ME: MECHANICAL ENGINEERING

Duration : Three hours *Maximum Marks* : 150

Read the following instructions carefully

1. This question paper contains **24** printed pages including pages for rough work. Please check all pages and report discrepancy, if any.
2. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the ORS.
3. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.
4. All the questions in this question paper are of objective type.
5. Questions must be answered on **O**bjective **R**esponse **S**heet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **Each question has only one correct answer**. In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as a wrong answer.
6. Questions 1 through 20 are 1-mark questions and questions 21 through 85 are 2-mark questions.
7. Questions 71 through 73 is one set of common data questions. The question pairs (76, 77), (78, 79), (80, 81), (82, 83) and (84, 85) are questions with linked answers. The answer to the second question of the above pairs will depend on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question will not be evaluated.
8. Unattempted questions will carry zero marks.
9. **NEGATIVE MARKING**: For Q.1 to Q.20, 0.25 mark will be deducted for each wrong answer. For Q.21 to Q.75, 0.5 mark will be deducted for each wrong answer. For the pairs of questions with linked answers, there will be negative marks only for wrong answer to the first question, i.e. for Q.76, Q.78, Q.80, Q.82 and Q.84, 0.5 mark will be deducted for each wrong answer. There is no negative marking for Q.77, Q.79, Q.81, Q.83 and Q.85.
10. Calculator **without data connectivity** is allowed in the examination hall.
11. Charts, graph sheets and tables are NOT allowed in the examination hall.
12. Rough work can be done on the question paper itself. Additional blank pages are given at the end of the question paper for rough work.

Q.1 – Q.20 carry one mark each.

Q.1. In the Taylor series expansion of e^x about x=2, the coefficient of $(x-2)^4$ is

(A) $\frac{1}{4!}$ (B) $\frac{2^4}{4!}$ (C) $\frac{e^2}{4!}$ (D) $\frac{e^4}{4!}$

Q.2. Given that $\ddot{x} + 3x = 0$, and $x(0) = 1$, $\dot{x}(0) = (0)$, what is $x(1)$?

(A) -0.99 (B) -0.16 (C) 0.16 (D) 0.99

Q.3. The value of $\lim x \to 8 \frac{x^{\frac{1}{3}}-2}{(x-8)}$ is

(A) $\frac{1}{16}$ (B) $\frac{1}{12}$ (C) $\frac{1}{8}$ (D) $\frac{1}{4!}$

Q.4. A coin is tossed 4 times. What is the probability of getting heads exactly 3 times?

(A) $\frac{1}{4}$ (B) $\frac{3}{8}$ (C) $\frac{1}{2}$ (D) $\frac{3}{4}$

Q.5. The matrix $\begin{bmatrix} 1 & 2 & 4 \\ 3 & 0 & 6 \\ 1 & 1 & p \end{bmatrix}$ has one eigenvalue equal to 3. The sum of the other two eigenvalues is

(A) p (B) $p-1$ (C) $p-2$ (D) $p-3$

Q.6. The divergence of the vector field $(x-y)\hat{i} + (y-x)\hat{j} + (x+y+z)\hat{k}$ is

(A) 0 (B) 1 (C) 2 (D) 3

Q.7. The transverse shear stress acting in a beam of rectangular cross-section, subjected to a transverse shear load, is

(A) variable with maximum at the bottom of the beam

(B) variable with maximum at the top of the beam

(C) uniform

(D) variable with maximum on the neutral axis

Q.8. A rod of length L and diameter D is subjected to a tensile load P. Which of the following is sufficient to calculate the resulting change in diameter?

(A) Young's modulus

(B) Shear modulus

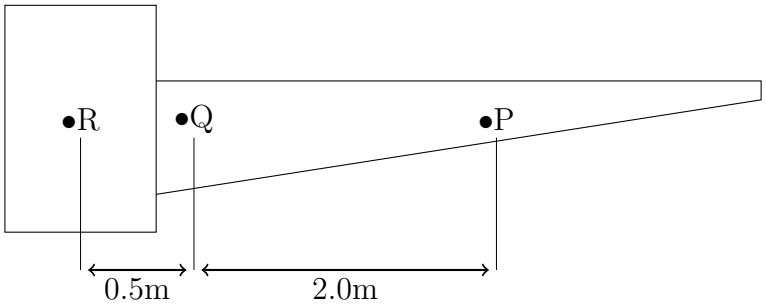
(C) Poisson's ratio

(D) Both Young's modulus and shear modulus

Q.9. A straight rod of length $L(t)$, hinged at one end and freely extensible at the other end, rotates through an angle $\theta(t)$ about the hinge. At time t, $L(t) = 1$ m, $\dot{L}(t) = 1$ m/s, $\theta(t) = \frac{\pi}{4}$rad and $\dot{\theta}(t) = 1$ rad/s. The magnitude of the velocity at the other end of the rod is

(A) 1m/s (B) $\sqrt{2}$m/s (C) $\sqrt{3}$m/s (D) 2m/s

Q.10. A cantilever type gate hinged at Q is shown in the figure. P and R are the centers of gravity of the cantilever part and the counterweight respectively. The mass of the cantilever part is 75 kg. The mass of the coutnerweight, for static balance, is



(A) 75kg (B) 150kg (C) 225kg (D) 300kg

Q.11. A planar mechanism has 8 links and 10 rotary joints. The number of degrees of freedom of the mechanism, using Greubler's criterion, is

(A) 0 (B) 1 (C) 2 (D) 3

Q.12. An axial residual compressive stress due to a manufacturing process is present on the outer surface of a rotating shaft subjected to bending. Under a given bending load, the fatigue life of the shaft in the presence of residual compressive stress is

(A) decreased

(B) increased or decreased, depending on the external bending load

(C) neither decreased nor increased

(D) increased

Q.13. 2 moles of oxygen are mixed adiabatically with another 2 moles of oxygen in a mixing chamber, so that the final total pressure and temperature of the mixture become same as those of the individual constituents at their intial states. The universal gas constant is given as R. The change in entropy due to mixing, per mole of oxygen, is given by

(A) $-R\ln 2$ (B) 0 (C) $R\ln 2$ (D) $R\ln 4$

Q.14. For flow of liquid over a heated plate, the following fluid properties are known:
viscosity = 0.001 Pa.s ; specific heat constant pressure = 1kJ/kg.K ;
thermal conductivity = 1 W/m.K.
The hydrodynamic boundary layer thickness at a specified location on the plate is 1 mm. The thermal boundary layer thickness at the same location is

(A) 0.001 mm (B) 0.01 mm (C) 1 mm (D) 1000 mm

Q.15. For the continuity equation given by $\bar{\nabla} \cdot \bar{V} = 0$ to be valid, where $\bar{V}$ is the velocity vector, which one of the following is a necessary condition?

(A) steady flow

(B) irrotational flow

(C) inviscid flow

(D) incompressible flow

Q.16. Which one of the following is NOT a necessary assumption for the air-standard Otto cycle?

(A) All processes are both internally as well as externally reversible.

(B) Intake and exhaust processes are constant volume heat rejection processes.

(C) The combustion process is a constant volume heat addition process.

(D) The working fluid is an ideal gas with constant specific heats.

Q.17. In an M/M/1 queueing system, the number of arrivals in an interval of length T is a Poisson random variable (i.e. the probability of there being n arrivals in an interval of length T is $\frac{e^{-\lambda T}(\lambda T)^n}{n!}$). The probability density function $f(t)$ of the inter-arrival time is given by

(A) $\lambda^2(e^{-\lambda^2 t})$ (B) $\frac{e^{-\lambda^2 t}}{\lambda^2}$ (C) $\lambda e^{-\lambda t}$ (D) $\frac{e^{-\lambda t}}{\lambda}$

Q.18. A set of 5 jobs is to be processed on a single machine. The processing time (in days) is given in the table below. The holding cost for each job is Rs. K per day.

Job	**Processing time**
P	5
Q	2
R	3
S	2
T	1

A schedule that minimizes the total inventory cost is

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

Q.19. For generating a Coon's surface we require

(A) a set of grid points on the surface

(B) a set of grid control points

(C) four bounding curves defining the surface

(D) two bounding curves and a set of grid control points

Q.20. Internal gear cutting operation can be performed by

(A) milling

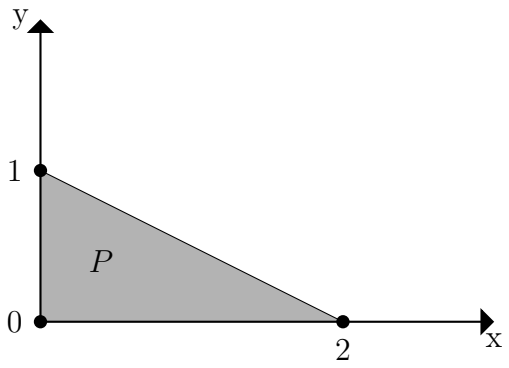
(B) shaping with rack cutter

(C) shaping with pinion cutter

(D) hobbing

Q.21 – Q.75 carry two marks each.

Q.21. Consider the shaded triangular region P shown in the figure. What is $\iint\limits_P xy\mathrm{d}x\mathrm{d}y$?



(A) $\frac{1}{6}$ (B) $\frac{2}{9}$ (C) $\frac{7}{2}$ (D) 1

Q.22. The directional derivative of the scalar function $f(x, y, z) = x^2 + 2y^2 + z$ at the point $P = (1, 1, 2)$ in the direction of vector $\overrightarrow{a} = 3\hat{i} - 4\hat{j}$ is

(A) -4 (B) -2 (C) -1 (D) 1

Q.23. For what value of a, if any, will the following system of equations in x, y and z have a solution?

$2x + 3y = 4$

$x + y + z = 4$

$x + 2y - z = a$

(A) Any real number (B) 0 (C) 1 (D) There is no such value

Q.24. Which of the following integrals is unbounded?

(A) $\int_0^{\pi/4} \tan x dx$ (B) $\int_0^{\infty} \frac{1}{x^2+1} dx$ (C) $\int_0^{\infty} xe^{-x} dx$ (D) $\int_0^1 \frac{1}{1-x} dx$

Q.25. The integral $\oint f(z)dz$ evaluated around the unit circle on the complex plane for $f(z) = \frac{\cos z}{z}$ is

(A) $2\pi i$ (B) $4\pi i$ (C) $-2\pi i$ (D) 0

Q.26. The length of the curve $y = \frac{2}{3}x^{\frac{3}{2}}$ from $x = 0$ to $x = 1$ is

(A) 0.27 (B) 0.67 (C) 1 (D) 1.22

Q.27. The eigenvectors of the matrix $\begin{bmatrix} 1 & 2 \\ 0 & 2 \end{bmatrix}$ are written in the form $\begin{bmatrix} 1 \\ a \end{bmatrix}$ and $\begin{bmatrix} 1 \\ b \end{bmatrix}$. What is $a + b$?

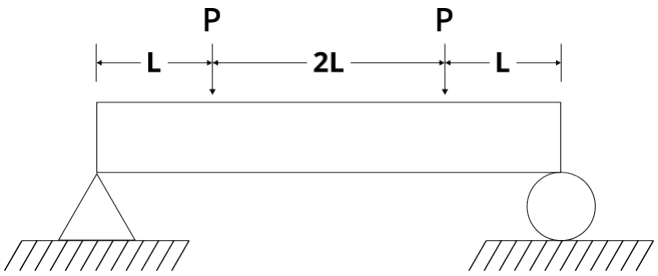
(A) 0 (B) $\frac{1}{2}$ (C) 1 (D) 2

Q.28. Let $f = y^x$. What is $\frac{\partial^2 f}{\partial x \partial y}$ at $x = 2$, $y = 1$?

(A) 0 (B) $\ln 2$ (C) 1 (D) $\frac{1}{\ln 2}$

Q.29. It is given that $y'' + 2y' + y = 0$, $y(0) = 0$, $y(1) = 0$. What is $y(0.5)$?

(A) 0 (B) 0.37 (C) 0.62 (D) 1.13



Q.30. The strain energy stored in the beam with flexural rigidity EI and loaded as shown in the figure is

(A) $\frac{P^2L^3}{3EI}$ (B) $\frac{2P^2L^3}{3EI}$ (C) $\frac{4P^2L^3}{3EI}$ (D) $\frac{8P^2L^3}{3EI}$

Q.31. (A) (B) (C) (D)

Q.32. (A) (B) (C) (D)

Q.33. (A) (B) (C) (D)

Q.34. (A) (B) (C) (D)

Q.35. (A) (B) (C) (D)

Q.36. (A) (B) (C) (D)

Q.37. (A) (B) (C) (D)

Q.38. (A) (B) (C) (D)

Q.39. (A) (B) (C) (D)

Q.40. (A) (B) (C) (D)

Q.41. (A) (B) (C) (D)

Q.42. (A) (B) (C) (D)

Q.43. (A) (B) (C) (D)

Q.44. (A) (B) (C) (D)

Q.45. (A) (B) (C) (D)

Q.46. (A) (B) (C) (D)

Q.47. (A) (B) (C) (D)

Q.48. (A) (B) (C) (D)

Q.49. (A) (B) (C) (D)

Q.50. (A) (B) (C) (D)

Q.51. (A) (B) (C) (D)

Q.52. (A) (B) (C) (D)

Q.53. (A) (B) (C) (D)

Q.54. (A) (B) (C) (D)

Q.55. (A) (B) (C) (D)

Q.56. (A) (B) (C) (D)

Q.57. (A) (B) (C) (D)

Q.58. (A) (B) (C) (D)

Q.59. (A) (B) (C) (D)

Q.60. (A) (B) (C) (D)

Q.61. (A) (B) (C) (D)

Q.62. (A) (B) (C) (D)

Q.63. (A) (B) (C) (D)

Q.64. (A) (B) (C) (D)