Mock Test 3

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 pair that best expresses a relationship similar to that expressed in the pair:

1. Road : Footpath
(A) Drawing room : Kitchen
(B) River : Riverbank
(C) Box : Lock
(D) Window : Shutter

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

2. What is the total weight of 25 discs?
Statements:
I. Two-fifth of the weight of a disc is 13 kg.
II. The weights of no two discs are equal.
(A) Statement I alone is sufficient.
(B) Statement II alone is sufficient.
(C) Combining I and II sufficient.
(D) Both statements I and II together are not sufficient.

3. A function $f(x)$ is linear and has a value of 50 at $x = -4$, and a value of 6 at $x = 7$. The value of the function at $x = 8$ is ________.

***Directions for question* 4:** Fill in the blank with the correct idiom or phrase:

4. An upholder of the truth will never hesitate _________ .
(A) to let the grass grow under one's feet
(B) to see red
(C) to throw in the towel
(D) to call a spade a spade

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

5. The five corporate offices of HUL are located in five metros namely A, B, C, D and E. E is 5 km to the North-east of A, and is 2 kms to the South-east of B. D is 5 km to the North-east of B. DE = _______.
(A) 6.92 km (B) 29 km
(C) 47.27 km (D) 5.39 km

Questions 6 to 10 carry Two Marks each.

***Directions for question* 6:** Out of the four sentences, select the most suitable sentence with respect to grammar and usage:

6. (A) In the olden days, people used to worship the nature.
(B) In the olden days, people used to be worshipping nature.
(C) In the olden days, people worshipped nature.
(D) In the olden days, people used to be worshipping the nature.

Directions for question 7: Read the following paragraph and choose the correct statement:

7. One can understand, although one cannot excuse, a frightened person misbehaving, even though there was no real reason for his fright. But what amazed and angered India was the contemptuous justification of the deed when General Dyer, who had been responsible for the firing at Amritsar, and his subsequent barbarous neglect of the thousands of wounded. "That was none of my business," he had said. Some people in England and in the British government mildly criticized Dyer, but the general attitude of the British people was displayed in a debate at the House of Lords, in which praise was showered on him. All this fed the flame of wrath in India, and a great bitterness rose all over the country.
(A) General Dyer is an example of a frightened person misbehaving.
(B) The general attitude of the British people was displayed in the fact that the victims of the massacre received a fair trial.
(C) When the British government saw a great movement uprising in India, their fears grew.
(D) General Dyer's actions can neither be understood nor excused.

Directions for questions 8: The following question is based on a short argument, a set of statements, or a plan of action. For each question, select the best answer from the given choices.

8. The coolant Freon used in refrigerators was found to damage the ozone layer of the earth. Hence an urgent need was felt to substitute Freon with some other coolant which will not damage the ozone layer.
Which of the following can be a direct inference from the above statements?
(A) A coolant cheaper than Freon is available for use in the refrigerator.
(B) Coolants which do not have any damaging effects are available for use in the refrigerators.

(C) The ozone layer is on the verge of extinction.
(D) Preserving the ozone layer intact is essential for the inhabitants of the earth.

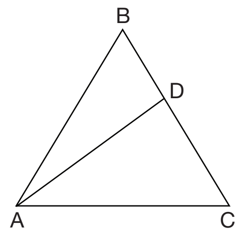
Directions for question 9: In the following question, the first and the last sentence of a passage are in order and numbered 1 and 6. The rest of the passage is split into 4 parts and numbered 2, 3, 4 and 5. These 4 parts are not arranged in the proper order. Read the sentences and arrange them in a logical sequence to make a passage and choose the correct sequence from the given options.

9. 1. Upon the same tree there are two birds of beautiful plumage, most friendly to each other.
2. This is the picture of the human soul.
3. One of the birds is eating fruits noisily while the other is sitting calm and silent without eating.
4. But the other one on top is calm and majestic.
5. The one on the lower branch is eating sweet and bitter fruits and is becoming sad and happy by turns.
6. Man is eating sweet and bitter fruits of this life, pursuing gold, sensory pleasures and the vanities of life so he is immersed in sorrow.

(A) 2, 4, 5, 3 (B) 3, 5, 4, 2
(C) 3, 4, 5, 2 (D) 5, 4, 3, 2

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

10.



In triangle ABC, AD is the angle bisector of $\angle BAC$. $\angle CAD = 60°$ $AB = 10$ cm and $CA = 12$ cm. Find the length of AD.

(A) 5 cm (B) 5.45 cm
(C) 4.55 cm (D) 4.03 cm

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. If 10 apples are to be distributed among Mahesh, Naresh and Ramesh, then the probability that Mahesh and Naresh together will get exactly 7 apples is ______.

(A) $(2/3)^{10}$ (B) $15 \times \left(\frac{2}{3}\right)^{10}$

(C) $5 \times \left(\frac{2}{3}\right)^{10}$ (D) $3 \times \left(\frac{2}{3}\right)^{10}$

12. If $z = x + iy$ and $i = \sqrt{-1}$, then the period of the complex function $f(z) = e^z$ is ______.

(A) π (B) πi
(C) 2π (D) $2\pi i$

13. The value of the definite integral $\int_1^5 \frac{\sqrt{x+5}}{\sqrt{x+5}+\sqrt{11-x}}\,dx$ is ______.

14. The iterative formula to find the 5th root of a positive real number 'R' by Newton-Raphson method is ______.

(A) $x_{K+1} = \frac{x_K^5 + R}{x_K^4}$ (B) $x_{K+1} = \frac{5x_K^4 + R}{4x_K^5}$

(C) $X_{K+1} = \frac{4x_K^5 + R}{5x_K^4}$ (D) $x_{K+1} = \frac{4x_K^5 - R}{x_K^4 + R}$

15. If 2, –3 and 5 are eigen values of a 3 × 3 matrix A with $X_1 = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$, $X_2 = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}$ and $X_3 = \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix}$ as their corresponding eigen vectors respectively, then the rank of the matrix $P = \begin{bmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{bmatrix}$ is ______.

16. A rod of length L, area of cross section A and fixed at one end is heated such that the increase in temperature is ΔT. If Young's modulus is E and coefficient of thermal expansion is α, the stress and strain developed in the rod respectively are

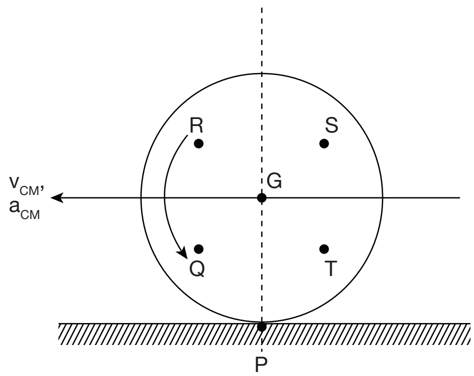
(A) $E\,\alpha\,\Delta T$, $\alpha\,\Delta T$ (B) 0, 0
(C) 0, $\alpha\,\Delta T$ (D) $E\,\alpha\,\Delta T$, 0

17. The state of stress at a point under plane stress condition is $\sigma_x = 20$ MPa, $\sigma_y = 50$ MPa and $\tau_{xy} = 20$ MPa. Radius of Mohr's circle representing the above state of stress (in N/mm²) is ________

18. A one-dimensional vibrating system, having a natural frequency of 10 Hz is executing forced vibrations under an excitor of variable frequency. If the damping ratio (ξ) of the system is 0.65, the frequency of excitor (in Hz) at which maximum amplitude of oscillation occurs is

(A) 10 (B) 3.937
(C) 6.597 (D) 8.735

19.



A thin uniform disc is rolling without slip on a rough horizontal floor. At the instant shown, the centre of mass G of disc has uniform acceleration a_{CM} and velocity V_{CM}, both directed towards left. P is the point of contact of disc with floor and some other points Q, R, S and T are marked on the disc. At the instant shown, the point on disc that is likely to have zero acceleration(ie, magnitude of acceleration is zero) is

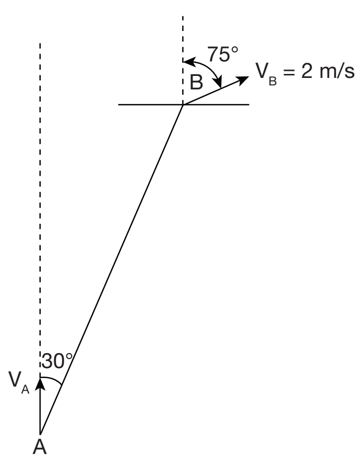
(A) Q (B) T
(C) S (D) P

20. For the given statements:

I. A square bar inside a square hole in a frame is a successfully constrained pair.
II. All lower pair joints have only one degree of freedom.

Indicate the correct answer.
(A) Both I and II are false
(B) Both I and II are true.
(C) I is true but II is false.
(D) I is false but II is true.

21.



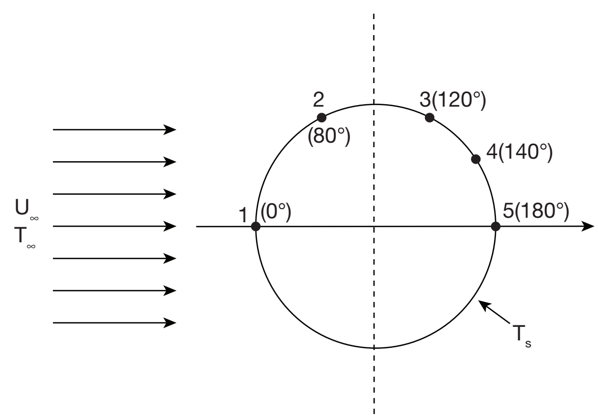
A rigid link AB is 3 m long and oriented at 30° to the vertical as shown in figure. The magnitude and direction of velocity V_B (= 2 m/s) and direction of velocity V_A are given in figure. The magnitude of V_A (in m/s) at this instant is

(A) 2.000 (B) 0.598
(C) 2.864 (D) 1.633

22. Grashof number signifies the ratio of
(A) Convective resistance in the fluid to conductive resistance in solid.
(B) Buoyancy force to viscous force in the liquid.
(C) Inertia force to viscous force in the liquid.
(D) Conductive resistance in the solid to convective resistance in the fluid.

23. Considering the relationship $Tds = dU + pdV$ between entropy(S), internal energy(U), pressure(p), temperature(T) and volume (V), which of the following statements is correct?
(A) It is valid only for an ideal gas.
(B) It is applicable only for a reversible process.
(C) For an irreversible process, $Tds > dU + pdV$
(D) It is equivalent to 1st law, for a reversible process.

24.



Consider a two dimensional transition/turbulent flow over a long cylinder as shown in figure. The free stream velocity is U_∞ and the free stream temperature T_∞ is lower than the surface temperature T_s. Consider the following statements.

(i) The local Nusselt number (Nu_L) at point 3 is more than the local Nusselt number (Nu_L) at point 1.
(ii) The local Nusselt number (Nu_L) at point 2 is the minimum value.
(iii) The local Nusselt number (Nu_L) at point 5 is less than the local Nusselt number at point 4.
(iv) The local Nusselt number (Nu_L) at point 4 is less than the local Nusslet number at point 3.

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

25. A body is completely submerged in water. It is kept such that the centre of gravity is below the centre of buoyancy. The body is under

(A) stable equilibrium
(B) unstable equilibrium
(C) neutral equilibrium
(D) neutral or unstable equilibrium

26. In a power plant, a pump having an isentropic efficiency of 0.80 is used for pumping water (density = 995 kg/m^3) from 75 kPa to 3.2 MPa. Assuming that the temperature of water remains the same, the specific work(in kJ/kg) done on the pump is
(A) 2.736 (B) 3.141
(C) 1.937 (D) 3.926

27. Chemical formula of the environment friendly refrigerant R 134 is
(A) $C_2Cl_2F_4$ (B) $C_2H_2F_4$
(C) $C_2Cl_3F_3$ (D) $CHClF_2$

28. At a railway station, there is only one ticket counter. Mean arrival rate of passengers is 40 per hour. Tickets are issued to passengers at an average rate of 50 per hour. Arrival rates and service rates can be assumed as Poisson distributed. Probability that a passenger has to wait at the counter is
(A) 0.5 (B) 0.6
(C) 0.7 (D) 0.8

29. Demand and forecast for last month was 1498 and 1250 respectively. Forecast for the current month using single exponential smoothening method with smoothening coefficient 0.3 is
(A) 1482 (B) 1395
(C) 1324 (D) 1301

30. The interpolator in a CNC machine controls
(A) spindle speed (B) coolant flow
(C) feed rate (D) tool range

31. During the assembly of machine tools, the equipment that is widely used to calibrate geometric features is
(A) Ultrasonic probe
(B) Coordinate Measuring Machine
(C) Laser interferometer
(D) Vernier calipers

32. Tendency of oxidation is a main problem in the welding of
(A) iron (B) copper
(C) silver (D) aluminium

33. In orthogonal turning of a metal piece the main cutting force was 450 N. Depth of cut was 2 mm and feed rate was 0.15 mm/revolution. The specific cutting pressure (in N/mm^2) was
(A) 1000 (B) 1500
(C) 2000 (D) 3000

34. Heating of steel having less than 0.8% carbon content above the upper critical temperature, soaking at that temperature and then cooling slowly to room temperature to form a pearlite and ferrite structure is known as
(A) Normalising (B) Tempering
(C) Annealing (D) Hardening

35. Non-consumable electrodes are used in
(A) Gas Metal Arc Welding
(B) Gas Tungsten Arc Welding
(C) Submerged Arc Welding
(D) Shielded Metal Arc Welding

Questions 26 to 55 carry Two Marks each.

36. If $P = \begin{bmatrix} 2 & 131 & -243 & 566 \\ 0 & -2i & 174 & -237 \\ 0 & 0 & 2i & 0 \\ 0 & 0 & -713 & -2 \end{bmatrix}$ then which of the following is equal to 16 P^{-1}, where P^{-1} is the inverse of the matrix P?
(A) P^2 (B) $P^2 + 16P$
(C) P^3 (D) $P^3 + 16P^2 + P$

37. In a PSU (Public Sector Undertaking), if an employee is selected at random, then the
(i) Probability that the employee has a Two-Wheeler (TW) or a Four-Wheeler (FW) is $\frac{7}{10}$
(ii) Probability that the employee has both a TW and a FW is $\frac{2}{5}$ and
(iii) Probability that the employee has a TW given that the employee has a FW is $\frac{2}{3}$.

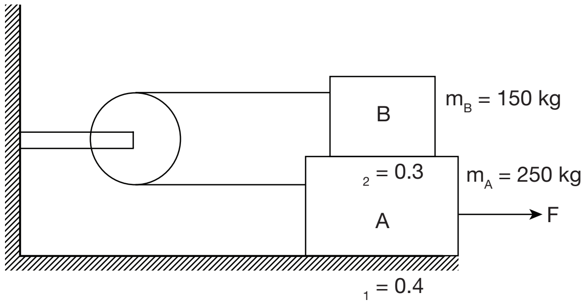
Then the probability that the randomly selected employee has a TW is ______.
(A) $\frac{3}{5}$ (B) $\frac{1}{2}$
(C) $\frac{1}{3}$ (D) $\frac{1}{4}$

38. The number of distinct stationary points of the function f(x, y) = $x^4 + y^4 - x^2 - y^2 + 1$ is ______.
(A) 3 (B) 4
(C) 7 (D) 9

39. The line integral $\int[(2x + y^2)dx + (3y - 4x)dy]$, when evaluated along a line segment from (0, 0) to (2, 1) is equal to ______.

40. The general solution of $\frac{d^2x}{dt^2} + 3\frac{dx}{dt} -$ 4x = 8 is ______.
(A) $c_1e^t + c_2e^{-4t} + 2$ (B) $c_1e^t + c_2e^{-4t} - 2$
(C) $c_1e^{-t} + c_2e^{4t} + 2$ (D) $c_1e^{-t} + c_2e^{4t} - 2$

41.



A block A of mass 250 kg is placed on a rough horizontal floor (coefficient of static friction $\mu_1 = 0.4$) Another block B of mass 150 kg is placed on A and coefficient of friction between A and B is $\mu_2 = 0.3$. The blocks are connected by a light inextensible thread passing over a smooth, light, fixed pulley as shown in figure. The minimum horizontal force F(in kN) needed to move the block B is

(A) 1.13 (B) 2.01
(C) 2.45 (D) 2.89

42. A pinion and gear with module 5 mm has a speed reduction ratio of 6 : 1. If centre distance is 420 mm, number of teeth on the pinion is _________ .

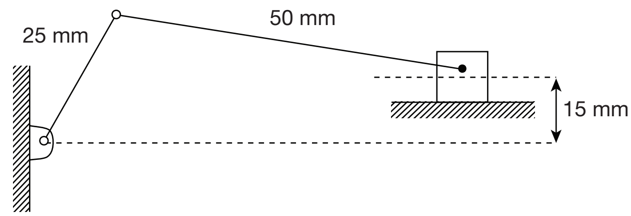
43. Consider a cantilever beam, having negligible mass and uniform flexural rigidity, with length 0.02 m. The frequency of transverse vibration of the beam, with a 0.6 kg mass attached at the free tip, is 80 Hz. The flexural rigidity (in N m^2) of the beam is

44. An ideal water jet of volume flow rate 0.06 m^3/s impinges on a fixed plate inclined 30° to its path. If jet diameter is 60 mm, force exerted in the direction of the jet (in N) is _________

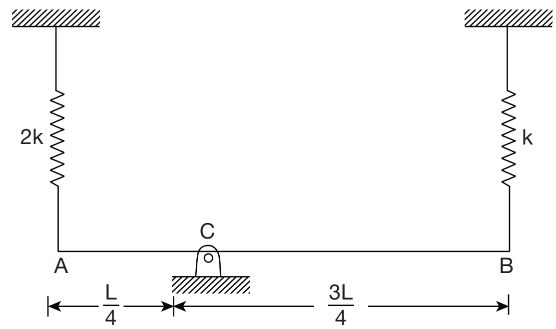
45. A block weighing 100 N is in contact with a level plane whose coefficients of static and kinetic frictions are 0.3 and 0.25 respectively. The block is acted upon by a horizontal force(in newton), $P = 5t$, where t denotes the time in second. The velocity (in m/s) attained by the block in 8 seconds is ________

46. A slider crank mechanism has a slider of mass 8 kg, stroke of 0.3 m and rotates with a uniform angular velocity of 12 rad/s. The primary inertia forces of the slider are partially balanced by a revolving mass of 5 kg at the crank, placed at a distance equal to crank radius. Neglect the mass of connecting rod and crank. When the crank angle (with respect to slider axis) is 20°, the unbalanced force (in newton) normal to the slider axis is ___________.

47. An off-set slider-crank mechanism is shown in figure at an instant. Conventionally, the quick return ratio (QRR) is considered to be greater than one. The value of QRR is ________.



48.



A uniform rigid rod AB of length L and mass m is hinged at C such that

$$AC = \frac{L}{4},\ CB = \frac{3L}{4}.$$

Ends A and B are supported by light springs of spring constants $2k$ and k respectively (see figure). The natural frequency of the
system is given by

(A) $\sqrt{\dfrac{27k}{7m}}$ (B) $\sqrt{\dfrac{39k}{7m}}$

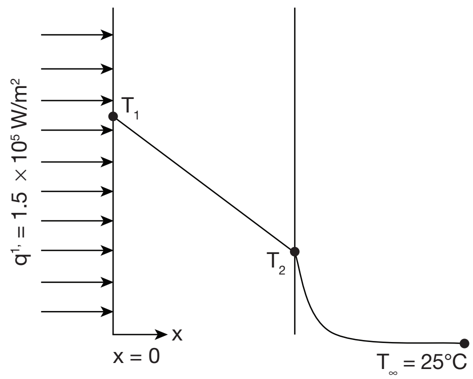
(C) $\sqrt{\dfrac{33k}{7m}}$ (D) $\sqrt{\dfrac{45k}{7m}}$

49. A hydrodynamic journal bearing is subjected to a radial load of 2500 N at a rotational speed of 2000 rpm. Bearing bore diameter is 50 mm and length is 45 mm. The bearing is lubricated with an oil of viscosity 0.03 Ns/m^2. If diametral clearance is 40 μm, Sommerfield number of the bearing is ______ .

50. A stress free rod of 250 mm length is held between two rigid immovable walls and subjected to a temperature increase of 200°C. Coefficient of thermal expansion and modulus of elasticity of the rod material are 1×10^{-5}/°C and 200 GPa respectively. Magnitude of longitudinal stress (in MPa) developed in the rod is ________ .

51. 3.5 kg of water is in saturated liquid state at 2 bar (v_f = 0.001061 m^3/kg, u_f = 504.0 kJ/kg, h_f = 505 kJ/kg). Heat is added in a constant pressure process till the temperature of water reaches 400°C (v = 1.5493 m^3/kg, u = 2967.0 kJ/kg, h = 3277.0 kJ/kg).
The heat added (in kJ) in the process is-

52.



Consider one dimensional steady state heat conduction across a wall (as shown in figure) of thickness 38 mm and thermal conductivity 16 W/m K. At $x = 0$, a constant heat flux $q'' = 1.5 \times 10^5$ W/m^2 is applied. On the otherside of the wall, heat is removed from the wall by convection with a fluid at 25°C and heat transfer coefficient of 250 W/m^2 K. The temperature (in °C) at $x = 0$ is_.

53. Water flows through a pipe of inner radius 2 cm at a rate of 0.8 kg/min. Viscosity of water is 0.001 kg/ms. Reynolds number of the flow is _____________ .

54. A fluid flows through a pipe of 10 cm diameter at a velocity of 10 cm/s. If the flow is fully developed laminar flow and kinematic viscosity of fluid is 10^{-5} m^2/s, value of coefficient of friction is ________ .

55. In a concentric shaft bearing arrangement, radial clearance between shaft and bearing is 1.5 mm. Diameter of shaft is 90 mm and tangential speed is 10 m/s. Dynamic viscosity of the lubricant is 0.1 Pas. If length of the bearing is 80 mm, frictional resisting force of the bearing (in newton) is ________

56. The non-dimensional fluid temperature profile near the surface of a convectively cooled flat plate is given by $\frac{T_w - T}{T_w - T_\infty} = d + c\left(\frac{y}{L}\right) + b\left(\frac{y}{L}\right)^2 + a\left(\frac{y}{L}\right)^3$, where y is measured perpendicular to the plate, L is the length and a, b, c and d are non-zero constants. T_w and T_∞ are the wall and ambient temperatures respectively. If the thermal conductivity of the fluid is k and the wall heat flux is q", the Nusselt number Nu $= \frac{q'' L}{(T_w - T_\infty)k}$ is equal to

(A) c (B) b
(C) d (D) $c + 2b$

57. In an air-standard Otto cycle, air is supplied at 0.12 MPa and 300 K. The ratio of specific heats(γ) and gas constant (R) for air are 1.4 and 288.8 J/kg K respectively. If the compression ratio is 7.5 and the maximum temperature in the cycle is 2500 K, the heat(in kJ/kg) supplied to the engine is _______.

58. A reversible heat engine receives 0.5 kJ of heat from a reservoir at 800 K and certain amount of heat from another reservoir at 1000 K. It rejects 1 kJ of heat to a third reservoir at 400 K. The net work output (in kJ) is

(A) 1.250 (B) 1.375
(C) 1.425 (D) 1.565

59. An ideal reheat Rankine cycle operates between pressure limits of A kPa and B MPa, with reheat being done at C MPa. The temperature at the inlet of both turbines is 550°C and the enthalpy of steam is 3295 kJ/kg at the exit of high pressure turbine and 2337 kJ/kg at the exit of low pressure turbine. The enthalpy of water at the exit of the pump is 201 kJ/kg. Use the following table for relevant data.

Super heated temperature (°C)	Pressure (MPa)	v (m^3/kg)	h kJ/kg	s kJ/kgK
550	C	0.08711	3521	7.1034
550	B	0.04263	3467	6.6359

Disregarding pump work, the cycle efficiency (in percentage) is _______.

60. At a service facility, jobs arrive at a rate of 6 per 8 hr. Average service time of a job is 45 minutes. If arrival of jobs follows Poisson distribution and service time follows exponential distribution, idle time (in hrs) at the service facility per 8 hr. is

(A) 2.5 (B) 3
(C) 3.5 (D) 4

61. In a wire drawing process, the length of the wire at any instant is given by $L(t) = L_0(1 + t^2)$ where t is the time in minutes and L_0 is the initial length. The true strain rate at the end of 0.5 min (in min^{-1}) is __________

62. In orthogonal turning of a cylindrical work piece, the following conditions are used. Cutting velocity : 175 m/min. Feed : 0.2 mm/rev. Depth of cut : 3 mm. Chip thickness ratio : 0.5
Orthogonal rake angle = 8°
Shear strength of the work piece : 260 MPa. Applying Merchants' theory, shear force required (in Newton) is ________

63. An assembly is specified as 30H6/g7. With respect to the specification, match group A with group B

Group A	**Group B**
P. H	I. Shaft tolerance grade
Q. g	II. Hole type
R. 7	III. Shaft type
S. 6	IV. Hole tolerance grade

(A) P – I Q – II R – III S – IV
(B) P – II Q – III R – I S – IV
(C) P – III Q – IV R – I S – II
(D) P – IV Q – I R – II S – III

64. If the values of Taylor's tool life exponent and tool changing time are 0.3 and 2 min respectively, then the tool life (in min) for maximum production rate is ________ .

65. An aluminium alloy casting of 300 mm outside diameter and height 200 mm has a cylindrical concentric hole of height 120 mm and diameter 100 mm at the top. A sand core is to be used for casting the hole portion. If the density of the molten alloy is 2500 kg/m^3 and sand core has a density of 1600 kg/m^3, net buoyancy force (in newton) acting on the core would be ________ .

Answer Keys

1. B **2.** D **3.** **2** **4.** D **5.** D **6.** C **7.** D **8.** D **9.** B **10.** B
11. B **12.** D **13.** **2** **14.** C **15.** **3** **16.** C **17.** **25** **18.** B **19.** A **20.** A
21. D **22.** B **23.** D **24.** C **25.** A **26.** D **27.** B **28.** D **29.** C **30.** C
31. C **32.** D **33.** B **34.** A **35.** B **36.** C **37.** B **38.** D **39.** 2.15 to 2.18
40. B **41.** C **42.** 24 **43.** 0.3950 to 0.4350 **44.** 317.5 to 319.5 **45.** 1.850 to 2.000
46. 35.50 to 37.5 **47.** 1.3000 to 1.3500 **48.** C **49.** 1.390 to 1.415 **50.** 400 **51.** 9695 to 9710
52. 980 to 982 **53.** 423 to 425 **54.** 0.015 to 0.017 **55.** 14.9 to 15.2 **56.** A
57. 1300 to 1350 **58.** B **59.** 37.5 to 39.5 **60.** C **61.** 0.75 to 0.85 **62.** 331 to 333
63. B **64.** 4.6 to 4.7 **65.** 8.31 to 8.33

Hints and Explanations

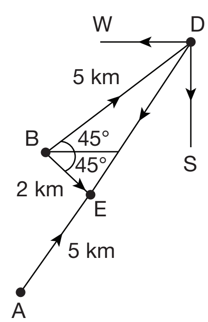
1. Choice (B) is correct. A footpath runs along the road on either side. Similarly, a riverbank runs along the river on either side. Choice (B)

2. I 2/5th of the weight of a single disc is 13 kg. But we don't know if each disc has the same weight or not. I alone is not sufficient.
We do not know the weight of each disc.
$\therefore$ We cannot find the total weight of 25 discs.
II alone is not sufficient
I, II we still cannot answer the question.
Choice (D)

3. Let $f(x) = ax + b$ where a and b are constants.
$f(-4) = 50$ and $f(7) = 6$
$-4a + b = 50$ ...... (1)
$\underline{7a + b = 6}$ ...... (2)
$-11\,a = 44$
$a = -4$
Substituting in (1), we get $16 + b = 50$
$\Rightarrow$ $b = 34$
$\therefore$ $f(x) = -4x + 34.$
When $x = 8$
$f(x) = -4\,(8) + 34 = -32 + 34 = 2$
$\therefore$ $f(8) = 2.$ Ans:2

4. The right choice is "to call a spade a spade" which means to speak very frankly and openly. None of the other options go as they are negative in connotation. "To see red" is to be afraid, "to throw in the towel" is to accept defeat and "to let the grass grow under one's feet" is to idle too long without any work.
Choice (D)

5.



$\angle B = 90°$
$DE = \sqrt{DB^2 + BE^2} = \sqrt{5^2 + 2^2}$ km
$= \sqrt{29}$ km ≈ 5.39 km. Choice (D)

6. "Nature" is not preceded by "the" so choices (A) and (D) are ruled out. In (B) the tense is incorrect for a completed action. Choice (C) uses the simple past tense for a completed action and it is correct.
Choice (C)

7. All the statements except (D) can be proved false by the passage itself. (A) is not what General Dyer was. Statement (B) too is a distortion of what is stated in the passage. The passage does not state that the victims got a fair trial. In fact, the trial was a travesty of justice and the public supported general Dyer's actions. Statement (C) is out of the scope of the text. Statement (D) is correct as understood from the first two lines of the passage. General Dyer was not a frightened person misbehaving so his actions can neither be understood nor excused. Choice (D)

8. Freon damages ozone layer. A need is felt to substitute Freon with some other coolant. This means that damage to ozone layer is harmful. Hence (D) is the correct answer.
As the cost is not the focus of the argument, (A) is wrong. (B) and (C) cannot be inferred. Choice (D)

9. Choice (B) is apt. The para, when rearranged, is the story of human life, metaphorically presented. 1 mentions two birds. In 3 both are described as "one" eating and the other not eating. 5 follows next as it tells as to what is being eaten, and more importantly, where it is sitting. 4 is a continuation of 5 as it tells the position of the other bird. So 5 and 4 is a definite pair. 2 is then concluding the analogy. 6 explains why it is the story of the human soul. Choice (B)

10. Area of triangle ABC = Area of ABD + Area of ADC

$\frac{1}{2}(AB)(AC)\sin\angle A = \frac{1}{2}(AB)(AD)\sin\angle BAD + \frac{1}{2}(AD)(AC)\sin\angle DAC = (AB)(AC)\sin 120°$

$= (AB)(AD)\sin 60° + (AD)(AC)\sin 60°$

$$AD = \frac{(AB)(AC)\sin 120°}{AB\sin 60° + AC\sin 60°}$$

$$= \frac{(AB)(AC)}{AB+AC} = \frac{60}{11} = 5.45 \text{ cm.}$$ Choice (B)

11. The total number of ways of distributing 10 apples among three persons Mahesh, Naresh and Ramesh = 3^{10}.
Mahesh and Naresh together has to get exactly 7 apples.
$\Rightarrow$ Mahesh and Naresh together get 7 apples and Ramesh gets 3 apples.
The number of ways of selecting 7 apples from 10 to distribute to Mahesh and Naresh = ${}^{10}C_7$.
The number of ways of distributing these 7 apples to Mahesh and Naresh = 2^7.
$\therefore$ The total number of ways of distributing 10 apples among the three persons such that Mahesh and Naresh together get 7 apples = ${}^{10}C_7 \times 2^7$.

$\therefore$ Required probability = $\dfrac{{}^{10}C_7 \times 2^7}{3^{10}}$

$$= \frac{\frac{10!}{3!\times 7!}\times 2^7}{3^{10}} = 15 \times \left(\frac{2}{3}\right)^{10}$$ Choice (B)

12. We have $e^z = e^{x+iy} = e^x(\cos y + i\sin y)$
$= e^x[\cos(y + 2\pi) + i\sin(y + 2\pi)]$
$= e^x \cdot e^{i(y+2\pi)} = e^{x+iy+2\pi i} = e^{z+2\pi i}$
$\therefore$ e^z is a periodic function with period $2\pi i$.
Choice (D)

13. We have $\displaystyle\int_1^5 \frac{\sqrt{x+5}}{\sqrt{x+5}+\sqrt{11-x}}dx$

$$= \int_1^5 \frac{\sqrt{x+5}}{\sqrt{x+5}+\sqrt{(1+5-x)+5}}dx = \frac{5-1}{2}$$

$\left(\because \displaystyle\int_a^b \frac{f(x)}{f(x)+f(a+b-x)}dx = \frac{b-a}{2}\right.$ and here $f(x) = \sqrt{5+x}$; $a = 1$ and $b = 5) = 2$ Ans : 2

14. We have to find the 5th root of 'R'
i.e., we have to find x such that $x = \sqrt[5]{R}$
$\Rightarrow$ $x^5 = R$
Let $f(x) = x^5 - R = 0$
$\Rightarrow$ $f'(x) = 5x^4$
$\therefore$ By Newton-Raphson method, we have

$$x_{K+1} = x_K - \frac{f(x_K)}{f'(x_K)} = x_K - \frac{\left(x_K^5 - R\right)}{5x_K^4}$$

$$= \frac{5x_K^5 - x_K^5 + R}{5x_K^4}$$

$$\therefore \quad x_{K+1} = \frac{4x_K^5 + R}{5x_K^4}$$ Choice (C)

15. Given that $X_1 = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$, $X_2 = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}$ and $X_3 = \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix}$ are eigenvectors of a 3 × 3 matrix A corresponding to the eigenvalues 2, –3 and 5 respectively. As all the eigen values of A are distinct, their corresponding eigenvectors X_1, X_2 and X_3 are linearly independent.

As the columns of the matrix $P = \begin{bmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{bmatrix}$ are linearly independent, P is non-singular.
$\Rightarrow$ Rank of P = Order of P = 3. Ans:3

16. Increase in length due to heating $\Delta L = \alpha\Delta TL$

Strain = $\dfrac{\Delta L}{L} = \dfrac{\alpha\Delta TL}{L} = \alpha\Delta T$

As it is a free expansion, stress developed is zero.
Choice (C)

17. $\sigma_x = 20$ MPa
$\sigma_y = 50$ MPa
$\tau_{xy} = 20$ MPa
Radius of Mohr's circle = Maximum shear stress

$$= \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^{\ 2}} = \sqrt{(-15)^2 + 20^2}$$

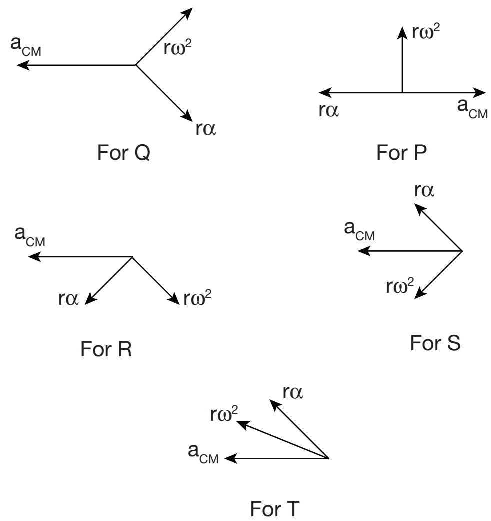
= 25 MPa = 25 N/mm^2 . Ans:25

18. $\xi < \dfrac{1}{\sqrt{2}} \Rightarrow \omega_r = \omega_n\sqrt{1-2\xi^2}$

$f_r = f_n\sqrt{1-2\xi^2}$

$= 10 \times \sqrt{1-2\times 0.65^2} = 10\times\sqrt{1-0.845} = 10 \times 0.3937$
= 3.937 Hz Choice (B)

19.



Every point is subjected to centripetal acceleration (αr) where r is the distance of that point from G and a translational acceleration (a_{CM}). The vector sum of these accelerations can be zero only for point Q.
Only point Q can have a resultant vector zero.
Choice(A)

20. A square bar inside a square hole in a frame is a completely constrained pair →I is false. Cylindrical pair, spherical pair, planar pair etc are also lower pairs and they have degree of freedom greater than 1. → II is false. Choice(A)

21. For rigidity of link AB, component of velocity of B along AB = component of velocity of A along AB

$V_B \cos(75° - 30°) = V_A \cos 30°$

$$V_A = \frac{V_B \cos 45°}{\cos 30°} = 2\times\frac{1}{\sqrt{2}}\times\frac{2}{\sqrt{3}}$$

$$= 2\times\sqrt{\frac{2}{3}} = 1.633 \text{ m/s}$$ Choice (D)

22. In free convection or natural convection, Grashof number signifies the ratio of buoyancy force to viscous force in the liquid. Choice(B)

23. $Tds = dU + pdV$ is applicable for both reversible process as well as irreversible process as it is a relation among properties of the system, which are independent of process/path. Choice(D)

24. Transition/Turbulent flow. Hence R_e = 140000 to 219,000. Point 1 and point 3 are local maximum for Nu_L with the Nu_L at point 3 $>Nu_L$ at point 1 → (i) is true. The Nu_L is minimum at point 2 → (ii) is true. From point 2 to 4, the Nu_L increases to reach a minimum value at point3, then decreases to become a minimum at point4 (But Nu_L at point 4 > Nu_L at point 2) and beyond point 4, Nu_L increases. Hence (iii) is false and (iv) is true.
Hence (i), (ii), and (iv) are true. Choice (C)

25. Choice (A)

26. Work done on pump, $W = \int_{p_1}^{p_2} vdp = \int_{p_1}^{p_2} \frac{dp}{\rho}$

$$= \frac{(p_2 - p_1)}{\rho} = \frac{(3200-75)\,kPa}{995\,(kg/m^3)} = \frac{3125}{995}$$

= 3.141 kJ/kg

$$W_{actual} = \frac{W}{\eta_{isen}} = 3.926 \text{ kJ/kg}$$ Choice(D)

27. Choice (B)

28. Arrival rate λ = 40 /hr
Service rate μ = 50/hr

Probability that a person has to wait $= \frac{\lambda}{\mu} = \frac{40}{50} = 0.8.$

Choice (D)

29. $F_t = \alpha D_{t-1} + (1 - \alpha)F_{t-1}$
$= 0.3 \times 1498 + (1 - 0.3) \times 1250$
$= 1324.4$ Choice (C)

30. Choice (C)

31. Choice (C)

32. Choice (D)

33. Cutting force F_c = 450 N
Depth cut d = 2 mm
Feed f = 0.15 mm/rev

Specific cutting pressure $= \frac{F_c}{fd}$

$$= \frac{450}{2\times 0.15} = 1500 \text{ N/mm}^2$$ Choice (B)

34. Choice (A)

35. Choice (B)

36. Given $P = \begin{bmatrix} 2 & 131 & -243 & 566 \\ 0 & -2i & 174 & -237 \\ 0 & 0 & 2i & 0 \\ 0 & 0 & -713 & -2 \end{bmatrix}$

The characteristic equation of P is |P – λI| = 0

$$\Rightarrow \begin{vmatrix} 2-\lambda & 131 & -243 & 566 \\ 0 & -2i-\lambda & 174 & -237 \\ 0 & 0 & 2i-\lambda & 0 \\ 0 & 0 & -713 & -2-\lambda \end{vmatrix} = 0$$

⇒ $(2 - \lambda)(-2i - \lambda)(2i - \lambda)(-2 - \lambda) = 0$
⇒ $(2 - \lambda)(2 + \lambda)(2i + \lambda)(2i - \lambda) = 0$
⇒ $(4 - \lambda^2)(-4 - \lambda^2) = 0$
⇒ $-(4 - \lambda^2)(4 + \lambda^2) = 0$
⇒ $16 - \lambda^4 = 0$
⇒ $\lambda^4 - 16 = 0$
∴ The characteristic equation of P is $\lambda^4 - 16 = 0$
Hence by Cayley – Hamilton theorem, we have

$P^4 - 16I_4 = 0 \rightarrow (1)$
Where I_4 = Identity matrix of order 4.
Multiplying (1) on both sides with P^{-1}, we have
$P^{-1}(P^4 - 16\, I_4) = P^{-1} \times 0$
$\Rightarrow \quad P^3 - 16\, P^{-1} = 0$
$\Rightarrow \quad 16P^{-1} = P^3$ Choice (C)

37. Let A and B denote the events of a randomly selected employee who has both a two-wheeler (TW) and a four-wheeler (FW).

$\therefore \quad P(A \cup B) = \dfrac{7}{10}$, $P(A \cap B) = \dfrac{2}{5}$ and $P(A/B) = \dfrac{2}{3}$

We know that $P(A/B) = \dfrac{P(A \cap B)}{P(B)}$

$\Rightarrow \quad P(B) = \dfrac{P(A \cap B)}{P(A/B)} = \dfrac{2/5}{2/3}$

$\Rightarrow \quad P(B) = \dfrac{3}{5}$

We know that $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

$\Rightarrow \quad \dfrac{7}{10} = P(A) + \dfrac{3}{5} - \dfrac{2}{5}$

$\Rightarrow \quad P(A) = \dfrac{7}{10} - \dfrac{3}{5} + \dfrac{2}{5} \Rightarrow P(A) = \dfrac{1}{2}$

Hence probability that a randomly selected employee has a two-wheeler (TW) $= \dfrac{1}{2}$.

Choice (B)

38. The given function is $f(x, y) = x^4 + y^4 - x^2 - y^2 + 1$

$f_x = \dfrac{\partial f}{\partial x} = 4x^3 - 2x$ and $f_y = \dfrac{\partial f}{\partial y} = 4y^3 - 2y$

At a stationary point, $f_x = 0$ and $f_y = 0$
$\Rightarrow \quad 4x^3 - 2x = 0$ and $4y^3 - 2y = 0$
$\Rightarrow \quad 2x(2x^2 - 1) = 0$ and $2y(2y^2 - 1) = 0$

$\Rightarrow \quad x = 0$ or $x = \pm\dfrac{1}{\sqrt{2}}$ and $y = 0$ or $y = \pm\dfrac{1}{\sqrt{2}}$

$\therefore$ The stationary points of $f(x, y)$ are

$(0, 0), \left(0, \dfrac{1}{\sqrt{2}}\right), \left(0, \dfrac{-1}{\sqrt{2}}\right), \left(\dfrac{1}{\sqrt{2}}, 0\right), \left(\dfrac{1}{\sqrt{2}}, \dfrac{1}{\sqrt{2}}\right),$

$\left(\dfrac{1}{\sqrt{2}}, \dfrac{-1}{\sqrt{2}}\right), \left(\dfrac{-1}{\sqrt{2}}, 0\right), \left(\dfrac{-1}{\sqrt{2}}, \dfrac{1}{\sqrt{2}}\right)$ and

$\left(\dfrac{-1}{\sqrt{2}}, \dfrac{-1}{\sqrt{2}}\right)$.

$\therefore$ The number of distinct stationary points = 9

Choice (D)

39. We have to evaluate $\int \left[(2x + y^2)dx + (3y - 4x)dy\right]$

along a line segment from (0, 0) to (2, 1).
The equation of the line joining (0, 0) and (2, 1) is $x = 2y$

$\Rightarrow \quad dx = 2dy$
Y varies from 0 to 1

$\therefore \quad \int \left[(2x + y^2)dx + (3y - 4x)dy\right]$

$= \displaystyle\int_{y=0}^{1} \left[(2(2y) + y^2)2dy + (3y - 4(2y))dy\right]$

$= \displaystyle\int_0^1 \left[8y + 2y^2 + 3y - 8y\right]dy$

$= \displaystyle\int_0^1 (2y^2 + 3y)dy = \left.\dfrac{2}{3}y^3 + \dfrac{3}{2}y^2\right]_0^1$

$= \dfrac{2}{3} + \dfrac{3}{2} = \dfrac{13}{6} = 2.167$ Ans:2.15 to 2.18

40. Given differential equation is

$\dfrac{d^2x}{dt^2} + 3\dfrac{dx}{dt} - 4x = 8 \quad \rightarrow (1)$

The general solution of (1) is $x = x_c + x_p \quad \rightarrow (2)$
Finding x_c :
The homogeneous linear differential equation corresponding to (1) is $\dfrac{d^2x}{dt^2} + 3\dfrac{dx}{dt} - 4x = 0 \rightarrow (3)$

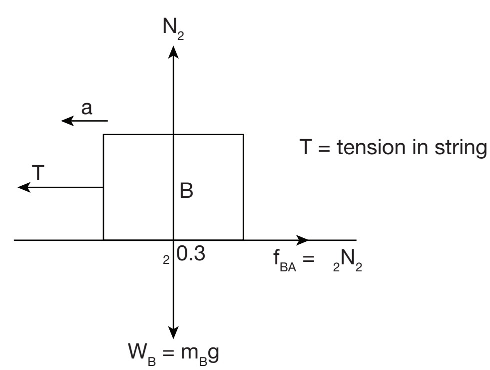
The auxiliary equation of (3) is $D^2 + 3D - 4 = 0$
$\Rightarrow \quad (D - 1)(D + 4) = 0$
$\Rightarrow \quad D = 1, -4$
$\therefore$ The complementary function of (1) is
$X_c = c_1e^t + c_2e^{-4t} \rightarrow (4)$
Finding x_p:

X_p = Particular integral $= \dfrac{1}{f(D)}X$

$= \dfrac{1}{(D^2 + 3D - 4)}8 = \dfrac{1}{(0^2 + 3 \times 0 - 4)}8$

$\therefore \quad x_p = -2 \rightarrow (5)$
Substituting (4) and (5) in (2), we get the general solution of (1) as $X = c_1e^t + c_2e^{-4t} - 2$ Choice (B)

41. Due to string constraint, block B and block A will move with same acceleration a.



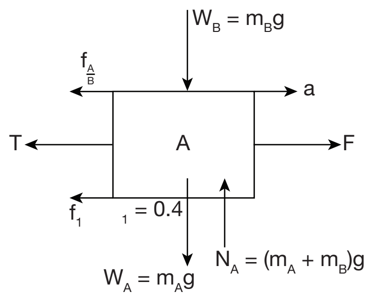
$W_B = mBg = 150 \times 9.81 = 1471.5$ N
$N_2 = W_B$ (for vertical equilibrium of B)

$= 1471.5$ N

$f_{\frac{B}{A}} = \mu_2 N_2 = 0.3 \times 1471.5 = 441.45$ N

$a = \dfrac{\left(T - f_{\frac{B}{A}}\right)}{m_B}$; When $a = 0$,

$T = f_{\frac{B}{A}} = 441.45$ N (i.e., when B is just about to move)



$f_1 = \mu_1 N_A = 0.4[250 + 150] \times 9.81 = 1569.60$ N

$F = T + f_1 + f_{\frac{A}{B}}$ (when A is about to move)

$= f_{\frac{B}{A}} + f_1 + f_{\frac{A}{B}} \left(\because f_{\frac{A}{B}} = f_{\frac{B}{A}} = 441.45\text{ N}\right)$

$= 2f_{\frac{B}{A}} + f_1$

$= 2 \times 441.45 + 1569.60$

$= 2452.50$ N $= 2.45$ kN Choice(C)

42. Module $m = 5$

Centre distance $= \dfrac{d_1 + d_2}{2} = 420$ mm

$\therefore \quad d_1 + d_2 = 840$ mm

$d_1 + d_2 = m(T_1 + T_2)$

$\Rightarrow \quad 840 = 5(T_1 + T_2)$

$\Rightarrow \quad T_1 + T_2 = 168$

$\dfrac{T_2}{T_1} = 6$

$\Rightarrow \quad T_1 + 6T_1 = 168$

$\Rightarrow \quad T_1 = 24$ Ans:24

43. $f_n = \dfrac{0.4985}{\sqrt{\delta}} \Rightarrow \delta = \left(\dfrac{0.4985}{f_n}\right)^2$

$\therefore \quad \delta = \left(\dfrac{0.4985}{80}\right)^2 = 3.8828 \times 10^{-5}$ m

But $\delta = \dfrac{WL^3}{3EI} = \dfrac{mgL^3}{3EI}$ (for cantilever with concentrated load at end)

$\Rightarrow \quad EI = \dfrac{mgL^3}{3\delta} = \dfrac{0.6 \times 9.81 \times (0.02)^3}{3 \times 3.8828 \times 10^{-5}} = 0.4042$ N m^2

Ans:0.3950 to 0.4350

44. $Q = 0.06$ m^3/s, $\theta = 30°$

$d = 60$ mm

$a = \dfrac{\pi d^2}{4} = \dfrac{\pi \times (60)^2}{4} \times 10^{-6} m^2 = 2.827 \times 10^{-3}$m^2

Force exerted $= \rho\, av^2 \sin^2\theta$

$= \dfrac{\rho a^2 v^2}{a} \sin^2\theta = \dfrac{\rho Q^2}{a} \sin^2\theta$

$= \dfrac{1000 \times (0.06)^2 \times (\sin 30)^2}{2.827 \times 10^{-3}} = 318.36$ N

Answer 317.5 to 319.5

45. Limiting friction $f_L = \mu_s N = 0.3 \times 100 = 30$ N

$P = 5t \rightarrow 30 = 5t$

$\therefore \quad t = \dfrac{30}{5} = 6$ s

Upto 6 s, the block will not move.

Beyond 6 s, the block moves and it is subjected to kinetic friction.

$f = \mu_k N = 0.25 \times 100 = 25$ N

From 6 s to 8 s, inpulse on block,

$J = \int_6^8 (P - f)\,dt = \int_6^8 (5t - 25)\,dt$

$= \left[2.5t^2 - 25t\right]_6^8$

$= 2.5\,[64 - 36] - 25[8 - 6] = 20$ kg m s^{-1}

But impulse $J = \Delta P = m\Delta V$

$= m(v - 0)$ ($\because$ u = 0 = initial velocity)

$\therefore \quad V = \dfrac{J}{m} = \dfrac{20}{\left(\dfrac{W}{g}\right)} = \dfrac{20 \times 9.81}{100} = 1.962$ m/s

Ans:1.850 to 2.000

46. Stroke L = 0.3 m

Hence crank radius $r = \dfrac{L}{2} = \dfrac{0.3}{2} = 0.15$ m

$\omega = 12$ rad/s

m (of revolving mass) = 5 kg

$\therefore \quad F_c$ = centrifugal force on $m = mr\omega^2$

$= 5 \times 0.15 \times 12^2 = 108$ N

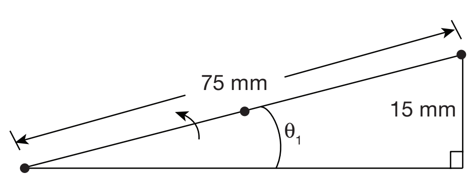
Crank angle, $\theta = 20°$

$\therefore \quad$ unbalanced force normal to slider axis,

$F_r = F_c \sin\theta = 108 \times \sin 20° = 36.94$ N

Ans:35.50 N to 37.50 N

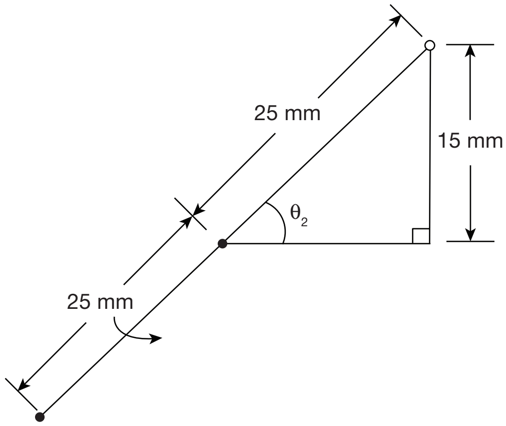
47.



Extended dead centre position

$\sin\theta_1 = \dfrac{15}{75} = 0.2$

$\Rightarrow$ $\theta_1 = \sin^{-1}(0.2) = 11.537°$



Folded dead centre position

$$\sin\theta_2 = \frac{15}{25} = 0.6$$

$\Rightarrow$ $\theta_2 = \sin^{-1}0.6 = 36.87°$

$\therefore$ $\alpha = (\theta_2 - \theta_1) = 36.87° - 11.537° = 25.333°$

$$\therefore \quad QRR = \left(\frac{180° + \alpha}{180° - \alpha}\right) = \frac{180 + 25.333}{180 - 25.333}$$

$$= \frac{205.333}{159.667} = 1.3276$$

Answer 1.3000 to 1.3500

48. I_c = moment of inertia of rod about hinge

$$C = I_G + md^2$$

$$= \frac{mL^2}{12} + m\left(\frac{L}{2} - \frac{L}{4}\right)^2$$

$$= \frac{mL^2}{12} + \frac{mL^2}{16} = \frac{7mL^2}{48}$$

$$\therefore \quad I_C = \frac{7mL^2}{48}$$

When the rod is rotated by a small angle θ from mean position, restoring forces at A and B are respectively $2kx_A$ and kx_B, where $x_A = \frac{L\theta}{4}$ and

$$x_B = \frac{3L\theta}{4}$$

$$\therefore \quad F_A = \frac{2kL\theta}{4} \text{ and } F_B = \frac{3kL\theta}{4}$$

The restoring torque, $T_R = T_A + T_B$

$$= F_A\left(\frac{L}{4}\right) + F_B\left(\frac{3L}{4}\right)$$

$$= \frac{2kL^2\theta}{16} + \frac{9kL^2\theta}{16} = \left(\frac{11kL^2}{16}\right)\theta$$

Inertial torque $T_i = I_c\alpha = \frac{7mL^2}{48}\alpha$

As per *D′* Alembert's principle, $T_i + T_R = 0$

$$\Rightarrow \quad \frac{7mL^2}{48}\alpha + \left(\frac{11kL^2}{16}\right)\theta = 0$$

$$\Rightarrow \quad \alpha = -\left(\frac{11kL^2}{16} \times \frac{48}{7mL^2}\right)\theta = -\left(\frac{33k}{7m}\right)\theta \quad (\Rightarrow \text{SHM})$$

$$\therefore \quad \omega^2 = \frac{33k}{7m}$$

$$\Rightarrow \quad \omega = \sqrt{\frac{33k}{7m}}.$$

Choice (C)

49. Load $P = 2500$ N

$L = 45$ mm $= 0.045$ m

$d = 50$ mm $= 0.05$ m

$$p = \frac{P}{A} = \frac{2500}{0.05 \times 0.045}$$

$N = 2000$ rpm

$$N_s = \frac{2000}{60} \text{ rps}$$

Diametral clearance C = 40 μ*m* = 40 × 10^{-3} mm

μ = 0.03 Ns/m²

$$\text{Sommerfield number} = \frac{\mu N_s}{p}\left(\frac{d}{c}\right)^2$$

$$= 0.03 \times \frac{2000}{60} \times \frac{0.05 \times 0.045}{2500} \times \left(\frac{50}{40 \times 10^{-3}}\right)^2 = 1.406.$$

Answer 1.39 to 1.415

50. $L = 250$ mm

$\Delta T = 200°C$

$E = 200$ GPa $= 2 \times 10^5$ N/mm²

$\alpha = 1 \times 10^{-5}$/°C

$\delta L = \alpha \Delta T L$

$$\frac{P}{E} = e = \frac{\delta L}{L} = \alpha \Delta T$$

$\Rightarrow$ Stress $\sigma = E\,\alpha\Delta T$

$= 2 \times 10^5 \times 1 \times 10^{-5} \times 200$

$= 400$ N/mm² $= 400$ MPa

Ans:400

51. $Q = m\,\Delta h$

$= 3.5\,(h_2 - h_1)$

$= 3.5 \times (3277 - 505)$

$= 3.5 \times 2772$

$= 9702$ kJ

Answer : 9695 to 9710

52. $$q'' = \frac{k(T_1 - T_2)}{L} = h(T_2 - T_\infty)$$

$$\therefore \quad T_2 = \frac{q''}{h} + T_\infty = \frac{1.5 \times 10^5}{250} + 25 = 625°C$$

$$T_1 = \frac{q''L}{k} + T_2$$

$$= \frac{1.5\times10^5 \times 0.038}{16} + 625$$

$= 356.25 + 625$

$= 981.25$ °C Ans:980 to 982

53. Radius = 2 cm = 0.02 m
Diameter = 0.02 × 2 = 0.04 m

Flow rate $Q = 0.8$ kg/min $= \dfrac{0.8}{1000\times60}$

$= 1.333 \times 10^{-5}$ m³/s
Viscosity $\mu = 0.001$ kg/ms $= 0.001$ Ns/m²

Reynolds number Re $= \dfrac{\rho Vd}{\mu} = \dfrac{\rho Q}{A}\times\dfrac{d}{\mu}$

$$= \frac{\rho Qd\times4}{\mu\pi d^2} = \frac{4Q\rho}{\pi\mu d}$$

$$= \frac{4\times1.333\times10^{-5}\times1000}{\pi\times0.001\times0.04}$$

$= 424.413$ Answer 423 to 425

54. $d = 10$ cm $= 0.1$ m
$V = 10$ cm/s $= 0.1$ m/s
$\nu = 10^{-5}$ m/s

$$\text{Re} = \frac{Vd}{\nu} = \frac{0.1\times0.1}{10^{-5}} = 1000$$

Coefficient of friction f $= \dfrac{16}{\text{Re}}$

$= \dfrac{16}{1000} = 0.016$ Answer 0.015 to 0.017

55. Clearance c = 1.5 mm = 0.0015 m
$d = 90$ mm $= 0.09$ m
$L = 80$ mm $= 0.08$ m
$\mu = 0.1$ Pas
$v = 10$ m/s

Wall shear stress $\tau_0 = \mu\dfrac{v}{c}$

$$= \frac{0.1\times10}{0.0015} = 666.67$$

Resisting force $= \tau_0 A = \tau_0 \times \pi dL$
$= 666.67 \times \pi \times 0.08 \times 0.09$
$= 15.08$ N Answer 14.9 to 15.2

56. $$\frac{T_w - T}{(T_w - T_\infty)} = d + C\left(\frac{y}{L}\right) + b\left(\frac{y}{L}\right)^2 + a\left(\frac{y}{L}\right)^3$$

$\therefore$ $T = T_w - (T_w - T_\infty) \times$

$$\left[d + c\left(\frac{y}{L}\right) + b\left(\frac{y}{L}\right)^2 + a\left(\frac{y}{L}\right)^3\right]$$

$$\therefore \quad \frac{\partial T}{\partial y} = 0 - (T_w - T_\infty)\times\left[0 + \frac{c}{L} + \frac{2by}{L^2} + \frac{3ay^2}{L^3}\right]$$

At $y = 0$, $\dfrac{\partial T}{\partial y} = -(T_w - T_\infty)\,\dfrac{c}{L}$

At $y = 0$, $q'' = -k\dfrac{\partial T}{\partial y}\Big|_{y=0}$

($\therefore$ heat flux through conduction)

$= k(T_w - T_\infty)\,\dfrac{c}{L}$

$$\therefore \quad \frac{q''}{(T_w - T_\infty)}\;\frac{L}{k} = c = Nu$$

$\therefore$ $Nu = c.$ Choice (A)

57. Process 1 – 2 is isentropic compression

$\dfrac{V_1}{V_2}$ = compression ratio = 7.5 (data)

$\gamma = 1.4$, $T_1 = 300$ K, $T_2 = ?$

$\dfrac{T_2}{T_1} = \left(\dfrac{V_1}{V_2}\right)^{\gamma-1}$ (for isentropic process)

$$\Rightarrow \quad T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 300\times(7.5)^{0.4} = 671.65 \text{ K}$$

$T_3 = 2500$ K (data)

$\therefore$ Heat supplied (at constant volume for Otto cycle)
$= mC_v(T_3 - T_2)$

$$= m\,\frac{R}{(\gamma-1)}(T_3 - T_2)$$

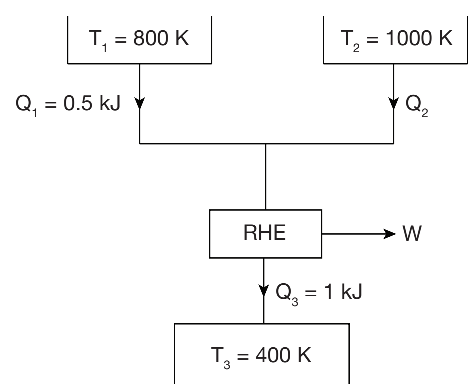
$$= 1 \times \frac{288.8}{(1.4-1)}\times(2500 - 671.65)$$

$$= \frac{288.8}{0.4}\times1828.35 = 1320{,}068.7 \text{ J/kg}$$

$= 1320.07$ kJ/kg

Answer = 1300 to 1350

58.



The arrangement is equivalent to two reversible heat engines rejecting heat to the third reservoir

$$\therefore \quad \frac{Q_3'}{Q_1} = \frac{T_3}{T_1}$$

$\Rightarrow \quad Q_3' = Q_1 \times \dfrac{T_3}{T_1} = 0.5 \times \dfrac{400}{800} = 0.25$ kJ

$\therefore \quad Q_3'' = Q_3 - Q_3' = 1 - 0.25 = 0.75$ kJ

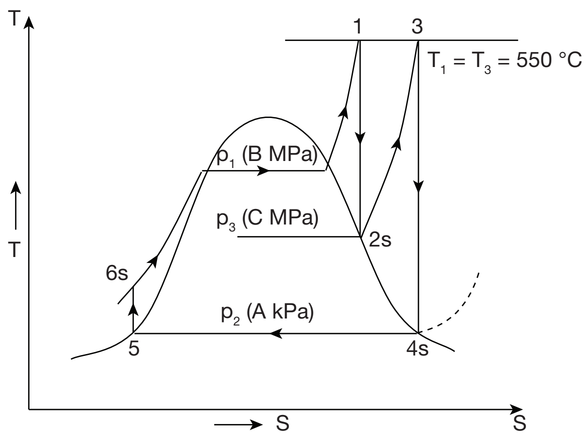
$$\frac{Q_2}{Q_3''} = \frac{T_2}{T_3}$$

$\Rightarrow \quad Q_2 = Q_3'' \times \dfrac{T_2}{T_3}$

$= 0.75 \times \dfrac{1000}{400} = 1.875$ kJ

Network output $= (Q_1 - Q_3') + (Q_2 - Q_3'')$
$= (0.5 - 0.25) + (1.875 - 0.75)$
$= 0.25 + 1.125 = 1.375$ kJ   Choice (B)

59.



Given $P_1 = B$ MPa
$P_2 = A$ kPa
$P_3 = C$ MPa
$T_1 = T_3 = 550$ °C (data)
$h_{2s} = 3295$ kJ/kg (data)
$h_{4s} = 2337$ kJ/kg (data)
$h_1 = 3467$ kJ/kg (from table)
$h_3 = 3521$ kJ/kg (from table)
$h_{6s} = 201$ kJ/kg (data)
Work done by turbine,
$W_1 = (h_1 - h_{2s}) + (h_3 - h_{4s})$
$= (3467 - 3295) + (3521 - 2337)$
$= 172 + 1184$
$= 1356$ kJ/kg
Heat supplied,
$Q_s = (h_1 - h_{6s}) + (h_3 - h_{2s})$
$= (3467 - 201) + (3521 - 3295)$
$= 3266 + 226$
$= 3492$ kJ/kg

$\therefore \quad \eta = \dfrac{W_T}{Q_s} = \dfrac{1356}{3492} = 0.3883 = 38.83\%$

Answer 37.5% to 39.5%

60. Arrival rate in 8 hrs (λ) = 6
Average service time = 45 min
Service rate in 8 hrs (μ) $= \dfrac{60 \times 8}{45} = 10.67$

Proportion of time the facility is engaged

$\rho = \dfrac{\lambda}{\mu} = \dfrac{6}{10.67} = 0.5625$

Proportion of idle time $= 1 - \rho = 1 - 0.5625 = 0.4375$
Idle time in 8 hrs $= 0.4375 \times 8 = 3.5$ hrs.   Choice (C)

61. $L(t) = L_0(1 + t^2)$

True strain $\varepsilon = \ln\left(\dfrac{A_0}{A}\right) = \ln\left(\dfrac{L}{L_0}\right)$

$= \ln\left[\dfrac{L_0\left(1+t^2\right)}{L_0}\right] = \ln(1 + t^2)$

True strain rate $= \dfrac{d\in}{dt} = \dfrac{d}{dt}\left[\ln\left(1+t^2\right)\right] = \dfrac{2t}{\left(1+t^2\right)}$

True strain rate at the end of 0.5 min

$= \dfrac{2\times 0.5}{1+(0.5)^2} = 0.8\ \text{min}^{-1}$.   Answer 0.75 to 0.85

62. Feed $= t_1 = 0.2$ mm
Depth of cut $= w = 3$ mm
Chip thickness ratio $= r = 0.5$
Shear strength $\tau = 260$ MPa
Rake angle $\alpha = 8°$

$\tan\phi = \dfrac{r\cos\alpha}{1-r\sin\alpha} = \dfrac{\cos\alpha}{\dfrac{1}{r}-\sin\alpha} = \dfrac{\cos 8}{2-\sin 8} = 0.532$

$\Rightarrow \quad \phi = 28°$
$\Rightarrow \quad \sin\phi = 0.4698$

Shear force $Fs = \dfrac{\tau w \times t_1}{\sin\varphi} = \dfrac{260\times 3\times 0.2}{0.4698} = 332$ N

Answer: 331 to 333

63. Choice (B)

64. Tool life for maximum production

$= \left(\dfrac{1}{n}-1\right)C_t = \left(\dfrac{1}{0.3}-1\right)2 = 4.67$ min

Answer: 4.6 to 4.7

65. Net buoyancy force = Weight of molten metal displaced – Weight of core

$= \dfrac{\pi d^2}{4} h \times g\left[\rho_m - \rho_s\right]$

$= \dfrac{\pi(0.1)^2}{4} \times 0.12 \times 9.81[2500-1600]$

$= 8.32$ N   Answer 8.31 to 8.33