Q.1 to Q.30 Carry One Mark Each.

1. Strokes theorem connects
   (a) a line integral and a surface integral
   (b) a surface integral and a volume integral
   (c) a line integral and a volume integral
   (d) gradient of a function and its surface integral

2. A lot has 10% defective items. Ten items are chosen randomly from this lot. The probability that exactly 2 of the chosen items are defective is
   (a) 0.0036 (b) 0.1937 (c) 0.2234 (d) 0.3874

3. $\int_{-a}^{a} \left(\sin^6 x + \sin^7 x\right) dx$ is equal to
   (a) $2\int_{0}^{a} \sin^6 x dx$ (b) $2\int_{0}^{a} \sin^7 x dx$
   (c) $2\int_{0}^{a} \left(\sin^6 x + \sin^7 x\right) dx$ (d) zero

4. **A** is a 3×4 real matrix and **A x = b** is an inconsistent system of equations. The highest possible rank of **A** is
   (a) 1 (b) 2 (c) 3 (d) 4

5. Changing the order of the integration in the double integral $I = \int_{0}^{8}\int_{\frac{x}{4}}^{2} f(x,y)\,dydx$ leads to $I = \int_{r}^{s}\int_{p}^{q} f(x,y)\,dxdy$. What is q?
   (a) 4y (b) $16y^2$ (c) x (d) 8

6. The time variation of the position of a particle in rectilinear motion is given by $x - 2t^3 + t^2 + 2t$. If ν is the velocity and a the acceleration of the particle in consistent units, the motion started with
   (a) ν=0, a=0 (b) ν=0, a=2 (c) ν=2 a=0 (d) ν=2 a=2

7. A simple pendulum of length 5m, with a bob of mass 1 kg, is in simple harmonic motion. As it passes through its mean position, the bob has a speed of 5 m/s. the net force on the bob at the mean position is
   (a) zero (b) 2.5 N (c) 5 N (d) 25 N

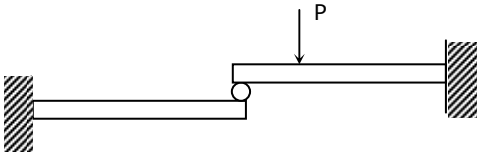
8. A uniform, slender cylindrical rod is made of a homogeneous and isotropic material. The rod rests on a frictionless surface. The rod is heated uniformly. If the radial and longitudinal thermal stresses are represented by σ_r and σ_z, respectively, then

(a) $\sigma_r = 0, \sigma_z = 0$ (b) $\sigma_r \neq 0, \sigma_z = 0$

(c) $\sigma_r = 0, \sigma_z \neq 0$ (d) $\sigma_r \neq 0, \sigma_z \neq 0$

9. Two identical cantilever beams are supported as shown, with their free ends in contact through a rigid roller. After the load P is applied, the free ends will have

(a) equal deflections but not equal slopes
(b) equal slopes but not equal deflections
(c) equal slopes as well as equal deflections
(d) neither equal slopes nor equal deflections



10. The number of degrees of freedom of a planar linkage with 8 links and 9 simple revolute joints is

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

11. There are four samples P, Q, R and S, with natural frequencies 64, 96, 128 and 256 Hz respectively. There are mounted on test setups for conducting vibration experiments. If a loud pure not of frequency 144 Hz is produced by some instrument, which of the samples will show the most perceptible induced vibration?

(a) P (b) Q (c) R (d) S

12. Which one of the following is a criterion in the design of hydrodynamic journal bearings?

(a) Sommerfeld number (b) Rating life

(c) Specific dynamic capacity (d) Rotation factor

13. The velocity components in the x and y directions of a two dimensional potential flow are u and v, respectively, then $\frac{\partial u}{\partial x}$ is equal to

(a) $\frac{\partial v}{\partial x}$ (b) $-\frac{\partial v}{\partial x}$ (c) $\frac{\partial v}{\partial y}$ (d) $-\frac{\partial v}{\partial y}$

14. In a case of one dimensional heat conduction in a medium with constant properties, T is the temperature at position x, at time t. then $\frac{\partial T}{\partial t}$ is proportional to

(a) $\frac{T}{x}$ (b) $\frac{\partial T}{\partial x}$ (c) $\frac{\partial^2 T}{\partial x \partial t}$ (d) $\frac{\partial^2 T}{\partial x^2}$

15. The following four figures have been drawn to represent a fictitious thermodynamics cycle, on the p-v and T-s planes.

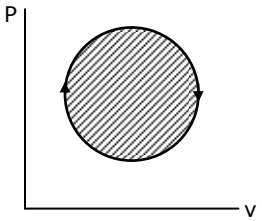


Figure 1

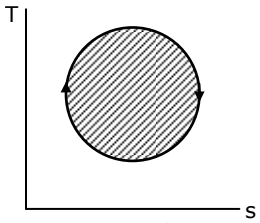


Figure 2

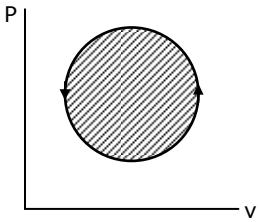
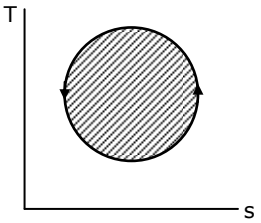


Figure 3



Figure

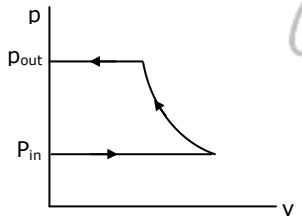
According to the first law of thermodynamics, equal areas are enclosed by

(a) Figures 1 and 2 (b) Figures 1 and 3

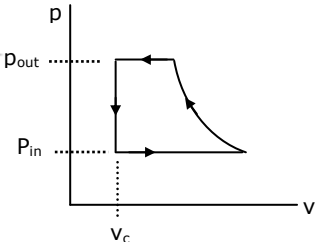
(c) Figures 1 and 4 (d) Figures 2 and 3

16. A p-v diagram has been obtained from a test on a reciprocating compressor. Which of the following represents that diagram?

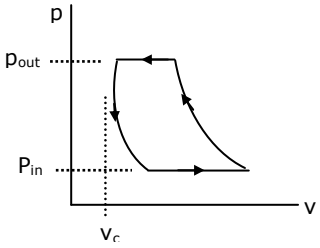
(a)



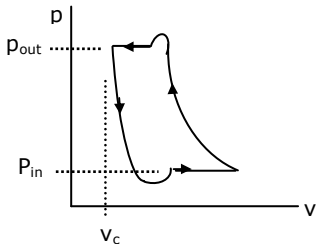
(b)



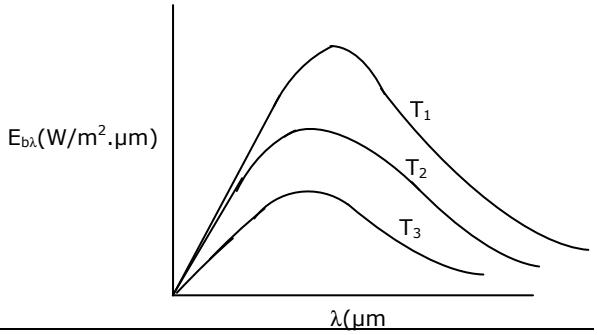
(c)



(d)



17. The following figure was generated from experimental data relating spectral black body emissive power to wave length at three temperatures T_1, T_2 and $T_3\,(T_1 > T_2 < T_3)$.



The conclusion is that the measurements are

(a) correct because the maxima in $E_{b\lambda}$ show that correct trend

(b) correct because Planck's law is satisfied

(c) wrong because the Stefan Boltzmann law is not satisfied

(d) wrong because Wien's displacement law is not satisfied

18. For a typical sample of ambient air (at 35°C, 75% relative humidity and standard atmospheric pressure), the amount of moisture in kg per kg of dry air will be approximately

(a) 0.002 (b) 0.027 (c) 0.25 (d) 0.75

19. Water at 42° is sprayed into a stream of air at atmospheric pressure, dry bulb temperature of 40°C and a wet bulb temperature of 20°C. The air leaving the spray humidifier is not saturated. Which of the following statements is true?

(a) Air gets cooled and humidified (b) Air gets heated and humidified

(c) Air gets heated and dehumidified (d) Air gets cooled and dehumidified

20. Match the items of List I (Equipment) with the items of List II (Process) and select the correct answer using the given codes.

List I (Equipment)	**List (Process)**
P – Hot Chamber Machine	1 – Cleaning
Q – Muller	2 – Core making
R – Dielectric Baker	3 – Die casting
S – Sand Blaster	4 – Annealing
	5 – Sand mixing

(a) P – 2 Q – 1 R – 4 S - 5 (b) P – 4 Q – 2 R – 3 S - 5

(c) P – 4 Q – 5 R – 1 S - 2 (d) P – 3 Q – 5 R – 2 S - 1

21. When the temperature of a solid metal increases.

(a) strength of the metal decreases but ductility increases

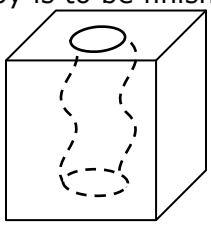
(b) both strength and ductility of the metal decrease

(c) both strength and ductility of the metal increase

(d) strength of the metal increases but ductility decreases

22. The strength of a brazed joint
    (a) decreases with increase in gap between the two joining surfaces
    (b) increases with increase in gap between the two joining surfaces
    (c) decreases up to certain gap between the two joining surfaces beyond which it increases
    (d) increases up to certain gap between the two joining surfaces beyond which it decreases

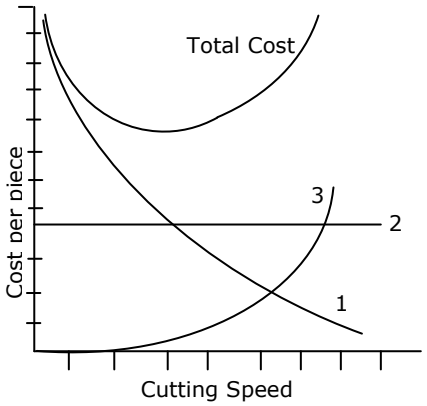
23. A zigzag cavity in a block of high strength alloy is to be finish machined. This can be carried out by using
    (a) electric discharge machining
    (b) electro-chemical machining
    (c) laser beam machining
    (d) abrasive flow machining



24. In order to have interfernce fit, it is essential that the lower limit of the shaft should be
    (a) greater than the upper limit of the hole
    (b) lesser than the upper limit of the hole
    (c) greater than the lower limit of the hole
    (d) lesser than the lower limit of the hole

25. When 3-2-1 principle in used to support and locate a three dimensional work-piece during machining, the number of degrees of freedom that are restricted is
    (a) 7 (b) 8 (c) 9 (d) 10

26. The figure below shows a graph, which qualitatively relates cutting speed and cost per piece produced.



The three curves, 1, 2 and 3 respectively represent

(a) machining cost, non-productive cost, tool changing cost
(b) non-productive cost, machining cost, tool changing cost
(c) tool changing cost, machining cost, non-productive cost
(d) tool changing cost, non-productive cost, machining cost

27. Which among the NC operations given below are continuous path operations?

Arc Welding (AW)	*Milling (M)*
Drilling (D)	Punching in Sheet Metal (P)
Laser Cutting of Sheet Metal (LC)	Spot Welding (SW)

(a) AW, LC and M
(b) AW, D, LC and M
(c) D, LC, P and SW
(d) D, LC and SW

28. An assembly activity is represented on an Operation Process Chart by the symbol

(a) □ (b) A (c) D (d) O

29. The sales of a product during the last four years were 860, 880, 870 and 890 units. The forecast for the fourth year was 876 units. If the forecast for the fifth year, using simple exponential smoothing, is equal to the forecast using a three period moving average, the value of the exponential smoothing constant α is

(a) $\frac{1}{7}$ (b) $\frac{1}{5}$ (c) $\frac{2}{7}$ (d) $\frac{2}{5}$

30. Consider a single server queuing model with Poisson arrivals $(\lambda = 4/\text{hour})$ and exponential service $(\mu = 4/\text{hour})$. The number in the system is restricted to a maximum of 10. the probability that a person who comes in leaves without joining the queue is

(a) $\frac{1}{11}$ (b) $\frac{1}{10}$ (c) $\frac{1}{9}$ (d) $\frac{1}{2}$

Q.31 to Q.80 Carry One Marks Each.

31. Which one of the following is an eigen vector of the matrix $\begin{bmatrix} 5 & 0 & 0 & 0 \\ 0 & 5 & 0 & 0 \\ 0 & 0 & 2 & 1 \\ 0 & 0 & 3 & 1 \end{bmatrix}$?

(a) $\begin{bmatrix} 1 \\ -2 \\ 0 \\ 0 \end{bmatrix}$ (b) $\begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$ (c) $\begin{bmatrix} 1 \\ 0 \\ 0 \\ -2 \end{bmatrix}$ (d) $\begin{bmatrix} 1 \\ -1 \\ 2 \\ 1 \end{bmatrix}$

32. With a 1 unit change in b, what is the change in x in the solution of the system of equations $x + y = 2, 1.01x + 0.99y = b$?

(a) zero (b) 2 units (c) 50 units (d) 100 units

33. By a change of variables x(u,v)=uv, y(u,v)= $\frac{v}{u}$ in a double integral, the integrand $f(x,y)$ changes to $f\left(uv, \frac{v}{u}\right)\phi(u,v)$. Then, $\phi(u,v)$ is

(a) $2\frac{v}{u}$ (b) 2uv (c) v^2 (d) 1

34. The right circular cone of largest volume that can be enclosed by a sphere of 1 m radius has a height of

(a) $\frac{1}{3}m$ (b) $\frac{2}{3}m$ (c) $\frac{2\sqrt{2}}{3}m$ (d) $\frac{4}{3}m$

35. If $x^2\frac{dy}{dx} + 2xy = \frac{2\ln x}{x}$, and $y(1) = 0$, then what is y(e)?

(a) e (b) 1 (c) $\frac{1}{e}$ (d) $\frac{1}{e^2}$

36. The line integral $\int \vec{V}.d\vec{r}$ of the vector function $\vec{V}(\vec{r}) = 2xyz\hat{i} + x^2z\hat{j} + x^2y\hat{k}$ from the origin to the point P(1,1,1)

(a) is 1 (b) is zero

(c) is −1

(d) cannot be determined without specifying the path

37. Starting from $x_0 = 1$, one step of Newton-Raphson method in solving the equation $x^3 + 3x - 7 = 0$ gives the next value (x_1) as

(a) $x_1 = 0.5$ (b) $x_1 = 1.406$ (c) $x_1 = 1.5$ (d) $x_1 = 2$

38. A single die is thrown twice. What is the probability that the sum is neither 8 or 9?

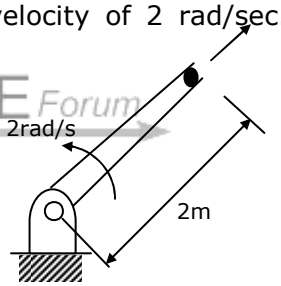
(a) $\frac{1}{9}$ (b) $\frac{5}{36}$ (c) $\frac{1}{4}$ (d) $\frac{3}{4}$

39. Two books of mass 1 kg each are kept on a table, one over the other. The coefficient of friction on every pair of contacting surfaces is 0.3. the lower book is pulled with a horizontal force F. the minimum value of F for which slip occurs between the two books is

(a) zero (b) 1.06 N (c) 5.74 N (d) 8.83 N

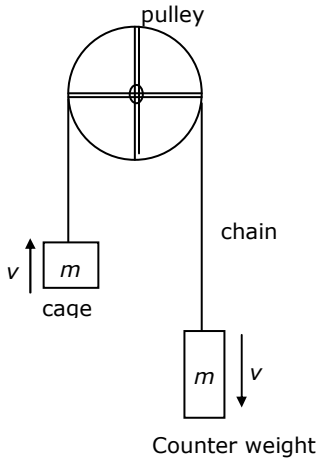
40. A shell is fired from a cannon. At the instant the shell is just about to leave the barrel, its velocity relative to the barrel is 3m/s, while the barrel is swinging upwards with a constant angular velocity of 2 rad/sec. The magnitude of the absolute velocity of the shell is

(a) 3 m/s
(b) 4 m/s
(c) 5 m/s
(d) 7 m/s

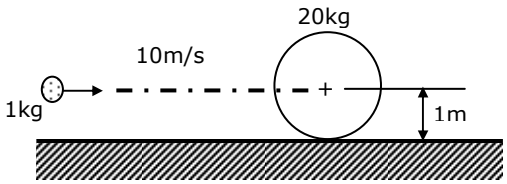


41. An elevator (lift) consists of the elevator cage and a counter weight, of mass m each. The cage and the counterweight are connected by a chain that passes over a pulley. The pulley is coupled to a motor. It is desired that the elevator should have a maximum stopping time of t seconds from a peak speed v. if the inertia of the pulley and the chain are neglected, the minimum power that the motor must have is

(a) $\frac{1}{2}mv^2$
(b) $\frac{mv^2}{2t}$
(c) $\frac{mv^2}{t}$
(d) $\frac{2mv^2}{t}$



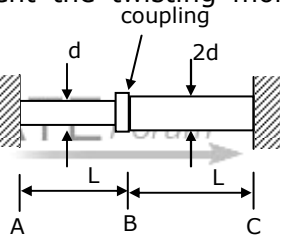
42. A 1 kg mass of clay, moving with a velocity of 10 m/s, strikes a stationary wheel and sticks to it. The solid wheel has a mass of 20 kg and a radius of 1 m. assuming that the wheel and the ground are both rigid and that the wheel is set into pure rolling motion, the angular velocity of the wheel immediately after the impact is approximately



(a) zero (b) $\frac{1}{3} rad/s$ (c) $\sqrt{\frac{10}{3}} rad/s$ (d) $\frac{10}{3} rad/s$

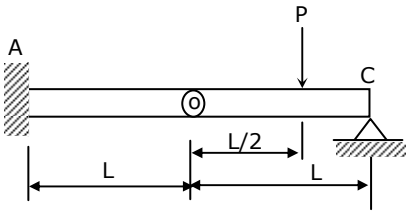
43. The two shafts AB and BC, of equal length and diameters d and 2d, are made of the same material. They are joined at B through a shaft coupling, while the ends A and C are built-in (cantilevered). A twisting moment T is applied to the coupling. If T_A and T_C represent the twisting moments at the ends A and C, respectively, then

(a) $T_C = T_A$
(b) $T_C = 8T_A$
(c) $T_C = 16T_A$
(d) $T_A = 16T_C$

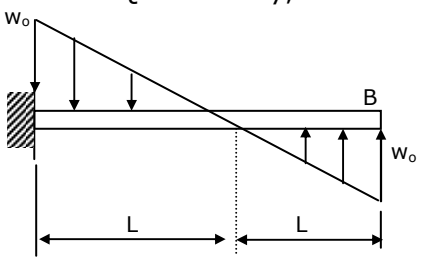


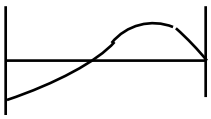
44. A beam is made up of two identical bars AB and BC, by hinging them together at B. The end A is built-in (cantilevered) and the end C is simply supported. With the load P acting as shown, the bending moment at A is

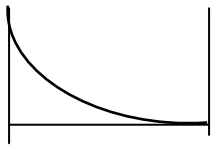
(a) zero
(b) $\frac{PL}{2}$
(c) $\frac{3PL}{2}$
(d) indeterminate

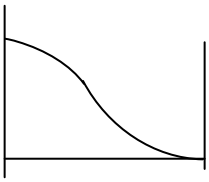


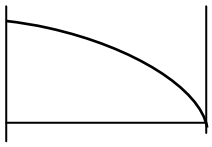
45. A cantilever beam carries the anti-symmetric load shown, where w_o is the peak intensity of the distributed load. Qualitatively, the correct bending moment diagram for this beam is



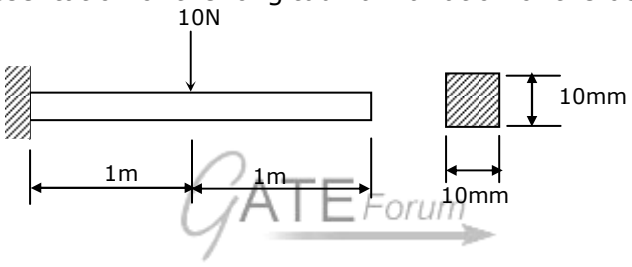
(a) 

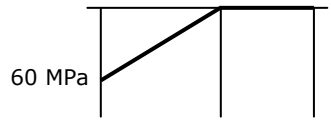
(b) 

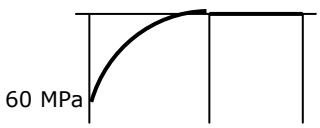
(c) 

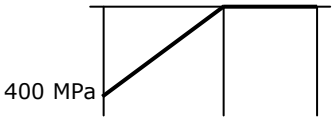
(d) 

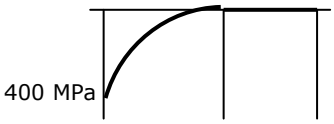
46. A cantilever beam has the square cross section of 10 mm× 10 mm. It carries a transverse load of 10 N. considering only the bottom fibres of the beam, the correct representation of the longitudinal variation of the bending stress is



(a) 

(b) 

(c) 

(d) 

47. In a cam-follower mechanism, the follower needs to rise through 20 mm during 60° of cam rotation, the first 30° with a constant acceleration and then with a deceleration of the same magnitude. The initial and final speeds of the follower are zero. The cam rotates at a uniform speed of 300 rpm. The maximum speed of the follower is

(a) 0.60 m/s (b) 1.20 m/s (c) 1.68 m/s (d) 2.40 m/s

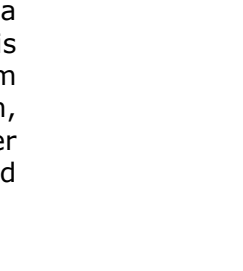
48. A rotating disc of 1 m diameter has two eccentric masses of 0.5 kg each at radii of 50 mm and 60 mm at angular positions of 0° and 150°, respectively. A balancing mass of 0.1 kg is to be used to balance the rotor. What is the radial position of the balancing mass?

(a) 50 mm (b) 120 mm (c) 150 mm (d) 280 mm

49. In a spring-mass system, the mass is 0.1 kg and the stiffness of the spring is 1 kN/m. By introducing a damper, the frequency of oscillation is found to be 90% of the original value. What is the damping coefficient of the damper?

(a) 1.2 N.s/m (b) 3.4 N.s/m (c) 8.7 N.s/m (d) 12.0 N.s/m

50. The Mohr's circle of plane stress for a point in a body is shown. The design is to be done on the basis of the maximum shear stress theory for yielding. Then, yielding will just begin if the designer chooses a ductile material whose yield strength is



(a) 45 MPa (b) 50 MPa (c) 90 MPa (d) 100 MPa

51. A weighing machine consists of a 2 kg pan resting on a spring. In this condition, the pan resting on the spring, the length of the spring is 200 mm. When a mass of 20 kg is placed on the pan, the length of the spring becomes 100 mm. For the spring, the un-deformed length l_o and the spring constant k (stiffness) are

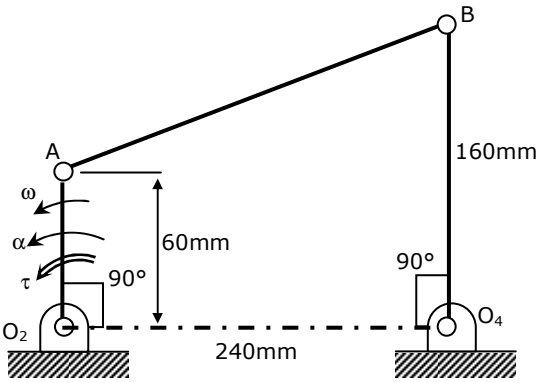
(a) $l_o = 220mm, k = 1862N/m$ (b) $l_o = 210mm, k = 1960N/m$

(c) $l_o = 200mm, k = 1960 - N/m$ (d) $l_o = 200mm, k = 2156N/m$

52. A venturimeter of 20 mm throat diameter is used to measure the velocity of water in a horizontal pipe of 40 mm diameter. If th

Common Data Questions

Common Data for Questions 76, 77, 78: An instantaneous configuration of a four-bar mechanism, whose plane is horizontal, is shown in the figure below. At this instant, the angular velocity and angular acceleration of link O_2A are ω=8rad/s and α=0, respectively, and the driving torque (τ) is zero. The link O_2A is balanced so that its center of mass falls at O_2.



76. Which kind of 4-bar mechanism is O_2ABO_4 ?

(a) Double-crank mechanism (b) Crank-rocker mechanism

(c) Double-rocker mechanism (d) Parallelogram mechanism

77. At the instant considered, what is the magnitude of the angular velocity of O_4B?

(a) 1 rad/s (b) 3 rad/s (c) 8 rad/s (d) $\frac{64}{3}$ rad/s

78. At the same instant, if the component of the force at joint A along AB is 30 N, then the magnitude of the joint reaction at O_2

(a) is zero

(b) is 30 N

(c) is 78 N

(d) cannot be determined from the given data

Common Data for Questions 79, 80: In two air standard cycles – one operating on the Otto and the other on the Brayton cycle – air is isentropically compressed from 300 to 450 K. heat is added to raise the temperature to 600 K in the Otto cycle and to 550 K in the Brayton cycle.

79. If η_o and η_B are the efficiencies of the Otto and Brayton cycles, then

(a) $\eta_o = 0.25, \eta_B = 0.18$ (b) $\eta_o = \eta_B = 0.33$

(c) $\eta_o = 0.5, \eta_B = 0.45$

(d) it is not possible to calculate the efficiencies unless the temperature after the expansion is given.

80. If W_o and W_B are work outputs per unit mass, then

(a) $W_o > W_B$ (b) $W_o < W_B$ (c) $W_o = W_B$

(d) it is not possible to calculate the work outputs unless the temperature after the expansion is given.

Linked Answer Questions: Q.81a to Q.85b carry two marks each.

Statement for Linked Answer Questions 81a & 81b: The complete solution for the ordinary differential equation $\frac{d^2y}{dx^2} + p\frac{dy}{dx} + qy = 0$ is $y = c_1e^{-x} + c_2e^{-3x}$

81. **(A)** Then, p and q are

(a) p = 3, q = 3 (b) p = 3, q = 4 (c) $p = 4, q = 3$ (d) $p = 4, q = 4$

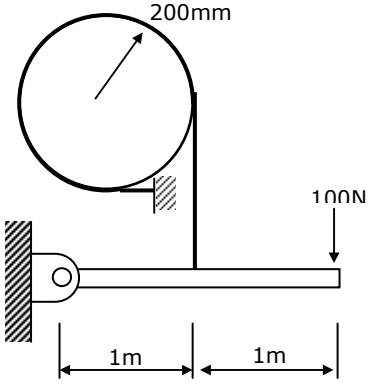
(B) Which of the following is a solution of the differential equation

$$\frac{d^2y}{dx^2} + p\frac{dy}{dx} + (q+1)y = 0\,?$$

(a) e^{-3x} (b) xe^{-x} (c) xe^{-2x} (d) x^2e^{-2x}

Statement for Linked Answer Questions 82a & 82b:

A band brake consists of a lever attached to one end of the band. The other end of the band is fixed to the ground. The wheel has a radius of 200 mm and the wrap angle of the band is 270°. The braking force applied to the lever is limited to 100N, and the coefficient of friction between the band and the wheel is 0.5. No other information is given.



82. **(A)** The maximum tension that can be generated in the band during braking is

(a) 1200 N (b) 2110 N (c) 3224 N (d) 4420 N

(B) The maximum wheel torque that can be completely braked is

(a) 200 N.m (b) 382 N.m (c) 604 N.m (d) 844 N.m

Statement for Linked Answer Questions 83a & 83b: Consider a linear programming problem with two variables and two constraints. The objective function is: Maximize $X_1 + X_2$. The corner points of the feasible region are (0,0), (0,2), (2,0) and $\left(\frac{4}{3},\frac{4}{3}\right)$.

83. **(A)** If an additional constraint $X_1 + X_2 \le 5$ is added, the optimal solution is

(a) $\left(\frac{5}{3},\frac{5}{3}\right)$ (b) $\left(\frac{4}{3},\frac{4}{3}\right)$ (c) $\left(\frac{5}{2},\frac{5}{2}\right)$ (d) (5,0)

(B) Let Y_1 and Y_2 be the decision variables of the dual and v_1 and v_2 be the slack variables of the dual of the given linear programming problem. The optimum dual variables are

(a) Y_1 and Y_2 (b) Y_1 and v_1 (c) Y_1 and v_2 (d) v_1 and v_2

Statement for Linked Answer Questions 84a & 84b:

The following table of properties was printed out for saturated liquid and saturated vapour of ammonia. The titles for only the first two columns are available. All that we know is that the other columns (columns 3 to 8) contain data on specific properties, namely, internal energy (kJ/kg), enthalpy (kJ/kg) and entropy (kJ/kg.K).

T(°C)	P(kPa)						
-20	190.2	88.76	0.3657	89.05	5.6155	1299.5	1418.0
0	429.6	179.69	0.7114	180.36	5.3309	1318.0	1442.2
20	857.5	272.89	1.0408	274.30	5.0860	1332.2	1460.2
40	1554.9	368.74	1.3574	371.43	4.8662	1341.0	1470.2

84. **(A)** The specific enthalpy data are in columns

(a) 3 and 7 (b) 3 and 8 (c) 5 and 7 (d) 5 and 8

(B) When saturated liquid at 40°C is throttled to –20°C, the quality at exit will be

(a) 0.189 (b) 0.212 (c) 0.231 (d) 0.788

Statement for Linked Answer Questions 85a & 85b: An un-insulated air conditioning duct of rectangular cross section 1 m × 0.5 m, carrying air at 20°C with a velocity of 10 m/s, is exposed to an ambient of 30°C. Neglect the effect of duct construction material. For air in the range of 20-30°C, data are as follows: thermal conductivity =0.025 W/m.K; viscosity = 18μPa.s; Prandtl number =0.73; density = 1.2 kg/m^3. The laminar flow Nusselt number is 3.4 for constant wall temperature conditions and, for turbulent flow, $Nu=0.023\ Re^{0.8}\ Pr^{0.33}$.

85. **(A)** The Reynolds number for the flow is

(a) 444 (b) 890 (c) 4.44×10^5 (d) 5.33×10^5

(B) The heat transfer per metre length of the duct, in watts, is:

(a) 3.8 (b) 5.3 (c) 89 (d) 769