \frac{a}{r} = \frac{4}{\sqrt{2}} = 2.8284.$$ Ans:2.8 to 2.9

22. $Pr = \frac{\mu C_p}{k} = \frac{0.001 \times 1000}{1} = 1$

But $\text{Pr}^{\frac{1}{3}} = \left(\frac{\delta h}{\delta t}\right) \rightarrow \delta_h = \delta_t$

$\therefore \delta_t = \delta_h = 0.237$ mm Ans:0.3 to 0.3

23. Choice (C)

24. EOQ = 5000 units

$C_c = ₹7$/unit

Annual carrying cost = $\frac{EOQ}{2} \times C_c$

$$= \frac{5000}{2} \times 7 = ₹17{,}500$$

At optimum total inventory cost, annual ordering cost = annual carrying cost

= ₹17,500 Ans:17,500

25. Arrival rate $\lambda = 5$ per hr

Service rate $\mu = \frac{1}{10}$ per minute

$$= \frac{60}{10} = 6 \text{ per hr.}$$

Average numbers waiting for service

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{5^2}{6(6-5)} = \frac{25}{6} = 4.16.$$ Choice (D)

26. For an ideal gas having a degree of freedom f, $C_v = \left(\frac{f}{2}\right)R$ and $C_p = \left(\frac{f}{2}+1\right)R$ where R is its specific gas constant, which depends upon molecular weight. $f = (3N - \text{I})$ where N is the number of atoms in the molecule and I = number of independent relations between molecules. Hence specific heats of an ideal gas depends upon its molecular weight and structure. Choice (C)

28. $C_{c_1} = 2\sqrt{mk} = 0.1$ kg/s

$C_{c_2} = 2\sqrt{3m \times 12k} = 6\ C_{c_1} = 6 \times 0.1 = 0.6$ kg/s

Ans:0.6

29. Values of enthalpy in kJ/kg

at exit of evaporater $h_1 = 230$

at inlet of condenser $h_2 = 282$

at exit of condenser $h_3 = 115$

$$\text{COP} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{230 - 115}{282 - 230} \quad [\because h_4 = h_3] = \frac{115}{52} = 2.21$$

Ans:2.20 to 2.22

30. $F = 3(N-1) - 2P_1$

$= 3(8-1) - 2 \times 10 = 21 - 20 = 1$. Ans:1

31. Power $P = T\omega$

$\therefore 12 \times 10^3 = T \times 420$

$\Rightarrow T = 28.57$ Nm Ans:28 to 29

32. $u = ax$

$v = ay$

Equation of stream line $\frac{u}{dx} = \frac{v}{dy}$

$\therefore \quad \frac{ax}{dx} = \frac{ay}{dy}$ or $\frac{dx}{x} = \frac{dy}{y}$

Integrating, $\ell n\ x = \ell n\ y + \ell n\ c$

$\Rightarrow \quad \frac{x}{y} = c$

For point (2, 1) $\frac{2}{1} = c$

Or $c = 2$

$\therefore$ The equation is $\frac{x}{y} = 2$

or $x = 2y$ or $x - 2y = 0$. Choice (A)

33. Higher limit of shaft is in between the Higher and Lower limits of hole. So it is a transition fit.

Choice (C)

34. f μ $\frac{\mu N}{p} \propto \frac{\mu N \ell d}{W}$ $\left(\because p = \frac{W}{\ell d}\right)$. Choice (A)

35. In a forced vortex, $v = \omega r$

or $v\ \mu\ r$ Choice (A)

36. Given system of linear equations is

$$\left.\begin{aligned} 2x_1 + 3x_2 + 5x_3 + 7x_4 &= 0 \\ -2x_2 + ax_3 &= 0 \\ 3x_3 + 2x_4 &= 0 \\ 6x_2 + bx_4 &= 0 \end{aligned}\right\} \quad \text{---------- (1)}$$

(1) can be written in matrix form as $AX = O$

Where $A = \begin{bmatrix} 2 & 3 & 5 & 7 \\ 0 & -2 & a & 0 \\ 0 & 0 & 3 & 2 \\ 0 & 6 & 0 & b \end{bmatrix}$; $X = d/4$ and $O = \frac{29}{9}$

Given that (1) has a non-trivial solution

$\Rightarrow$ Det $(A) = 0$ $\Rightarrow \quad \frac{31}{9} = 0$

$\Rightarrow \quad 2\ \frac{40}{9} = 0$ $\Rightarrow \quad 2\ \frac{34}{9} = 0$

$\Rightarrow \quad 2(-6b + 12a) = 0$ $\Rightarrow \quad 2a - b = 0.$

Choice (D)

37. Let $f(x) = y\sqrt{y}$

The coefficient of x^3 in the Maclaurin's series expansion of $f(x) = \frac{dy}{dx}$

$f(x) = \sqrt{-1} \Rightarrow f(x) = \frac{\pi}{4} + 2n\pi\ \ \frac{\pi}{4} + n\pi$

$\Rightarrow \quad \mathbf{f}'(x) = \frac{\pi}{8} + 2n\pi \times \frac{\pi}{8} + n\pi\ \ \frac{2}{t}$ and

$f'(x) = \frac{t^3}{3} + \frac{3}{2}t^2 + 2\cos t\ \ \frac{d}{4} \times \frac{1}{4} \times \frac{1}{8}\ \ \frac{8}{3}$

$\therefore \quad f'(0) = \frac{5}{3}$

The coefficient of x^3 in the Maclaurin's series expansion of $\frac{2}{3} = \frac{1}{2} = \frac{2}{3} = -0.3125$

Ans:–0.32 to –0.31

38. Given that X and Y denote the numbers shown up on the die in the first roll and the second roll respectively

$\therefore \quad P(X + Y = 6/X - Y = 2) = \frac{3}{5} = \frac{3}{4}$

$= 50^{+0.020}_{+0.000} = 50^{+0.045}_{+0.025}$

($\because$ X and Y are independent random variables)

$\frac{\lambda}{\mu} = \frac{\lambda}{3\mu}$. Choice (B)

39. Given $f = 3xy^2 + yz^3$

$\Rightarrow \quad \nabla f = \frac{3\lambda}{\mu} + \frac{\lambda}{(\mu)^3} + \frac{d^2y}{dx^2}$

$= 3y^2\ \frac{dy}{dx} + (6xy + z^3)\ \sqrt{2x-3} + 3yz^2$

$\oint_C \left(xydy - \frac{3}{2}y^2dx\right)$,

$\nabla f_{at(2,-1,1)} = 3\frac{280}{2187} - 11\frac{140}{6561} - 3\frac{280}{6561}$

Let $\frac{140}{2187} = 4\frac{m^2k}{W} + 3\bar{k}$

Unit vector along $\bar{a} = \hat{n} = \frac{\bar{a}}{|\bar{a}|} = \frac{4i + 3\bar{k}}{\sqrt{4^2 + 3^2}}$

$= \frac{4}{5}\ i + \frac{3}{5}\ \bar{k}$

The directional derivative of f in the direction of $\bar{a}$ is $\nabla f.\ \hat{n} = (3i - 11j - 3\bar{k}).\left(\frac{4}{5}i + \frac{3}{5}\bar{k}\right)$

$= \frac{12}{5} - \frac{9}{5} = \frac{3}{5}$. Choice (A)

40. Given differential equation is

$x^2\frac{d^2y}{dx^2} - 3x\ \frac{dy}{dx} + 2y = x^3$ ---------- (1)

(1) is a Cauchy's homogeneous linear equation

Put $x = e^z (OR)\ z = \ln x$

$\Rightarrow \quad x\ \frac{dy}{dx} = \theta\ y$ and $x^2\ \frac{d^2y}{dx^2} = \theta\ (\theta - 1)\ y$, where

$\theta = \frac{d}{dz}$

$\therefore$ (1) becomes $\theta\ (\theta - 1)\ y - 3\theta y + 2y = (e^z)^3$

$\Rightarrow \quad (\theta^2 - \theta - 3\theta + 2)y = e^{3z}$

$\Rightarrow \quad (\theta^2 - 4\theta + 2)\ y = e^{3z}$ ---------- (2)

The particular integral of (1) is

$$y_p = \frac{1}{f(e)} X = \frac{1}{(e^2 - 4\theta + 2)} e^{3z}$$

$$= \frac{1}{(3^2 - 4\times 3 + 2)} e^{3z}$$

$y_p = -e^{3z} = -(e^z)^3 = -x^3$. Choice (A)

41. $r_1 = 1$ m, $r_2 = 1.5$ m

$F_{22} = ?$

$F_{11} + F_{12} = 1$ ($\because$ enclosure);

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

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

$A_1 F_{12} = A_2 F_{21}$

$$\Rightarrow \quad F_{21} = \frac{A_1}{A_2} = \frac{\pi d_1 \ell}{\pi d_2 \ell} = \frac{d_1}{d_2} = \frac{r_1}{r_2} = \frac{1}{1.5} = \frac{2}{3}$$

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

$$\therefore \quad F_{22} = 1 - F_{21} = 1 - \frac{2}{3} = \frac{1}{3}.$$ Choice (D)

42. $T_2 = 64$, $T_4 = 40$, $T_5 = 104$

Sl. No.	Operation	Arm 3	Gear 2	Gear 4	Gear 5
1.	Arm is fixed and gear 2 is given 1 rotation CW	0	+1	$-\left(\frac{T_2}{T_4}\right) = -\frac{64}{40} = -1.6$	$-1.6 \times \left(\frac{T_4}{T_5}\right) = -1.6 \times \frac{40}{104} = -0.61538$
2.	Arm is fixed and gear 2 is given +x rotation (CW)	0	+x	–1.6x	–0.61538 x
3.	Arm is given +y rotation (CW)	+y	+y	+y	+y
4.	Resultant	+y	x + y	–1.6x + y	–0.61538x + y

Given $x + y = 700$ -----(i)

($\because$ Gear 2 is given +700 rpm)

and $-0.61538x + y = 0$ -----(ii)

($\because$ Gear 5 is fixed)

$$\text{(i)} - \text{(ii)} \Rightarrow 1.61538x = 700 \Rightarrow x = \frac{700}{1.61538}$$

$\therefore \quad x = 433.3345$

$y = 700 - x = 700 - 433.3345 = 266.6655$ rpm

Hence rpm of arm is 266.6655 rpm (*CW*)

Ans:266 to 267

43. Applying steady flow energy equation (SFEE)

$$h_1 + \frac{v_1^2}{2} + gz_1 + q = h_2 + \frac{v_2^2}{2} + gz_2 + w$$

where w = work done /kg of steam

As it is an adiabatic turbine, heat input $q = 0$

$$\therefore \quad 3200 \times 10^3 + \frac{160^2}{2} + 9.81 \times 10$$

$$= 2600 \times 10^3 + \frac{100^2}{2} + 9.81 \times 6 + w$$

$\Rightarrow \quad W = 607839.24$

$\therefore$ Power output $= \dot{m} \times W$

$= 18 \times 607839.24$

$= 10941.11$ kW $= 10.94$ MW.

Ans:10.92 to 10.96

44. Cutting velocity $= V_c = 180$ m/min

Feed = 0.2 mm/rev

Depth of cut = 3 mm

Chip thickness ratio $r = 0.5$

Rake angle $\alpha = 7°$

Shear strength $\tau = 248$ MPa

$$\tan\phi = \frac{\cos\alpha}{\frac{1}{r} - \sin\alpha} = \frac{\cos 7}{2 - \sin 7} = 0.5285$$

$\Rightarrow \quad \sin\phi = 0.4672$

Shear force $F = \tau \times a = \frac{\tau t_1 w}{\sin\varphi}$

$$= \frac{\tau \times \text{feed} \times \text{depth of cut}}{\sin\varphi}$$

$$= \frac{248 \times 0.2 \times 3}{0.4672} = 318.47 \text{ N.}$$ Ans:318 to 319

45. $F = ₹60{,}000$ / month

$v = ₹200$/unit; $s = ₹300$/unit

Quantity produced / month

$Q = 2000 \times 0.9 = 1800$ units

$F + P = Q(s - v)$ where P = monthly profit

$\therefore \quad 60{,}000 + P = 1800(300 - 200)$

$\Rightarrow \quad P = ₹120{,}000$ Ans:120,000

46. Head loss $h = \frac{32\mu\bar{u}L}{\omega d^2} = \frac{128\mu QL}{\omega d^4}$

$\therefore \quad h \mu \frac{Q}{d^4}$

$$\frac{h_2}{h_1} = \frac{2Q_1}{\left(\frac{d_1}{2}\right)^4} \Big/ \frac{Q_1}{d_1^4} = \frac{2}{\left(\frac{1}{2}\right)^4} = 2 \times 2^4 = 32$$

Choice (B)

47. Solidification time $t = C\left(\frac{V}{A}\right)^2$

where V = volume and A = surface area

$\frac{V}{A}$ for a cube $= \frac{a}{6}$, where a = side size

$$\therefore \quad \frac{t_2}{t_1} = \left(\frac{a_2}{6}\right)^2 \Big/ \left(\frac{a_1}{6}\right)^2 = \left(\frac{a_2}{a_1}\right)^2 = \left(\frac{5}{3}\right)^2$$

$$\Rightarrow \quad t_2 = 3 \times \left(\frac{5}{3}\right)^2 = 8.33 \text{ minutes} \qquad \text{Ans:8.3 to 8.4}$$

48. $P_1 = 3$ bar $= 300$ k Pa, $V_1 = 1.5\ m^3$, $T_1 = 300$ K, $V_2 = m^3$

$$m = \frac{P_1V_1}{RT_1} = \frac{P_1V_1}{\left(\frac{\bar{R}}{M}T_1\right)} = \frac{300 \times 1.5}{\left(\frac{8.314}{28}\right) \times 300}$$

$= 5.0517$ kg $\qquad (\because R = \frac{\bar{R}}{M})$

$Q_{1-2} = W_{1-2}$ for isothermal process

$$= mRT_1 \ln\left(\frac{V_2}{V_1}\right)$$

$$= 5.0517 \times \left(\frac{8.314}{28}\right) \times 300 \ln\left(\frac{3}{1.5}\right)$$

$= 311.915$ kJ

$$\Delta S = S_2 - S_1 = \frac{Q_{1-2}}{T_1} = \frac{311.915}{300}$$

$= 1.0397$ kJ/K. $\qquad$ Ans:1.0390 to 1.0400

49. Maximum bending moment (at the centre of beam)

$$M = \frac{wl^2}{8} = \frac{2 \times 6^2}{8} = 9 \text{ kN m}$$

Maximum bending stress $f = \frac{M}{z} = \frac{M}{\left(\frac{\pi d^3}{32}\right)}$

$$= \frac{9 \times 10^3 \times 32 \times 10^{-6}}{\pi \times (0.08)^3} = 179.05 \text{ MPa.} \qquad \text{Choice (B)}$$

50. $$AE = \left\{\left(h_1 + \frac{V_1^2}{2000}\right) - h_2\right\} - T_0(S_1 - S_2)$$

$$= \left\{C_P(T_1 - T_2) + \frac{V_1^2}{2000}\right\} - T_0(S_1 - S_2)$$

$$(S_2 - S_1) = C_P \ln\frac{T_2}{T_1} - R\ln\left(\frac{P_2}{P_1}\right)$$

$$= 1.005 \ln\left(\frac{300}{600}\right) - 0.287 \ln\left(\frac{1}{6}\right)$$

$= -0.696613 + 0.514235$

$= -0.182378$ kJ/kg K

$\therefore \quad (S_1 - S_2) = 0.182378$ kJ/kg K

$$\therefore \quad AE = \left\{1.005(600 - 300) + \frac{60^2}{2000}\right\} -$$

300×0.182378

$= (301.50 + 1.8) - 54.7134$

$= 248.5866$ kJ/kg. $\qquad$ Ans:248.0000 to 249.0000

51. Torque transmitted by tooth,

$$T = \frac{Power}{2\pi N} = \frac{5 \times 10^3}{2\pi \times 40} = 19.894 \text{ N m}$$

Tangential force on tooth,

$$F_t = \frac{T}{r} = \frac{2T}{D} = \frac{2T}{mZ} = \frac{2 \times 19.894}{0.004 \times 24}$$

$\left(\because m = 0.004 \text{ m and } z = 24 \text{ teeth}\right) = 414.458$ N

But $F_t = \sigma w m y C_v$

$$\Rightarrow \quad \sigma = \frac{F_t}{wmyC_v}$$

$(w = 0.032$ m, $m = 0.004$ m, $y = 0.3$, $C_v = \frac{1}{1.5})$

$$= \frac{414.458 \times 1.5}{0.032 \times 0.004 \times 0.3 \times 1}$$

$= 16.1898 \times 10^6 \frac{N}{m^2} = 16.1898 \frac{N}{m^2}$

$= 16.1898$ MPa $\cong 16.20$ MPa. $\qquad$ Choice (A)

52. The rod is subjected to an axial compressible stress $\frac{P}{a^2}$ and a bending moment $\frac{P \times a}{2}$

Bending stress (Tensile at bottom)

$$= \frac{M}{Z} = \frac{Pa}{2} \Big/ \frac{a^3}{6} = \frac{3P}{a^2}$$

Stress at point A

= Axial stress (compressive) + bending stress (tensile)

$$= \frac{P}{a^2} - \frac{3P}{a^2} = -\frac{2P}{a^2} \qquad \text{Choice (B)}$$

53. At neutral point, velocity of strip = Surface velocity of the roll

$$= \frac{\pi DN}{60} = \frac{\pi \times 0.3 \times 100}{60}$$

$= 1.57$ m/s $\qquad$ Ans:1.56 to 1.58

54. Counter flow heat exchanger $\dot{m}_h = \frac{7200}{3600} = 2$ kg/s

$C_{ph} = 1.95$ kJ/kg K $= 1950$ J/kg K

$T_{hi} = 90$ °C, $T_{ho} = 55$°C

$T_{ci} = 25$ °C, $T_{co} = 45$ °C

$U = 450$ W/m² K

$$\therefore \quad \text{LMTD} = \frac{\theta_1 - \theta_2}{\ell n\left(\frac{\theta_1}{\theta_2}\right)} = \frac{50 - 30}{\ell n\left(\frac{50}{30}\right)}$$

$$= \frac{20}{\ell n\left(\frac{5}{3}\right)} = 39.15\ ^\circ\text{C}$$

$$\dot{Q} = C_h (T_{hi} - T_{ho}) = \dot{m}_h \times C_{ph} \left(T_{h_i} - T_{h_o}\right)$$

= UA (LMTD)

$\therefore$ $2 \times 1950(90 - 55) = 450 \times A \times 39.15$

$\Rightarrow$ $A = \dfrac{2 \times 1950 \times 35}{450 \times 39.15} = 7.748 \text{ m}^2$ Choice (C)

55. Initial area of cross section $A_0 = \dfrac{\pi}{4}(60)^2$

$= 2827.43 \text{ mm}^2$

Flow stress $\sigma_y = 300$ MPa

Extrusion ratio $\dfrac{A_0}{A_1} = 4$

Extrusion force at ideal condition

$EF = A_0 \sigma_y \ln \dfrac{A_0}{A_1}$

$= 2827.43 \times 300 \times \ln 4 = 1175{,}896$ N

Pressure on ram $= \dfrac{EF}{A_0} = \dfrac{1175896}{2827.43} = 415.89 \text{ N/mm}^2$

Choice (B)

56. $\omega_n = 5\ \omega \rightarrow \dfrac{\omega}{\omega n} = \dfrac{1}{5} = 0.2$

$\xi = 0.25$, $k = 250$ N/m and $F_{max} = 20$ N

$\therefore$ Amplitude $A = \dfrac{F}{\sqrt{\left(k - m\omega^2\right)^2 + (c\omega)^2}}$

$$= \frac{\frac{F}{k}}{\sqrt{\left\{1 - \left(\frac{\omega}{\omega_n}\right)^2\right\}^2 + \left(2\xi \frac{\omega}{\omega_n}\right)^2}}$$

$$= \frac{\frac{20}{250}}{\sqrt{\left\{1 - \left(\frac{1}{5}\right)^2\right\}^2 + \left(2 \times 0.25 \times \frac{1}{5}\right)^2}}$$

$$= \frac{\frac{2}{25}}{\sqrt{\left(1 - \frac{1}{25}\right)^2 + \left(\frac{1}{10}\right)^2}} = \frac{\frac{2}{25}}{\sqrt{\left(\frac{24}{25}\right)^2 + \left(\frac{1}{10}\right)^2}}$$

$$= \frac{\frac{2}{25}}{\sqrt{0.9216 + 0.01}} = \frac{0.08}{\sqrt{0.9316}}$$

$$= \frac{0.08}{0.9652} = 0.083 \text{ m.}$$ Choice (A)

57. Angular velocity $\omega = 50$ rad/s

Volume of air before rotation

= Volume of paraboloid formed

$\pi \times (0.12)^2 \times (1.48 - 1) = \dfrac{1}{2}\pi r^2 Z$

$\Rightarrow$ $r^2 Z = 0.0138$ ------ (1)

$Z = \dfrac{\omega^2 r^2}{2g} = \dfrac{50^2 r^2}{2 \times 9.81} = 127.42\ r^2$

$\Rightarrow$ $r^2 = \dfrac{Z}{127.42}$

Substituting in (1) $\dfrac{Z^2}{127.42} = 0.0138$

$\Rightarrow$ $Z = 1.326$ m. Ans:1.31 to 1.34

58. $r = 0.2\ m$, $\omega = 10$ rad/s

$n = \dfrac{\ell}{r} = \dfrac{800}{400} = 4$

Acceleration of slider, $f_{max} = r\omega^2 \left[1 + \dfrac{1}{n}\right]$

$= 0.2 \times 10^2 \left[1 + \dfrac{1}{4}\right]$

$= 0.2 \times 100 \times 1.25 = 25 \text{ m/s}^2$. Ans:24.90 to 25.10

59. The problem can be split into two as follows

Considering the simply supported part BC,

$R_B + R_C = 200$ kN

Due to symmetry, $R_B = R_C = 100$ kN

Bending moment at the midpoint D

$= R_C \times 1.5 - 100 \times 0.5$

$= 100 \times 1.5 - 50 = 100$ kNm. Ans:100

60. Heat enters the body at B, parallel to X-axis and leaves the body at A, parallel to Y-axis

Hence $\dfrac{\partial T}{\partial y} = 0$ at B (and $\dfrac{\partial T}{\partial x} = 0$ at A)

$\dot{Q}$ at $B = \dot{Q}$ at A

$\Rightarrow$ $A_B K \left(\dfrac{\partial T}{\partial x}\right)_B = A_A . K \left(\dfrac{\partial T}{\partial y}\right)_A$

$\Rightarrow$ $\left(\dfrac{\partial T}{\partial x}\right)_B = \dfrac{A_A}{A_B} . \left(\dfrac{\partial T}{\partial y}\right)_A = \dfrac{0.5 \times t}{1.5 \times t} \times 18$ K/m

$= 6$ K/m. Choice (A)

61. $D = 8$ cm; $L = 10$ cm

$N = 3000$ rpm

$V_C = 55 \text{ cm}^3$

$V_S = \dfrac{\pi D^2}{4} L = \dfrac{\pi \times 8^2 \times 10}{4} = 502.65 \text{ cm}^3$

Compression ratio $r = \dfrac{V_S + V_C}{V_C} = \dfrac{502.65 + 55}{55} = 10.14$

Air standard efficiency

$\eta_a = 1 - \left(\dfrac{1}{r}\right)^{\gamma - 1} = 1 - \left(\dfrac{1}{10.14}\right)^{0.4} = 0.6041$

Brake thermal efficiency $= 0.6041 \times 0.5 = 0.302$

$= \dfrac{\text{Brake power (kW)} \times 3600}{m_f \text{ (kg/hr)} \times CV \text{ (kJ/kg)}}$

i.e., $0.302 = \dfrac{22 \times 3600}{m_f \times 43000}$

$\Rightarrow \quad m_f = \dfrac{22 \times 3600}{0.302 \times 43000} = 6.099$ kg/hr Choice (B)

62. Heat supplied = Heat utilized

$0.5\,J = m[C_p\,\Delta T + LH] = a \times h \times \rho[C_p\,\Delta T + LH]$

$= 0.04 \times 10^{-6} \times \text{h} \times 2700$

$[896(933 - 303) + 398 \times 10^3] = 103.948\,h$

$\Rightarrow \quad h = \dfrac{0.5}{103.948} \times 10^3$ mm = 4.81 mm. Choice (D)

63. $m_A = m_B = 2$ kg

The centre of mass of the system is at C, at 0.5 m from A and B.

$I_{CM} = m_A r_1^2 + m_B r_2^2 = 2 \times (0.5)^2 + 2 \times (0.5)^2 = 1$ kg m^2

If ω is the angular velocity of rod, angular momentum of system

$L_f = I_{cm}\omega = 1 \times \omega = \omega$ kg m^2/s

Angular impulse (about CM) $= J\left(\dfrac{\ell}{2}\right)$

$= 10 \times 0.5 = 5$ kg m^2/s

= change in angular momentum $= L_f - L_i$

$= L_f$ ($\because L_i = 0$, initially) $= \omega$

$\therefore \quad \omega = 5$ rad/s Ans:4.95 to 5.15

64. Standard deviation $\sigma = \dfrac{t_p - t_0}{6}$

Variance of critical path $= \Sigma\sigma^2 = \dfrac{7}{9}$

Critical activity	Standard deviation (σ)	Variance (σ^2)
A	$\frac{1}{3}$	$\frac{1}{9}$
B	$\frac{2}{3}$	$\frac{4}{9}$
C	$\frac{1}{3}$	$\frac{1}{9}$
D	$\frac{1}{3}$	$\frac{1}{9}$

Standard deviation of critical path

$= \sqrt{Variance\ of\ \ critical\ path} = \sqrt{\dfrac{7}{9}} = 0.8819$ days

65. Trimming allowance

$TA = 4$ mm on radius

$d_1 = 48$ mm

$d_2 = 48 + 2 \times 8 = 64$ mm

Neglecting corner radius,

Blank dia $= \sqrt{d_2^2 + 4d_1h + 2TA}$

$= \sqrt{64^2 + 4 \times 48 \times 50} + 2 \times 4 = 125.03$ mm.

Choice (B)