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Question Booklet

MECHANICAL ENGINEERING

(Objective)

Time Allowed : 2 Hours

Maximum Marks : 40

Read the following instructions carefully before you begin to answer the questions.

IMPORTANT INSTRUCTIONS

1. This Question Booklet contains 80 questions in all.
2. All questions carry equal marks.
3. Attempt all questions.
4. Immediately after commencement of the examination, you should check up your Question Booklet and ensure that the Question Booklet Series is printed on the top right-hand corner of the Booklet and the Booklet contains 16 printed pages and no page or question is missing or unprinted or torn or repeated. If you find any defect in this Booklet, get it replaced immediately by a complete Booklet of the same series.
5. You must write your Roll Number in the space provided on the top of this page. Do not write anything else on the Question Booklet.
6. An Answer Sheet will be supplied to you separately by the Invigilator to mark the answers. You must write your Name, Roll No. and other particulars on the first page of the Answer Sheet provided, failing which your Answer Sheet will not be evaluated.
7. You will encode your Roll Number and the Question Booklet Series A, B, C or D as it is printed on the top right-hand corner of this Question Booklet with Black/Blue ballpoint pen in the space provided on Page-2 of your Answer Sheet. If you do not encode or fail to encode the correct series of your Question Booklet, your Answer Sheet will not be evaluated correctly.
8. Questions and their responses are printed in English only in this Booklet. Each question comprises four responses—(A), (B), (C) and (D). You are to select ONLY ONE correct response and mark in your Answer Sheet. In case you feel that there are more than one correct response, mark the response which you consider the best. In any case, choose ONLY ONE response for each question. Your total marks will depend on the number of correct responses marked by you in the Answer Sheet.
9. In the Answer Sheet, there are four brackets—(A), (B), (C) and (D) against each question. To answer the questions you are to mark with Black/Blue ballpoint pen ONLY ONE bracket of your choice for each question. Select one response for each question in the Question Booklet and mark in the Answer Sheet. If you mark more than one answer for one question, the answer will be treated as wrong. Any erasure or change is not allowed.
10. You should not remove or tear off any sheet from the Question Booklet. You are not allowed to take this Question Booklet and the Answer Sheet out of the Examination Hall during the examination. After the examination has concluded, you must hand over your Answer Sheet to the Invigilator. Thereafter, you are permitted to take away the Question Booklet with you.
11. Failure to comply with any of the above instructions will render you liable to such action or penalty as the Commission may decide at their discretion.

SEAL

1. The solution of $\frac{dy}{dx} + \frac{y}{x} = 2xy^2$ is

(A) $y = \frac{cx}{1+e^{x^2}}$

(B) $y = \frac{1}{(1-2x)^2}$

(C) $y = \frac{cx^2}{1+e^{-x^2}}$

(D) $y = \frac{cx}{1+e^{-x^2}}$

Option incorrect

$\frac{2}{2+ce^{x^2}}$
 $= \frac{1}{1+ce^{x^2}}$

$\frac{dy}{y} + \frac{y}{x} = 2xy^2$
 $\frac{dy}{y} + \frac{1}{x} = 2xy$
 $\frac{dy}{y} + \frac{1}{x} = 2x \cdot \frac{1}{y}$
 $\frac{dy}{y} + \frac{1}{x} = \frac{2x}{y}$
 $\frac{dy}{y} = \frac{2x}{y} - \frac{1}{x}$
 $\frac{dy}{y} = \frac{2x^2 - 1}{xy}$
 $\frac{dy}{y} = \frac{2x^2 - 1}{x} \cdot \frac{1}{y}$
 $\frac{dy}{y} = \frac{2x^2 - 1}{x} \cdot \frac{1}{y}$
 $\frac{dy}{y} = \frac{2x^2 - 1}{x} \cdot \frac{1}{y}$
 $\frac{dy}{y} = \frac{2x^2 - 1}{x} \cdot \frac{1}{y}$

4. The Laplace transform of $t^2 \sin 2t$ is

(A) $\frac{(4-3s^2)}{(s^2+4)^3}$

(B) $\frac{(4+3s^2)}{(s+4)^3}$

(C) $\frac{4(3s^2-4)}{(s^2+4)^3}$

(D) $\frac{4(4-3s^2)}{(s+4)^3}$

$\left[\frac{2}{s^2+4} \right]$
 $2 \cdot \frac{(-2s)}{(s^2+4)^2}$
 $-4 \cdot \frac{s}{(s^2+4)^2}$

2. The particular solution of $(D^3 - D)y = e^x + e^{-x}$ is

(A) $\frac{1}{2}x^2(e^x + e^{-x})$

(B) $\frac{1}{2}x(e^x + e^{-x})$

(C) $\frac{1}{2}x^2(e^x - e^{-x})$

(D) $\frac{1}{2}(e^x + e^{-x})$

Option incorrect

$\frac{xe^x - e^{-x}}{2}$

5. The inverse Laplace transform of $\frac{4s+15}{16s^2+25}$ is

(A) $\cos\left(\frac{5t}{4}\right) + \frac{3}{4}\sin\left(\frac{5t}{4}\right)$

(B) $\frac{3}{4}\cos\left(\frac{5t}{4}\right) + \frac{1}{4}\sin\left(\frac{5t}{4}\right)$

(C) $\cos\left(\frac{5t}{4}\right) + \sin\left(\frac{5t}{4}\right)$

(D) $\frac{1}{4}\cos\left(\frac{5t}{4}\right) + \frac{3}{4}\sin\left(\frac{5t}{4}\right)$

$4 \cdot \frac{(e^{2t})^2}{(2s)^2}$
 $- \frac{15}{s^2}$

3. The Laplace transform of $t^3 e^{-2t}$ is

(A) $\frac{6}{(s-2)^4}$

(B) $\frac{6}{(s+2)^4}$

(C) $\frac{3}{(s+2)^4}$

(D) $\frac{6}{s^4}$

6. The value of $\int_0^{\frac{\pi}{4}} \int_0^1 r dr d\theta$ is

(A) $\frac{1}{8}(\pi-2)$

(B) $\frac{\pi}{4}$

(C) $\frac{1}{4}(\pi-2)$

(D) $\frac{\pi}{8}$

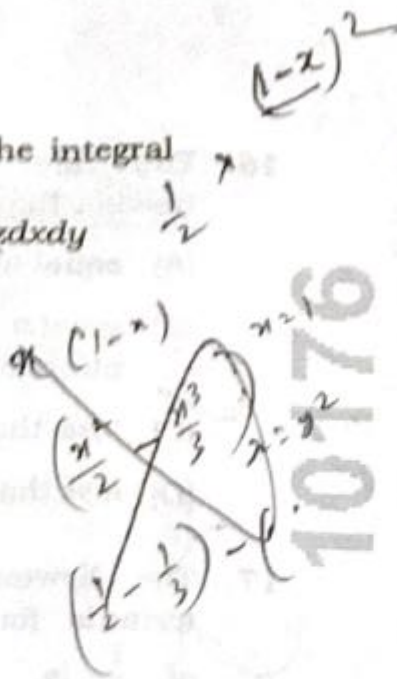
$\frac{1}{4} \cdot \frac{5}{s^2} + \frac{25}{16}$
 $\frac{5}{s^2} + \frac{15}{16}$
 $\frac{1}{2} \times \frac{\pi}{4}$

$\frac{1}{4} \cdot \frac{5}{s^2} + \frac{25}{16}$
 $\frac{5}{s^2} + \frac{15}{16}$
 $\int x f(x) dx$

7. The value of the integral

$$\int_0^1 \int_0^{1-x} \int_0^{1-x-y} x dz dx dy$$

- (A) $\frac{8}{35}$
- (B) $\frac{4}{35}$
- (C) $\frac{6}{35}$
- (D) $\frac{3}{35}$



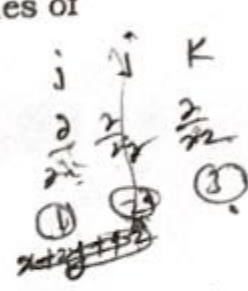
10. If

$$\vec{F} = (x+2y+az)\vec{i} + (bx-3y-z)\vec{j} + (4x+cy+2z)\vec{k}$$

is irrotational, then the values of a, b and c are

- (A) $a=4, b=2, c=1$
- (B) $a=-4, b=-2, c=-1$
- (C) $a=4, b=-2, c=-1$
- (D) $a=4, b=2, c=-1$

$4+9z$



8. The value of the integral

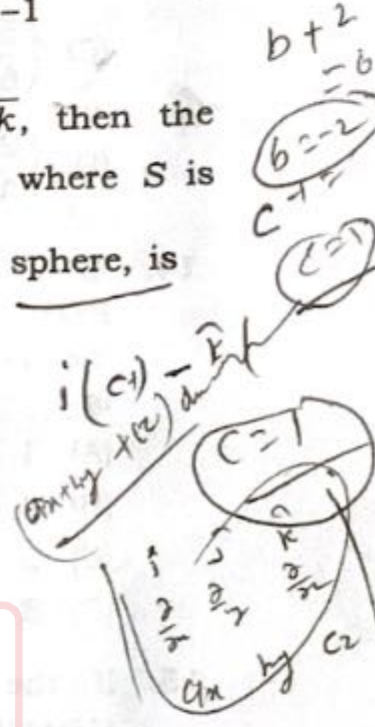
$$\int_0^a \int_{y^2}^{\sqrt{a^2-x^2}} \int_0^{\sqrt{a^2-x^2-y^2}} dx dy dz$$

- (A) $\frac{\pi a^3}{6}$
- (B) $4\pi a^3$
- (C) $\frac{\pi a^2}{3}$
- (D) $4\pi a^2$



11. If $\vec{F} = ax\vec{i} + by\vec{j} + cz\vec{k}$, then the value of $\iint_S \vec{F} \cdot \vec{n} dS$, where S is the surface of unit sphere, is

- (A) $\frac{2\pi}{3}(a+b+c)$
- (B) $\frac{4\pi}{3}(a+b+c)$
- (C) $\frac{\pi}{4}(a+b+c)$
- (D) $\frac{\pi}{3}(a+b+c)$

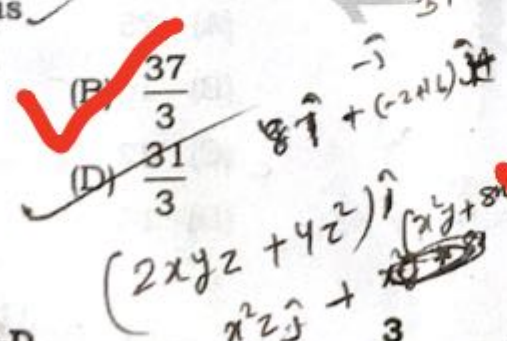


9. The directional derivative of

$$\phi = x^2yz + 4xz^2 - 6$$

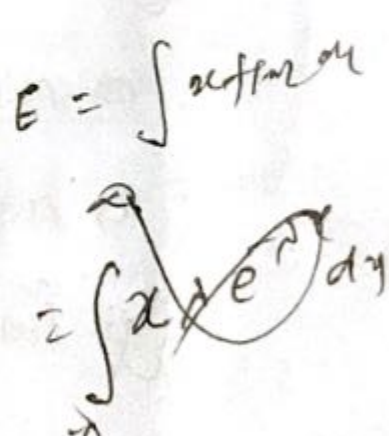
at $(1, -2, -1)$ in the direction of $(2\vec{i} - \vec{j} - 2\vec{k})$ is

- (A) $\frac{35}{3}$
- (B) $\frac{37}{3}$
- (C) $\frac{41}{3}$
- (D) $\frac{31}{3}$



12. The mean value of the density function $f(x) = \lambda e^{-\lambda x}$, $\lambda > 0, x > 0$ is

- (A) λ
- (B) $\frac{1}{\lambda^2}$
- (C) λ^2



13. In a binomial distribution, the sum and product of the mean and variance are $\frac{25}{3}$ and $\frac{50}{9}$ respectively. Then the distribution is

Option incorrect

- (A) $\left(\frac{3}{4} + \frac{1}{4}\right)^{25}$
- (B) $\left(\frac{1}{2} + \frac{1}{2}\right)^{25}$
- (C) $\left(\frac{5}{6} + \frac{1}{6}\right)^{25}$
- (D) $\left(\frac{2}{3} + \frac{1}{3}\right)^{25}$

$\sigma^2 = \frac{25}{3}$
 $\mu = \frac{50}{9}$

14. In a Poisson distribution, if $P(X=1) = P(X=2)$, then the mean of the Poisson distribution is

- (A) 1
- (B) 4
- (C) 2
- (D) 3

15. If the mean is 5 and the standard deviation is 2, then the equation of the normal distribution is

- (A) $f(x) = \frac{1}{2\sqrt{2\pi}} e^{-\frac{(x-5)^2}{8}}$
- (B) $f(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(x-5)^2}{8}}$
- (C) $f(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(x-5)^3}{8}}$
- (D) $f(x) = \frac{1}{2\sqrt{2\pi}} e^{-\frac{(x-5)^3}{8}}$

16. The rate of convergence of Newton-Raphson method is

- (A) equal to regula falsi method
- (B) greater than regula falsi method
- (C) less than bisection method
- (D) less than regula falsi method

1.618

17. The Newton-Raphson iterative formula for finding the value of $\frac{1}{\sqrt{N}}$ is

- (A) $x_{n+1} = \left(x_n + \frac{1}{Nx_n}\right)$
- (B) $x_{n+1} = \frac{1}{2} \left(x_n - \frac{1}{Nx_n}\right)$
- (C) $x_{n+1} = \frac{1}{2} \left(x_n^2 + \frac{1}{Nx_n}\right)$
- (D) $x_{n+1} = \frac{1}{2} \left(x_n + \frac{1}{Nx_n}\right)$

18. For the data y_1, y_2, y_3

x	2	4	6	8
f(x)	3	5	6	7

$\int_2^8 f(x) dx$, when found by the trapezoidal rule, is

- (A) 25
- (B) 16
- (C) 32
- (D) 18

$\frac{h}{2} [y_0 + y_n + 2(\dots)]$
 $\frac{2}{2} [3 + 7 + 2(5+6)]$
 $(7.5)^2$
 $\frac{16 + 3 \times 11}{2}$
 $(2.5)^4$

19. The value of $\tan^{-1}\left(\frac{p-qx}{q+px}\right)$ is

(A) $\tan^{-1}\frac{q}{p} - \left(1 - \frac{x^2}{2} + \frac{x^4}{4} - \frac{x^6}{6} + \dots\right)$

(B) $\tan^{-1}\frac{p}{q} - \left(x + \frac{x^3}{3} + \frac{x^5}{5} + \frac{x^7}{7} + \dots\right)$

(C) $\tan^{-1}\frac{q}{p} - \left(x + \frac{x^2}{2} + \frac{x^4}{4} + \frac{x^6}{6} + \dots\right)$

(D) $\tan^{-1}\frac{p}{q} - \left(x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \dots\right)$

20. The value of $\left(\frac{1^x + 2^x + 3^x + 4^x}{4}\right)^{\frac{1}{x}}$ as $x \rightarrow 0$ is

- (A) 8
- (B) 24
- (C) 12
- (D) 4

21. If the value of the line integral $\int_C \vec{F} \cdot d\vec{r}$ does not depend on the path C, then \vec{F} is

- (A) incompressible
- (B) irrotational
- (C) compressible
- (D) solenoidal

$p=1, q=20$
 $\int \frac{p-y}{q+xy} dy = \int \frac{1-y}{20+xy} dy = \int \frac{1}{20+xy} dy - \int \frac{y}{20+xy} dy$

22. By Green theorem, the value of $\int_C y^2 dy + xy dx$ for C: boundary of the region lying between $y=0$, $y=\sqrt{x}$ and $x=9$, is

- (A) $-\frac{81}{4}$
- (B) $-\frac{81}{2}$
- (C) $\frac{243}{4}$
- (D) $\frac{81}{4}$

23. If $e^{ax} \cos y$ is harmonic, then a is equal to

- (A) ± 2
- (B) ± 1
- (C) 3
- (D) i

24. The value of the integral $\int_C \frac{3z+4}{z(2z+1)} dz$ where C is the circle $|z|=1$, is

- (A) $2\pi i$
- (B) πi
- (C) $4\pi i$
- (D) $3\pi i$

25. The minimum value of the function $x^2 + y^2 + 6x + 12$ is

- (A) 3
- (B) 0
- (C) 6
- (D) -3

$\lim_{x \rightarrow 0} \frac{1}{x} \left\{ \dots \right\}$

$9 - 18 + 12 = 21 - 18 = 3$

$p = 2x + 6$
 $q = 2y$
 $x = -3$
 $y = 0$



26. If A is a symmetric matrix and $n \in \mathbb{N}$, then A^n is

- (A) skew-symmetric matrix
- (B) diagonal matrix
- (C) null matrix
- (D) symmetric matrix

27. Let A and B be real symmetric matrices of size $n \times n$. Then which of the following is true?

- (A) $A = A^{-1}$
- (B) $AB = BA$
- (C) $(AB)^T = BA$
- (D) $AA^T = I$

Handwritten notes for Q27:
 $A = A^T$
 $B = B^T$
 $(AB)^T = B^T A^T = BA$
 $(A^T B)^T = B A^T = BA$

28. Let $A = \begin{pmatrix} 2 & -0.1 \\ 0 & 3 \end{pmatrix}$ and

$A^{-1} = \begin{pmatrix} \frac{1}{2} & a \\ 0 & b \end{pmatrix}$. Then $(a+b)$ is

- (A) $3/20$
- (B) $11/20$
- (C) $7/20$
- (D) $7/10$

Handwritten calculations for Q28:
 $\frac{1}{60} = a$
 $\frac{1}{20} = b$

29. The eigenvalues and corresponding eigenvectors of a 2×2 matrix are given below :

Eigenvalues	Eigenvectors
$\lambda_1 = 8$	$x_1 = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$
$\lambda_2 = 4$	$x_2 = \begin{pmatrix} 1 \\ -1 \end{pmatrix}$

The matrix is

- (A) $\begin{pmatrix} 2 & 4 \\ 4 & 2 \end{pmatrix}$
- (B) $\begin{pmatrix} 6 & 2 \\ 2 & 6 \end{pmatrix}$
- (C) $\begin{pmatrix} 4 & 6 \\ 6 & 4 \end{pmatrix}$
- (D) $\begin{pmatrix} 4 & 8 \\ 8 & 4 \end{pmatrix}$

Handwritten calculations for Q29:
 $(6-\lambda)^2 - 4 = 0$
 $(6-\lambda+2)(6-\lambda-2) = 0$
 $(8-\lambda)(4-\lambda) = 0$

30. Match each differential equation in Group-I to its family of solution curve from Group-II :

Group-I	Group-II
P. $\frac{dy}{dx} = \frac{y}{x}$	1. Circle
Q. $\frac{dy}{dx} = -\frac{y}{x}$	2. Straight line
R. $\frac{dy}{dx} = \frac{x}{y}$	3. Hyperbola
S. $\frac{dy}{dx} = -\frac{x}{y}$	

Choose the correct matching.

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

Handwritten notes for Q30:
 $y^2 = x^2 + k$
 $x^2 - y^2 = k$
 Hyperbola

Handwritten notes for Q30:
 $\ln y = \ln x + c$
 $y = kx$

Handwritten notes for Q30:
 $y^2 = -x^2 = k$



By $\sigma_{max} = \frac{1}{2} \left(\frac{\sigma}{\tau} + \frac{\tau}{\sigma} \right)$

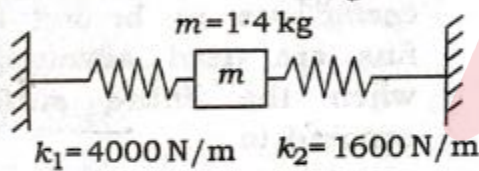
31. What is the effect of reactive gyroscopic couple when an aeroplane takes right turn and propeller rotates in clockwise direction?

- (A) The tail of the aeroplane is dipped and the nose is raised
- (B) The tail of the aeroplane is raised and the nose is dipped
- (C) Reactive gyroscopic couple has no effect when propeller rotates in clockwise direction
- (D) None of the above

Questions Incomplete.

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32. The natural frequency of the spring-mass system shown in the figure is closest to



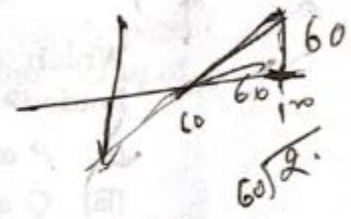
- (A) 12 Hz
- (B) 16 Hz
- (C) 8 Hz
- (D) 10 Hz

Question Incomplete

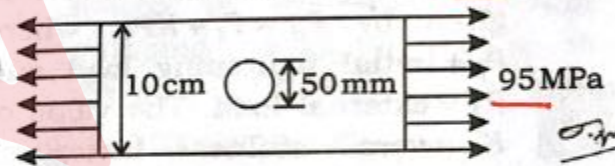
$\omega = \sqrt{\frac{56000}{1.4}}$

34. The stresses at a point on the circumference of a circular rod in tension and shear are 120 MPa and 60 MPa respectively. If the yield strength of the rod material is 340 MPa, then the factor of safety in the rod material using maximum shear stress theory is nearly equal to

- (A) 4.0
- (B) 2.5
- (C) 3.0
- (D) 2.0



35. A large uniform plate containing a rivet hole shown in the following figure is subjected to a uniform uniaxial tensile stress of 90 MPa:



The maximum stress in the plate is

- (A) 190 MPa
- (B) 285 MPa
- (C) 95 MPa
- (D) 100 MPa

36. A rotating bar made of steel ($S_{ut} = 630 \text{ N/mm}^2$) is subjected to a completely reversed stress. The corrected endurance limit of the bar is 315 N/mm². Calculate the fatigue strength of the bar for a life of 90000 cycles.

- (A) 386.63 N/mm²
- (B) 630 N/mm²
- (C) 285 N/mm²
- (D) 350 N/mm²

$\frac{\sigma_a}{\sigma_e} + \frac{\sigma_m}{S_{ut}} = 1$

33. The damping ratio of a single degree of freedom spring-mass-damper system with mass of 1 kg, stiffness 100 N/m and viscous damping coefficient of 25 N-s/m is

- (A) 1.22
- (B) 1.23
- (C) 1.25
- (D) 1.21

$\xi = \frac{c}{25 \text{ s/m}}$
 $25 \times 2 \times 10$

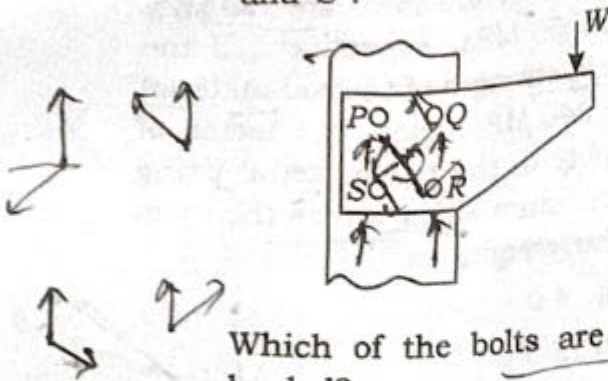
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$\frac{12.57}{25} = 25.0$

$\frac{1}{20} \sqrt{\frac{56000}{14}}$

$\frac{1}{40} \times \frac{2}{20} \times \frac{10}{10} \times \frac{510}{10}$

37. Consider the bracket bolted as shown below with 4 bolts P, Q, R and S :



Which of the bolts are heavily loaded?

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

38. The design load for a bolt is given by $P_d = P_1 + KP_2$, where P_1 = initial tightening load and P_2 = external load. The value of K (overall stiffness factor for joint) for hard copper gasket is

- (A) 0.1-0.25
- (B) 0.25-0.50
- (C) 0.50-0.75
- (D) 1.0-1.25

39. The Reynolds number of a fluid flowing over a flat plate at a distance of 16 cm from the leading edge is 25600. The thickness (in mm) of the boundary layer at this point will be

- (A) 7.5
- (B) 10.0
- (C) 10.5
- (D) 5.0

$$\delta_c = \frac{5x}{\sqrt{Re}}$$

40. For maximum power transmission through a pipeline, the frictional head loss is equal to

- (A) $H/2$
- (B) $H/3$
- (C) $H/5$
- (D) $H/4$

41. A draught of 1 mm of water is equivalent to

- (A) 10 N/m^2
- (B) 100 N/m^2
- (C) 1 N/mm^2
- (D) 1 N/cm^2

$$1000 \times 10 \times 10^{-6}$$

42. In spite of large heat transfer coefficients in boiling liquids, fins are used advantageously when the entire surface is exposed to

- (A) film boiling
- (B) transition boiling
- (C) nucleate boiling
- (D) all modes of boiling

43. Heat is conducted through 10 cm thick wall at the rate of 30 W/m^2 , when the temperature difference across the wall is 10°C . What is the thermal conductivity of the wall material?

- (A) 0.30 W/m-K
- (B) 3.0 W/m-K
- (C) 30 W/m-K
- (D) 0.03 W/m-K

$$30 = \frac{k \Delta T}{L}$$

$$= \frac{5 \times 10}{160 \times 100}$$

44. For a grey surface
- (A) absorptivity is equal to reflectivity
 - (B) emissivity is equal to transmissivity
 - (C) reflectivity is equal to emissivity
 - (D) emissivity is constant

45. Consider a heat engine that operates at 80% maximum possible efficiency. If the temperatures of the heat source and heat sink conform to the ratio 5 : 3, then what fraction of heat supplied is converted to work?

- (A) 0.28
- (B) 0.32
- (C) 0.40
- (D) 0.24

Handwritten calculations for Q45:

$$\eta = 0.8 \times \left(1 - \frac{3}{5}\right)$$

$$= 0.8 \times \frac{2}{5}$$

$$= \frac{1.6}{5} = \frac{16}{50} = 0.32$$

Q45 = 1
2.52

46. A heat engine is supplied with 280 kJ/s of heat at a constant fixed temperature of 520 K and heat rejection takes place at 260 K temperature. If the engine is reversible, then the heat rejected (in kJ/s) would be approximately equal to

- (A) 110
- (B) 140
- (C) 155
- (D) 85

Handwritten calculation for Q46:

$$\frac{280}{520} = \frac{Q_R}{260}$$

47. Which one of the following types of swirls is generated by a precombustion chamber in the diesel engine?

- (A) Compression swirl
- (B) Induction swirl
- (C) Combustion-induced swirl
- (D) Squish

48. The commercially available petrol in India has an octane rating of

- (A) 40-50
- (B) 60-75
- (C) 85-90
- (D) 20-30

49. Adjustment in the fuel injection timing in the fuel injection pumping of diesel engine is made by adjusting

- (A) needle valve
- (B) control rack
- (C) pump camshaft
- (D) plunger rotation

50. The refrigerating efficiency, i.e., the ratio of actual COP to reversible COP of a refrigeration cycle is 0.8, the condenser and evaporator temperatures are 51 °C and -30 °C respectively. If the cooling capacity of the plant is 2.4 kW, then what is the work requirement in kW?

- (A) 1.33
- (B) 1.25
- (C) 2.01
- (D) 1.00

Handwritten calculation for Q50:

$$\frac{2.4}{0.8} = 3$$

51. Aqua ammonia solution used in vapour-absorption refrigeration system is a solution of ammonia in

- (A) lithium bromide
- (B) water
- (C) hydrogen
- (D) carbon tetrachloride

52. Two reversible refrigerators are arranged in series and their coefficients of performance are 4 and 5 respectively. The COP of the composite refrigeration system would be

- (A) 2.0
- (B) 3.0
- (C) 4.5
- (D) 1.5

$\frac{T_L}{T_H - T_L} = 4$
 $\frac{4}{5-4}$

53. On a psychrometric chart, the constant wet-bulb temperature lines coincide with

- (A) constant enthalpy lines
- (B) constant dew point temperature lines
- (C) constant volume lines
- (D) constant relative humidity lines

$\frac{4}{5-4}$
 $\frac{T_L}{4 - T_L}$
 $20 - 5T_L = T_L$
 $\frac{20}{6} = 2$

54. In Parson's reaction turbine, when α is the angle with the direction of motion of the blade at which steams enter the blade, then the maximum efficiency of the turbine is given by

- (A) $\frac{2\cos^2 \alpha}{1 + \cos^2 \alpha}$
- (B) $\frac{2\cos^2 \alpha}{1 - \cos \alpha}$
- (C) $\frac{2\cos^2 \alpha}{1 + 2\cos^2 \alpha}$
- (D) $\frac{2\cos \alpha}{1 + \cos \alpha}$

55. Iron at room temperature has BCC structure and atomic radius of 1.24 Å. The lattice constant of iron will be

- (A) 2.864 Å
- (B) 1.864 Å
- (C) 0.864 Å
- (D) 3.864 Å

$1.52 \times 1.49 \times 1.23$
 $53a = \frac{4 \times 1.24}{3}$

56. In a eutectoid reaction

- (A) single-phase liquid produces homogenous mixture of two solid phases
- (B) single-phase solid produces homogenous mixture of two solid phases on cooling
- (C) mixture of a solid phase and a liquid phase will together form a second solid phase
- (D) None of the above

$\frac{26 \times 10}{4 - \frac{20}{6}}$



57. The structure of martensite is
 (A) body-centred cubic
 (B) body-centred tetragonal
 (C) orthorhombic
 (D) close-packed cubic
58. In a heat treatment process, the steel is heated in a furnace to above upper critical temperature and subsequently cooled in it with the furnace switched off. The process is
 (A) normalizing
 (B) tempering
 (C) austempering
 (D) annealing
59. In a continuous casting process
 (A) ingot is produced from melts
 (B) die cast products are produced in bulk
 (C) blooms or billets may be produced from melts
 (D) All of the above
60. In a typical pattern, draft is provided
 (A) along the direction of withdrawal of the pattern
 (B) all over the surface of the pattern
 (C) inside the pattern
 (D) None of the above
61. The 'camber' is a term related to
 (A) rolling
 (B) extrusion
 (C) drawing
 (D) forging
62. In a friction stir welding (FSW) process
 (A) a rotating consumable tool is used
 (B) a rotating non-consumable tool is used
 (C) a rotating filler material is used
 (D) None of the above
63. Which of the following materials may be having best machinability?
 (A) Magnesium
 (B) Aluminium
 (C) Stainless steel
 (D) Titanium
64. The best suited process for perforation is
 (A) EDM
 (B) EBM
 (C) LBM
 (D) None of the above

65. A basic hole has

- (A) zero tolerance
- (B) both the deviations positive
- (C) both the deviations negative
- (D) zero fundamental deviation

66. A part program for any arbitrary object is given as follows :

N001 G71 G91 M03 S500 EOB
 N002 G00 X10.00 Y10.00 EOB
 N003 G00 Z-10.00 EOB
 N004 G84 Z-25.00 F60 EOB
 N005 G80 EOB
 N006 M02 EOB

The above programming format will be used for

- (A) canned cycle for tapping
- (B) canned cycle for boring
- (C) canned cycle for grooving
- (D) canned cycle for drilling

67. Which of the following softwares is used as the CAD/CAM tool?

- (A) Solidworks
- (B) Rhino
- (C) AutoCAD
- (D) CATIA

68. ABC analysis is based on

- (A) the quantity of the item used in a year
- (B) the annual usage value of the item
- (C) the life of the item
- (D) the unit price of the item

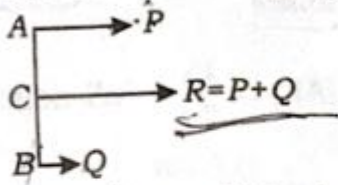
69. Which of the following control charts is used to detect small shift in the process mean?

- (A) \bar{X} and S chart
- (B) Proportion non-conforming chart
- (C) CUSUM chart
- (D) \bar{X} and R chart

70. In PERT, the activity duration follows

- (A) beta distribution
- (B) binomial distribution
- (C) Poisson distribution
- (D) normal distribution

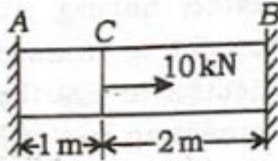
71. Two unlike parallel forces are shown in the following figure :



The resultant R will be located by the relation

- (A) $P \times AB = Q \times AC$
- (B) $P \times BC = Q \times AC$
- (C) $P \times AB = Q \times BC$
- (D) $P \times AC = Q \times BC$

72. A prismatic bar is supported between two rigid supports as shown in the figure below :



The support reaction will be

- (A) $R_A = 20/3 \text{ kN}, R_B = 10/3 \text{ kN}$
- (B) $R_A = 10 \text{ kN}, R_B = 10 \text{ kN}$
- (C) $R_A = 5 \text{ kN}, R_B = 5 \text{ kN}$
- (D) $R_A = 10/3 \text{ kN}, R_B = 20/3 \text{ kN}$

73. The maximum tension in a flat belt is 300 N. The mass of the belt is 1 kg/m. The linear velocity of the belt for maximum power transmission is equal to

- (A) 10 m/s
- (B) $\frac{100}{3}$ m/s
- (C) $\frac{1}{100}$ m/s
- (D) $\sqrt{300}$ m/s

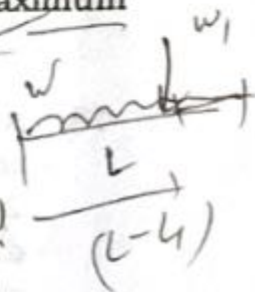
74. The state of plane stress at a point is given as : $\sigma_x = \sigma_y = 100 \text{ MPa}$ and $\tau_{xy} = 0$. The radius of Mohr's circle will be

- (A) 50 units
- (B) 0
- (C) 100 units
- (D) None of the above



75. A cantilever beam of diameter D , length L , cross-section A subjected to a uniformly distributed load W and a concentrated load W_1 at a distance L_1 from free end will have maximum bending moment of

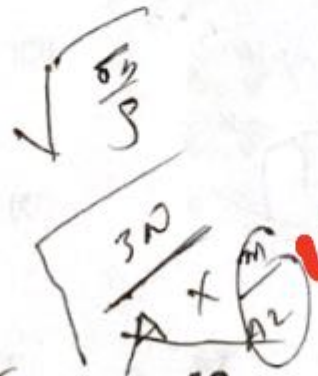
- (A) $\frac{WL^2}{2} + W_1L_1$
- (B) $\frac{W(L-L_1)^2}{2} + W_1(L-L_1)$
- (C) $\frac{W(L-L_1)^2}{2} + \frac{W(L+L_1)^2}{2}$
- (D) $\frac{WL^2}{2} + W_1(L-L_1)$



76. The length of a column which gives the same value of buckling load by Euler and Rankine-Gordon formula is equal to

- (A) $\frac{\pi^2 EK}{f_a - \pi^3 E}$
- (B) $\sqrt{\frac{\pi EK}{E_a - f_a}}$
- (C) $\sqrt{\frac{\pi^2 EK^2}{E_a + f_a}}$
- (D) $\sqrt{\frac{\pi^2 EK}{f_a - \pi^2 E_a}}$

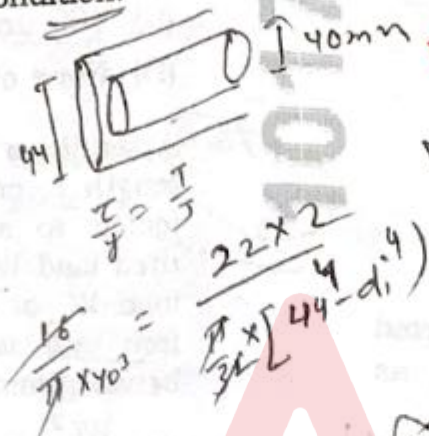
$\frac{\pi^2 EK}{L^2} = f_a$



Length of shaft?
Option incorrect
31.07

77. It is required to replace a solid shaft of diameter 40 mm with a hollow shaft of external diameter 44 mm. Determine the internal diameter of the hollow shaft for the same constant torque of 1.2 kN-m and same maximum shear stress condition.

- (A) 17.5 mm
- (B) 16.5 mm
- (C) 15.5 mm
- (D) 18.5 mm

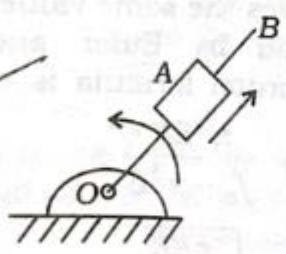


79. Which of the following tooth profiles can take very heavy load?

- (A) $14\frac{1}{2}^\circ$ full-depth involute system
- (B) 20° full-depth involute system
- (C) $14\frac{1}{2}^\circ$ stub involute system
- (D) $14\frac{1}{2}^\circ$ composite system

78. A link OB is rotating with a constant angular velocity of 2 rad/s in counterclockwise direction and a block is sliding radially outward on it with a uniform velocity of 0.75 m/s with respect to the rod. If OA = 1 m, then the magnitude of the absolute acceleration of the block at location A in m/s^2 is

- (A) 5
- (B) 6
- (C) 3
- (D) 4



Handwritten calculations for question 78:

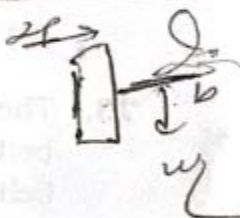
$$a_r = \frac{v^2}{r} = \frac{0.75^2}{1} = 0.5625$$

$$a_t = r \cdot \omega^2 = 1 \cdot 2^2 = 4$$

$$a_{abs} = \sqrt{a_r^2 + a_t^2} = \sqrt{0.5625^2 + 4^2} = 4.07$$

80. A piston having weight of all reciprocating masses of R is connected to crankpin through a connecting rod of length l and weight W_c with its centre of gravity at a distance of b from crankpin centre and is reciprocating with an acceleration of α_p . The reciprocating inertial force is

- (A) $(R + \frac{b}{l} W_c) \frac{\alpha_p}{g}$
- (B) $(R - \frac{l-b}{l} W_c) \frac{\alpha_p}{g}$
- (C) $(R - \frac{b}{l} W_c) \frac{\alpha_p}{g}$
- (D) $(R + \frac{l-b}{l} W_c) \frac{\alpha_p}{g}$



Handwritten calculations for question 80:

$$a_r = \frac{v^2}{r} = \frac{0.75^2}{1} = 0.5625$$

$$2 \times 2 \times 0.75 = 3$$

Handwritten notes at the bottom:

$$\frac{v^2}{r} = \frac{0.75^2}{1} = 0.5625$$