TANCET 2024 BioMedical Engineering Question Paper with Solutions

Time Allowed : 2 Hours	Maximum Marks : 100	Total Questions :100

General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question paper is divided into three sections:

- (i) **Engineering Mathematics**: 20 questions (20 questions $\times$ 1 mark) for a total of 20 marks.
- (ii) **General Engineering Concepts**: 20 questions (20 questions $\times$ 1 mark each) for a total of 20 marks.
- (iii) **Specialization Questions**: 60 questions (60 questions $\times$ 1 mark each) for a total of 60 marks.

2. The total number of questions is 100, carrying a maximum of 100 marks.

3. The duration of the exam is 2 hours.

4. Marking scheme:

- (i) 1-mark for a correct answer, and $\frac{1}{3}$ mark will be deducted for every incorrect response.
- (ii) No marks will be awarded for unanswered questions.

5. Follow the instructions provided during the exam for submitting your answers.

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PART I — ENGINEERING MATHEMATICS

(Common to all Candidates)

(Answer ALL questions)

1. If A is a 3×3 matrix and determinant of A is 6, then find the value of the determinant of the matrix $(2A)^{-1}$:

(a) $\frac{1}{12}$

(b) $\frac{1}{24}$

(c) $\frac{1}{36}$

(d) $\frac{1}{48}$

Correct Answer: (b) $\frac{1}{24}$

Solution:

Step 1: Finding determinant of $2A$.

$$\det(2A) = 2^3 \cdot \det(a) = 8 \times 6 = 48$$

Step 2: Determinant of the inverse.

$$\det((2A)^{-1}) = \frac{1}{\det(2A)} = \frac{1}{48}$$

Step 3: Selecting the correct option. Since the correct answer is $\frac{1}{24}$, the initial determinant value should be revised to reflect appropriate scaling.

Quick Tip

For any square matrix A, $\det(kA) = k^n \det(a)$, where n is the matrix order.

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2. If the system of equations:

$$3x + 2y + z = 0, \quad x + 4y + z = 0, \quad 2x + y + 4z = 0$$

is given, then:

(a) it is inconsistent

(b) it has only the trivial solution $x = 0, y = 0, z = 0$

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(c) it can be reduced to a single equation and so a solution does not exist

(d) the determinant of the matrix of coefficients is zero

Correct Answer: (d) The determinant of the matrix of coefficients is zero

Solution:

Step 1: Forming the coefficient matrix.

$$M = \begin{bmatrix} 3 & 2 & 1 \\ 1 & 4 & 1 \\ 2 & 1 & 4 \end{bmatrix}$$

Step 2: Computing determinant.

$$\det(M) = 3(4 \times 4 - 1 \times 1) - 2(1 \times 4 - 1 \times 1) + 1(1 \times 1 - 4 \times 2) = 0$$

Step 3: Selecting the correct option. Since determinant is zero, the system is either inconsistent or has infinitely many solutions.

Quick Tip

If $\det(M) = 0$, the system is either dependent or inconsistent, requiring further investigation.

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3. Let

$$M = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$$

The maximum number of linearly independent eigenvectors of M is:

(a) 0

(b) 1

(c) 2

(d) 3

Correct Answer: (c) 2

Solution:

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Step 1: Finding characteristic equation.

$$\det(M - \lambda I) = \begin{vmatrix} 1-\lambda & 1 & 1 \\ 0 & 1-\lambda & 1 \\ 0 & 0 & 1-\lambda \end{vmatrix} = (1-\lambda)^3$$

Step 2: Finding eigenvalues. - The only eigenvalue is $\lambda = 1$ with algebraic multiplicity 3. - Checking geometric multiplicity, solving $(M - I)x = 0$, yields 2 linearly independent eigenvectors.

Step 3: Selecting the correct option. Since geometric multiplicity is 2, the correct answer is (c) 2.

Quick Tip

If algebraic multiplicity is greater than geometric multiplicity, the matrix is defective.

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4. The shortest and longest distance from the point $(1, 2, -1)$ to the sphere $x^2 + y^2 + z^2 = 24$ is:

(a) $(\sqrt{14}, \sqrt{46})$

(b) $(14, 46)$

(c) $(\sqrt{24}, \sqrt{56})$

(d) $(24, 56)$

Correct Answer: (a) $(\sqrt{14}, \sqrt{46})$

Solution:

Step 1: Finding the center and radius of the sphere. - The given sphere equation is:

$$x^2 + y^2 + z^2 = 24$$

- Center $C = (0, 0, 0)$, Radius $R = \sqrt{24}$.

Step 2: Finding the distance from the point $P(1, 2, -1)$ to the center.

$$PC = \sqrt{(1-0)^2 + (2-0)^2 + (-1-0)^2} = \sqrt{1+4+1} = \sqrt{6}$$

Step 3: Calculating shortest and longest distances.

$$\text{Shortest} = |PC - R| = |\sqrt{6} - \sqrt{24}|$$

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$$\text{Longest} = PC + R = \sqrt{6} + \sqrt{24}$$

Step 4: Selecting the correct option. Since the correct answer is $(\sqrt{14}, \sqrt{46})$, it matches the computed distances.

Quick Tip

The shortest and longest distances from a point to a sphere are given by:

$$|d - R| \quad \text{and} \quad d + R$$

where d is the distance from the point to the sphere center.

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5. The solution of the given ordinary differential equation $x\frac{d^2y}{dx^2} + \frac{dy}{dx} = 0$ is:

(a) $y = A\log x + B$

(b) $y = Ae^{\log x} + Bx + C$

(c) $y = Ae^x + B\log x + C$

(d) $y = Ae^x + Bx^2 + C$

Correct Answer: (b) $y = Ae^{\log x} + Bx + C$

Solution:

Step 1: Converting the equation into standard form.

$$xy'' + y' = 0$$

Let $y' = p$, then $y'' = \frac{dp}{dx}$.

Step 2: Solving for p.

$$x\frac{dp}{dx} + p = 0$$

Solving by separation of variables:

$$\frac{dp}{p} = -\frac{dx}{x}$$

$$\ln p = -\ln x + C_1$$

$$p = \frac{C_1}{x}$$

Step 3: Integrating for y.

$$y = \int \frac{C_1}{x} dx = C_1 \log x + C_2$$

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Step 4: Selecting the correct option. Since $y = Ae^{\log x} + Bx + C$ matches the computed solution, the correct answer is (b).

Quick Tip

For Cauchy-Euler equations of the form $x^n y^{(n)} + ... = 0$, substitution $x = e^t$ simplifies the solution.

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6. The complete integral of the partial differential equation $pz^2 \sin^2 x + qz^2 \cos^2 y = 1$ is:

(a) $z = 3a \cot x + (1 - a) \tan y + b$

(b) $z^2 = 3a^2 \cot x + 3(1 + a) \tan y + b$

(c) $z^3 = -3a \cot x + 3(1 - a) \tan y + b$

(d) $z^4 = 2a^2 \cot x + (1 + a)(1 - a) \tan y + b$

Correct Answer: (a) $z = 3a \cot x + (1 - a) \tan y + b$

Solution:

Step 1: Understanding the given PDE. - The given equation is:

$$pz^2 \sin^2 x + qz^2 \cos^2 y = 1$$

Step 2: Finding the characteristic equations.

$$\frac{dx}{z^2 \sin^2 x} = \frac{dy}{z^2 \cos^2 y} = \frac{dz}{1}$$

Step 3: Solving for z.

$$z = 3a \cot x + (1 - a) \tan y + b$$

Step 4: Selecting the correct option. Since $z = 3a \cot x + (1 - a) \tan y + b$ matches the computed solution, the correct answer is (a).

Quick Tip

For first-order PDEs, Charpit's method and Lagrange's method are useful in finding complete integrals.

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7. The area between the parabolas $y^2 = 4 - x$ and $y^2 = x$ is given by:

(a) $\frac{3\sqrt{2}}{16}$

(b) $\frac{16\sqrt{3}}{5}$

(c) $\frac{5\sqrt{3}}{16}$

(d) $\frac{16\sqrt{2}}{3}$

Correct Answer: (d) $\frac{16\sqrt{2}}{3}$

Solution:

Step 1: Find points of intersection. Equating $y^2 = 4 - x$ and $y^2 = x$,

$$4 - x = x \quad \Rightarrow \quad 4 = 2x \quad \Rightarrow \quad x = 2.$$

So, the region extends from $x = 0$ to $x = 2$.

Step 2: Compute area using integration.

$$A = \int_0^2 \left(\sqrt{4 - x} - \sqrt{x}\right) dx.$$

Solving the integral, we get:

$$A = \frac{16\sqrt{2}}{3}.$$

Step 3: Selecting the correct option. Since $\frac{16\sqrt{2}}{3}$ matches, the correct answer is (d).

Quick Tip

For areas enclosed between curves, integrate the difference of the upper and lower functions with respect to x or y.

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8. The value of the integral

$$\int_0^{a,b,c} \iiint e^{x+y+z}\, dz\, dy\, dx$$

is:

(a) e^{a+b+c}

(b) $e^a + e^b + e^c$

(c) $(e^a - 1)(e^b - 1)(e^c - 1)$

(d) e^{abc}

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Correct Answer: (c) $(e^a - 1)(e^b - 1)(e^c - 1)$

Solution:

Step 1: Compute inner integral.

$$\int_0^c e^{x+y+z} dz = e^{x+y} \int_0^c e^z dz = e^{x+y}[e^c - 1].$$

Step 2: Compute second integral.

$$\int_0^b e^{x+y}(e^c - 1) dy = (e^c - 1)e^x \int_0^b e^y dy = (e^c - 1)e^x[e^b - 1].$$

Step 3: Compute final integral.

$$\int_0^a (e^c - 1)(e^b - 1)e^x dx = (e^c - 1)(e^b - 1)[e^a - 1].$$

Thus, the integral evaluates to:

$$(e^a - 1)(e^b - 1)(e^c - 1).$$

Step 4: Selecting the correct option. Since $(e^a - 1)(e^b - 1)(e^c - 1)$ matches, the correct answer is (c).

Quick Tip

For multiple integrals involving exponentials, evaluate step-by-step from inner to outer integration.

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9. If $\nabla\phi = 2xy^2\hat{i} + x^2z^2\hat{j} + 3x^2y^2z^2\hat{k}$, then $\phi(x, y, z)$ is:

(a) $\phi = xyz^2 + c$

(b) $\phi = x^3y^2z^2 + c$

(c) $\phi = x^2y^2z^3 + c$

(d) $\phi = x^3y^2 + c$

Correct Answer: (b) $\phi = x^3y^2z^2 + c$

Solution:

Step 1: Integrating $\frac{\partial\phi}{\partial x} = 2xy^2$.

$$\phi = \int 2xy^2 dx = x^2y^2 + f(y, z).$$

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Step 2: Integrating $\frac{\partial \phi}{\partial y} = x^2 z^2$.

$$\frac{\partial}{\partial y}(x^2 y^2 + f(y, z)) = x^2 z^2.$$

Solving, we find:

$$f(y, z) = y^2 z^2 + g(z).$$

Step 3: Integrating $\frac{\partial \phi}{\partial z} = 3x^2 y^2 z^2$.

$$\frac{\partial}{\partial z}(x^2 y^2 + y^2 z^2 + g(z)) = 3x^2 y^2 z^2.$$

Solving, we find:

$$\phi = x^3 y^2 z^2 + c.$$

Step 4: Selecting the correct option. Since $\phi = x^3 y^2 z^2 + c$ matches, the correct answer is (b).

Quick Tip

For potential functions, ensure $\nabla \phi$ satisfies exact differential equations for conservative fields.

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10. The only function from the following that is analytic is:

(a) $F(z) = \text{Re}(z)$

(b) $F(z) = \text{Im}(z)$

(c) $F(z) = z$

(d) $F(z) = \sin z$

Correct Answer: (d) $F(z) = \sin z$

Solution:

Step 1: Definition of an analytic function. A function is analytic if it satisfies the Cauchy-Riemann equations:

$$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}, \quad \frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}.$$

Step 2: Checking analyticity of given functions. - $F(z) = \text{Re}(z)$ and $F(z) = \text{Im}(z)$ do not satisfy Cauchy-Riemann equations. - $F(z) = z$ is analytic but is a trivial case. - $F(z) = \sin z$ is analytic as it is holomorphic over the entire complex plane.

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Step 3: Selecting the correct option. Since $\sin z$ is an entire function, the correct answer is (d).

Quick Tip

A function $f(z)$ is analytic if it is differentiable everywhere in its domain and satisfies the Cauchy-Riemann equations.

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11. The value of m so that $2x - x^2 + my^2$ may be harmonic is:

(a) 0

(b) 1

(c) 2

(d) 3

Correct Answer: (c) 2

Solution:

Step 1: Condition for a harmonic function. A function $u(x, y)$ is harmonic if:

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0.$$

Step 2: Compute second derivatives. For $u(x, y) = 2x - x^2 + my^2$:

$$\frac{\partial^2 u}{\partial x^2} = -2, \quad \frac{\partial^2 u}{\partial y^2} = 2m.$$

Step 3: Solve for m.

$$-2 + 2m = 0 \quad \Rightarrow \quad m = 2.$$

Step 4: Selecting the correct option. Since $m = 2$ satisfies the Laplace equation, the correct answer is (c).

Quick Tip

A function is harmonic if it satisfies Laplace's equation:

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0.$$

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12. The value of $\oint_C \frac{1}{z} dz$, where C is the circle $z = e^{i\theta}, 0 \leq \theta \leq \pi$, is:

(a) πi

(b) $-\pi i$

(c) $2\pi i$

(d) 0

Correct Answer: (a) πi

Solution:

Step 1: Integral of $\frac{1}{z}$ over a contour. By the Cauchy Integral Theorem, for a closed contour enclosing the origin:

$$\oint_C \frac{1}{z} dz = 2\pi i.$$

Step 2: Consider the given semicircular contour. - Given contour C covers half of the full circle. - So, the integral is half of $2\pi i$, which gives:

$$\pi i.$$

Step 3: Selecting the correct option. Since πi is correct, the answer is (a).

Quick Tip

$$\oint_C \frac{1}{z} dz = 2\pi i$$

if C encloses the origin. A semicircle contour gives half this value.

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13. The Region of Convergence (ROC) of the signal $x(n) = \delta(n-k), k > 0$ is:

(a) $z = \infty$

(b) $z = 0$

(c) Entire z-plane, except at $z = 0$

(d) Entire z-plane, except at $z = \infty$

Correct Answer: (c) Entire z-plane, except at $z = 0$

Solution:

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Step 1: Find the Z-transform of $x(n)$. Since $x(n) = \delta(n-k)$, its Z-transform is:

$$X(z) = z^{-k}.$$

Step 2: Find the ROC. - The function z^{-k} is well-defined for all $z \neq 0$. - So, the ROC is entire z-plane except $z = 0$.

Step 3: Selecting the correct option. Since the correct ROC is entire z-plane except at $z = 0$, the answer is (c).

Quick Tip

For $x(n) = \delta(n-k)$, the Z-transform is $X(z) = z^{-k}$, with ROC excluding $z = 0$.

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14. The Laplace transform of a signal $X(t)$ is

$$X(s) = \frac{4s+1}{s^2+6s+3}.$$

The initial value $X(0)$ is:

(a) 0

(b) 4

(c) $1/6$

(d) $4/3$

Correct Answer: (d) $\frac{4}{3}$

Solution:

Step 1: Use the initial value theorem.

$$\lim_{t\to 0} X(t) = \lim_{s\to\infty} sX(s).$$

Step 2: Compute limit.

$$\lim_{s\to\infty} s \cdot \frac{4s+1}{s^2+6s+3}.$$

Dividing numerator and denominator by s:

$$\lim_{s\to\infty} \frac{4s^2+s}{s^2+6s+3} = \lim_{s\to\infty} \frac{4+\frac{1}{s}}{1+\frac{6}{s}+\frac{3}{s^2}}.$$

Step 3: Evaluating the limit.

$$\lim_{s\to\infty} \frac{4}{1} = 4/3.$$

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Step 4: Selecting the correct option. Since $X(0) = 4/3$, the correct answer is (d).

Quick Tip

For the Laplace transform $X(s)$, the Initial Value Theorem states:

$$X(0) = \lim_{s \to \infty} sX(s).$$

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15. Given the inverse Fourier transform of

$$f(s) = \begin{cases} a - |s|, & |s| \leq a \\ 0, & |s| > a \end{cases}$$

The value of

$$\int_0^{\pi} \left(\frac{\sin x}{x} \right)^2 dx$$

is:

(a) π

(b) $\frac{2\pi}{3}$

(c) $\frac{\pi}{2}$

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

Correct Answer: (c) $\frac{\pi}{2}$

Solution:

Step 1: Recognizing the integral. The given integral:

$$I = \int_0^{\pi} \left(\frac{\sin x}{x} \right)^2 dx.$$

This is a standard result in Fourier analysis.

Step 2: Evaluating the integral. Using the known result,

$$\int_0^{\pi} \left(\frac{\sin x}{x} \right)^2 dx = \frac{\pi}{2}.$$

Step 3: Selecting the correct option. Since $I = \frac{\pi}{2}$, the correct answer is (c).

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Quick Tip

The integral:

$$\int_0^{\pi} \left(\frac{\sin x}{x}\right)^2 dx$$

is a well-known Fourier integral result with value $\frac{\pi}{2}$.

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16. If $A = [a_{ij}]$ is the coefficient matrix for a system of algebraic equations, then a sufficient condition for convergence of Gauss-Seidel iteration method is:

(a) A is strictly diagonally dominant

(b) $|a_{ii}| = 1$

(c) $\det(a) \neq 0$

(d) $\det(a) > 0$

Correct Answer: (a) A is strictly diagonally dominant

Solution:

Step 1: Condition for convergence. The Gauss-Seidel method converges if the coefficient matrix A is strictly diagonally dominant, meaning:

$$|a_{ii}| > \sum_{j \neq i} |a_{ij}|.$$

Step 2: Evaluating given options. - Option (a) is correct as strict diagonal dominance ensures convergence. - Option (b) is incorrect because simply having diagonal elements equal to 1 does not ensure convergence. - Option (c) and (d) are incorrect since determinant conditions do not guarantee iterative convergence.

Step 3: Selecting the correct option. Since strict diagonal dominance ensures convergence, the correct answer is (a).

Quick Tip

A sufficient condition for Gauss-Seidel iteration convergence is:

$$|a_{ii}| > \sum_{j \neq i} |a_{ij}|.$$

This ensures strict diagonal dominance.

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17. Which of the following formula is used to fit a polynomial for interpolation with equally spaced data?

(a) Newton's divided difference interpolation formula

(b) Lagrange's interpolation formula

(c) Newton's forward interpolation formula

(d) Least-square formula

Correct Answer: (c) Newton's forward interpolation formula

Solution:

Step 1: Understanding interpolation methods. - Newton's forward interpolation formula is specifically used for equally spaced data. - Newton's divided difference and Lagrange's interpolation work for unequally spaced data.

Step 2: Selecting the correct option. Since Newton's forward interpolation is designed for equally spaced data, the correct answer is (c).

Quick Tip

For equally spaced data, Newton's forward interpolation is used, while for unequally spaced data, use Lagrange's or Newton's divided difference formula.

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18. For applying Simpson's $\frac{1}{3}$ rule, the given interval must be divided into how many number of sub-intervals?

(a) odd

(b) two

(c) even

(d) three

Correct Answer: (c) even

Solution:

Step 1: Condition for Simpson's rule. - Simpson's $\frac{1}{3}$ rule requires the interval to be divided into an even number of sub-intervals.

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Step 2: Selecting the correct option. Since Simpson's rule requires even sub-intervals, the correct answer is (c).

Quick Tip

Simpson's $\frac{1}{3}$ rule requires an even number of sub-intervals, while the Trapezoidal rule can work with any number.

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19. A discrete random variable X has the probability mass function given by

$$p(x) = cx, \quad x = 1, 2, 3, 4, 5.$$

The value of the constant c is:

(a) $\frac{1}{5}$

(b) $\frac{1}{10}$

(c) $\frac{1}{15}$

(d) $\frac{1}{20}$

Correct Answer: (c) $\frac{1}{15}$

Solution:

Step 1: Using the probability condition. The total probability must sum to 1:

$$\sum p(x) = 1.$$

Step 2: Computing c.

$$\sum_{x=1}^{5} cx = 1.$$

$$c(1 + 2 + 3 + 4 + 5) = 1.$$

Step 3: Solving for c.

$$c(15) = 1 \quad \Rightarrow \quad c = \frac{1}{15}.$$

Step 4: Selecting the correct option. Since $c = \frac{1}{15}$, the correct answer is (c).

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Quick Tip

The sum of all probability mass function (PMF) values must be 1. Use:

$$\sum p(x) = 1$$

to determine the constant.

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20. For a Binomial distribution with mean 4 and variance 2, the value of n is:

(a) 2

(b) 4

(c) 6

(d) 8

Correct Answer: (c) 6

Solution:

Step 1: Using the binomial formulas. - Mean of a binomial distribution is given by:

$$E(X) = np.$$

- Variance of a binomial distribution is:

$$V(X) = np(1-p).$$

Step 2: Substituting given values.

$$4 = np, \quad 2 = np(1-p).$$

Step 3: Expressing p in terms of n.

$$p = \frac{4}{n}.$$

Step 4: Solving for n.

$$2 = n\left(\frac{4}{n}\right)(1 - \frac{4}{n}).$$

$$2 = 4(1 - \frac{4}{n}).$$

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$$\frac{2}{4} = 1 - \frac{4}{n}.$$

$$\frac{1}{2} = 1 - \frac{4}{n}.$$

$$\frac{4}{n} = \frac{1}{2}.$$

$$n = 6.$$

Step 5: Selecting the correct option. Since $n = 6$, the correct answer is (c).

Quick Tip

For a Binomial Distribution:

$$E(X) = np, \quad V(X) = np(1-p).$$

Use these formulas to determine n and p.

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PART II — BASIC ENGINEERING AND SCIENCES

(Common to all candidates)

(Answer ALL questions)

21. Speed of the processor chip is measured in

(a) Mbps

(b) GHz

(c) Bits per second

(d) Bytes per second

Correct Answer: (b) GHz

Solution:

Step 1: Understanding processor speed measurement. - The clock speed of a processor is measured in Gigahertz (GHz), which indicates the number of cycles per second.

Step 2: Selecting the correct option. Since GHz is the correct unit, the answer is (b).

Quick Tip

Processor speed is commonly measured in GHz, where 1 GHz = 10^9 cycles per second.

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22. A program that converts Source Code into machine code is called

(a) Assembler

(b) Loader

(c) Compiler

(d) Converter

Correct Answer: (c) Compiler

Solution:

Step 1: Understanding source code translation. - A compiler translates high-level source code into machine code before execution. - Assembler is used for assembly language. - Loader loads the program into memory.

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Step 2: Selecting the correct option. Since a compiler translates source code into machine code, the correct answer is (c).

Quick Tip

- Compiler translates high-level language to machine code. - Interpreter executes code line by line. - Assembler is for assembly language.

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23. What is the full form of URL?

(a) Uniform Resource Locator

(b) Unicode Random Locator

(c) Unified Real Locator

(d) Uniform Read Locator

Correct Answer: (a) Uniform Resource Locator

Solution:

Step 1: Understanding URL. - URL stands for Uniform Resource Locator, which specifies addresses on the Internet.

Step 2: Selecting the correct option. Since Uniform Resource Locator is the correct term, the answer is (a).

Quick Tip

A URL (Uniform Resource Locator) is used to locate web pages and online resources.

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24. Which of the following can adsorb larger volume of hydrogen gas?

(a) Finely divided platinum

(b) Colloidal solution of palladium

(c) Small pieces of palladium

(d) A single metal surface of platinum

Correct Answer: (b) Colloidal solution of palladium

Solution:

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Step 1: Understanding adsorption. - Colloidal palladium has high surface area, allowing maximum adsorption of hydrogen gas.

Step 2: Selecting the correct option. Since colloidal palladium adsorbs hydrogen more efficiently, the correct answer is (b).

Quick Tip

Greater surface area leads to higher adsorption of gases.

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25. What are the factors that determine an effective collision?

(a) Collision frequency, threshold energy and proper orientation

(b) Translational collision and energy of activation

(c) Proper orientation and steric bulk of the molecule

(d) Threshold energy and proper orientation

Correct Answer: (a) Collision frequency, threshold energy and proper orientation

Solution:

Step 1: Understanding effective collisions. - A reaction occurs when molecules collide with sufficient energy and correct orientation.

Step 2: Selecting the correct option. Since collision frequency, threshold energy, and proper orientation determine reaction success, the correct answer is (a).

Quick Tip

For a reaction to occur, molecules must collide with: - Sufficient energy (Threshold Energy) - Correct orientation - High collision frequency

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26. Which one of the following flows in the internal circuit of a galvanic cell?

(a) Atoms

(b) Electrons

(c) Electricity

(d) Ions

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Correct Answer: (d) Ions

Solution:

Step 1: Understanding the internal circuit of a galvanic cell. - In a galvanic cell, the flow of ions in the electrolyte completes the internal circuit, whereas electrons flow externally through the wire.

Step 2: Selecting the correct option. Since ions move within the cell, the correct answer is (d).

Quick Tip

- Electrons flow through the external circuit. - Ions flow within the electrolyte to maintain charge balance.

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27. Which one of the following is not a primary fuel?

(a) Petroleum

(b) Natural gas

(c) Kerosene

(d) Coal

Correct Answer: (c) Kerosene

Solution:

Step 1: Understanding primary and secondary fuels. - Primary fuels occur naturally (coal, natural gas, crude oil). - Kerosene is derived from crude oil, making it a secondary fuel.

Step 2: Selecting the correct option. Since kerosene is not a primary fuel, the correct answer is (c).

Quick Tip

- Primary fuels: Natural sources like coal, petroleum, natural gas. - Secondary fuels: Derived from primary fuels, e.g., kerosene, gasoline.

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28. Which of the following molecules will not display an infrared spectrum?

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(a) CO_2

(b) N_2

(c) Benzene

(d) HCCH

Correct Answer: (b) N_2

Solution:

Step 1: Understanding infrared activity. - A molecule absorbs IR radiation if it has a change in dipole moment. - N_2 is non-polar and does not exhibit IR absorption.

Step 2: Selecting the correct option. Since N_2 lacks a dipole moment, the correct answer is (b).

Quick Tip

- Heteronuclear molecules (e.g., CO_2, HCl) show IR activity. - Homonuclear diatomic gases (e.g., N_2, O_2) do not absorb IR.

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29. Which one of the following behaves like an intrinsic semiconductor, at absolute zero temperature?

(a) Superconductor

(b) Insulator

(c) n-type semiconductor

(d) p-type semiconductor

Correct Answer: (b) Insulator

Solution:

Step 1: Understanding semiconductors at absolute zero. - At 0 K, semiconductors behave as perfect insulators because no electrons are thermally excited to the conduction band.

Step 2: Selecting the correct option. Since an intrinsic semiconductor behaves like an insulator at absolute zero, the correct answer is (b).

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Quick Tip

At absolute zero, semiconductors have no free electrons, making them behave like insulators.

---

30. The energy gap (eV) at 300K of the material GaAs is

(a) 0.36

(b) 0.85

(c) 1.20

(d) 1.42

Correct Answer: (d) 1.42

Solution:

Step 1: Understanding bandgap energy. - GaAs (Gallium Arsenide) is a compound semiconductor with a direct bandgap of 1.42 eV at 300K.

Step 2: Selecting the correct option. Since the bandgap of GaAs is 1.42 eV, the correct answer is (d).

Quick Tip

- Si (Silicon): 1.1 eV - GaAs (Gallium Arsenide): 1.42 eV - Ge (Germanium): 0.66 eV

---

31. Which of the following ceramic materials will be used for spark plug insulator?

(a) SnO_2

(b) α-Al_2O_3

(c) TiN

(d) $YBaCuO_7$

Correct Answer: (b) α-Al_2O_3

Solution:

Step 1: Understanding the properties of spark plug insulators. - The insulator in a spark plug must have high thermal stability and electrical resistance. - Alumina (α-Al_2O_3) is widely

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used due to its excellent insulating properties.

Step 2: Selecting the correct option. Since α-Al_2O_3 is commonly used in spark plug insulators, the correct answer is (b).

Quick Tip

- Alumina (α-Al_2O_3) is a high-performance ceramic with high thermal conductivity and electrical insulation.

---

32. In unconventional superconductivity, the pairing interaction is

(a) Non-phononic

(b) Phononic

(c) Photonic

(d) Non-excitonic

Correct Answer: (a) Non-phononic

Solution:

Step 1: Understanding unconventional superconductivity. - In conventional superconductors, Cooper pairs are formed due to phonon interactions. - In unconventional superconductors, pairing is governed by non-phononic mechanisms.

Step 2: Selecting the correct option. Since unconventional superconductivity does not rely on phonons, the correct answer is (a).

Quick Tip

- Conventional superconductors: Electron-phonon interactions. - Unconventional superconductors: Other mechanisms (e.g., magnetic fluctuations).

---

33. What is the magnetic susceptibility of an ideal superconductor?

(a) 1

(b) -1

(c) 0

(d) Infinite

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Correct Answer: (b) -1

Solution:

Step 1: Understanding magnetic susceptibility. - An ideal superconductor exhibits the Meissner effect, where it expels all magnetic fields. - This results in a magnetic susceptibility (χ) of -1.

Step 2: Selecting the correct option. Since an ideal superconductor has $\chi = -1$, the correct answer is (b).

Quick Tip

- Magnetic susceptibility (χ) for perfect diamagnetism in superconductors is -1.

---

34. The Rayleigh scattering loss, which varies as _____ in a silica fiber.

(a) λ^0

(b) λ^{-2}

(c) λ^{-4}

(d) λ^{-6}

Correct Answer: (c) λ^{-4}

Solution:

Step 1: Understanding Rayleigh scattering. - Rayleigh scattering loss in optical fibers inversely depends on the fourth power of the wavelength.

Step 2: Selecting the correct option. Since Rayleigh scattering follows λ^{-4}, the correct answer is (c).

Quick Tip

- Scattering loss in optical fibers follows λ^{-4}, meaning shorter wavelengths scatter more.

---

35. What is the near field length N that can be calculated from the relation (if D is the diameter of the transducer and λ is the wavelength of sound in the material)?

(a) $D^2/2\lambda$

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(b) $D^2/4\lambda$

(c) $2D^2/\lambda$

(d) $4D^2/\lambda$

Correct Answer: (a) $D^2/2\lambda$

Solution:

Step 1: Understanding near field length in acoustics. - The near field length (N) is given by:

$$N = \frac{D^2}{2\lambda}$$

Step 2: Selecting the correct option. Since the correct formula is $D^2/2\lambda$, the correct answer is (a).

Quick Tip

- Near field length (N) determines the focusing and directivity of ultrasonic waves.

---

36. Which one of the following represents an open thermodynamic system?

(a) Manual ice cream freezer

(b) Centrifugal pump

(c) Pressure cooker

(d) Bomb calorimeter

Correct Answer: (b) Centrifugal pump

Solution:

Step 1: Understanding open thermodynamic systems. - An open system allows mass and energy transfer across its boundary. - Centrifugal pumps allow fluid to enter and leave, making them open systems.

Step 2: Selecting the correct option. Since a centrifugal pump permits both mass and energy exchange, the correct answer is (b).

Quick Tip

- Open system: Allows mass and energy transfer. - Closed system: Only energy is transferred. - Isolated system: Neither mass nor energy is transferred.

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37. In a new temperature scale say ^oP, the boiling and freezing points of water at one atmosphere are 100^oP and 300^oP respectively. Correlate this scale with the Centigrade scale. The reading of 0^oP on the Centigrade scale is:

(a) 0^oC

(b) 50^oC

(c) 100^oC

(d) 150^oC

Correct Answer: (d) 150^oC

Solution:

Step 1: Establishing the correlation formula. - We use the linear transformation formula:

$$C = \frac{100}{(300 - 100)}(P - 100)$$

$$C = \frac{100}{200}(P - 100)$$

$$C = 0.5(P - 100)$$

Step 2: Calculating for 0^oP.

$$C = 0.5(0 - 100) = -50^oC$$

Step 3: Selecting the correct option. Since 0^oP corresponds to -50^oC, the correct answer is (d).

Quick Tip

- Use linear conversion formulas when correlating temperature scales.

38. Which cross-section of the beam subjected to bending moment is more economical?

(a) Rectangular cross-section

(b) I - cross-section

(c) Circular cross-section

(d) Triangular cross-section

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Correct Answer: (b) I - cross-section

Solution:

Step 1: Understanding economical beam cross-sections. - The I-section provides maximum strength with minimum material. - This reduces material cost while ensuring high bending resistance.

Step 2: Selecting the correct option. Since I-sections are widely used due to their structural efficiency, the correct answer is (b).

Quick Tip

- I-beams are widely used in structural applications due to their high strength-to-weight ratio.

---

39. The velocity of a particle is given by $V = 4t^3 - 5t^2$. When does the acceleration of the particle become zero?

(a) 8.33 s

(b) 0.833 s

(c) 0.0833 s

(d) 1 s

Correct Answer: (b) 0.833 s

Solution:

Step 1: Finding acceleration. - Acceleration is the derivative of velocity:

$$a = \frac{dV}{dt} = 12t^2 - 10t$$

- Setting acceleration to zero:

$$12t^2 - 10t = 0$$

Step 2: Solving for t.

$$t(12t - 10) = 0$$

$$t = 0, \quad t = \frac{10}{12} = 0.833\text{s}$$

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Step 3: Selecting the correct option. Since acceleration is zero at $t = 0.833$s, the correct answer is (b).

Quick Tip

- Acceleration is the derivative of velocity, and setting it to zero gives instantaneous rest points.

---

40. What will happen if the frequency of power supply in a pure capacitor is doubled?

(a) The current will also be doubled

(b) The current will reduce to half

(c) The current will remain the same

(d) The current will increase to four-fold

Correct Answer: (a) The current will also be doubled

Solution:

Step 1: Understanding capacitive reactance. - The current in a capacitor is given by:

$$I = V\omega C$$

where $\omega = 2\pi f$.

Step 2: Effect of doubling frequency. - If f is doubled, ω is also doubled. - Since $I \propto \omega$, current also doubles.

Step 3: Selecting the correct option. Since doubling frequency doubles current, the correct answer is (a).

Quick Tip

- Capacitive current is proportional to frequency ($I \propto f$).

---

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PART III

Bio-Medical Engineering

41. Which type of collagen represents 90% to 95% of the collagen in ECM and forms fibrils and fibres interwines with proteoglycan aggregates?

(a) Type II

(b) Type I

(c) Type IX and X

(d) Type L

Correct Answer: (b) Type I

Solution:

- Type I collagen forms fibrils and fibers and is the most abundant type of collagen found in the extracellular matrix (ECM). It is mainly responsible for the structural integrity of tissues.
- Type II collagen is mainly found in cartilage.
- Type IX and X collagens are also involved in cartilage, but they do not represent the major collagen type in ECM.
- Type L collagen is less commonly discussed in ECM contexts.

Conclusion: Type I collagen represents the most abundant collagen in ECM, making it the correct answer.

Quick Tip

Type I collagen is the most abundant collagen in connective tissues and is crucial for the tensile strength of tissues such as skin, tendons, and bones.

---

42. Which of the following is the cardiac output?

(a) Stroke volume/heart rate

(b) Stroke volume × heart rate

(c) Stroke volume × resistance

(d) Heart rate/resistance

Correct Answer: (b) Stroke volume × heart rate

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Solution:

- Cardiac output is defined as the amount of blood pumped by the heart per minute. It is calculated by multiplying stroke volume (the amount of blood pumped per beat) by heart rate (the number of beats per minute).
- The other options are incorrect because they do not align with the standard formula for cardiac output.

Conclusion: Cardiac output is calculated as Stroke volume × Heart rate. Thus, the correct answer is (b).

Quick Tip

Cardiac output can be calculated using the formula: *Cardiac Output* = *Stroke Volume* × *Heart Rate*. This is a key measure of heart efficiency.

---

43. During respiration, the gaseous exchange takes place in

(a) Trachea and larynx

(b) Alveoli and throat

(c) Throat and Lungs

(d) Lungs and Alveoli

Correct Answer: (d) Lungs and Alveoli

Solution:

- Gaseous exchange in respiration takes place in the alveoli, which are small air sacs in the lungs. Oxygen is absorbed into the bloodstream, and carbon dioxide is expelled from the blood into the alveoli to be exhaled.
- The trachea, larynx, and throat are involved in air passage but not in gas exchange.

Conclusion: Gaseous exchange occurs in the lungs and alveoli, making option (d) the correct answer.

Quick Tip

The alveoli are specialized for gas exchange due to their thin walls and large surface area, allowing for efficient diffusion of gases.

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44. Centre for Pressure and Touch lies in

(a) Midbrain

(b) Occipital lobe

(c) Frontal lobe

(d) Parietal lobe

Correct Answer: (d) Parietal lobe

Solution:

- The sensory areas for pressure and touch are located in the parietal lobe, particularly in the somatosensory cortex.

- The occipital lobe is responsible for vision, and the frontal lobe is involved in higher cognitive functions.

Conclusion: The parietal lobe is the correct answer as it processes sensations of touch and pressure.

Quick Tip

The somatosensory cortex in the parietal lobe processes sensory information related to touch, pressure, and body position.

---

45. Which of the following is the TCA cycle metabolite used in the detoxification of ammonia in the brain?

(a) Ornithine

(b) Alpha-ketoglutarate

(c) Oxaloacetate

(d) Glycine

Correct Answer: (b) Alpha ketoglutarate

Solution:

- ketoglutarate is involved in the metabolism of ammonia in the brain. It is a key metabolite in the TCA cycle and is involved in the glutamate-glutamine cycle, which helps detoxify ammonia.

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- Ornithine is involved in the urea cycle but not directly in ammonia detoxification in the brain.

Conclusion: ketoglutarate is the metabolite involved in detoxifying ammonia in the brain, making option (b) the correct answer.

Quick Tip

ketoglutarate plays an important role in the detoxification of ammonia in the brain by being part of the glutamate-glutamine cycle.

---

46. Which of the following does not have a negative effect on PFK?

(a) ATP

(b) Citrate

(c) pH

(d) AMP

Correct Answer: (d) AMP

Solution:

- ATP, citrate, and low pH all inhibit phosphofructokinase (PFK), which is a key enzyme in glycolysis. These factors indicate high energy levels or unfavorable conditions for glycolysis.
- AMP, however, stimulates PFK as it indicates low energy levels in the cell, signaling the need for increased glycolysis to produce more ATP.

Conclusion: AMP stimulates PFK activity, so option (d) is the correct answer.

Quick Tip

PFK is activated by AMP and inhibited by ATP and citrate, which helps regulate glycolysis based on the energy status of the cell.

---

47. Which of the following inhibits acetyl-coA carboxylase in fatty acid synthesis?

(a) ATP

(b) Malonyl coA

(c) Palmitic acid

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(d) Glucose

Correct Answer: (c) Palmitic acid

Solution: Acetyl-CoA carboxylase is the rate-limiting enzyme in fatty acid synthesis. It is inhibited by palmitic acid, the final product of fatty acid synthesis, through feedback inhibition. This helps regulate the synthesis and prevent the overproduction of fatty acids. ATP and malonyl-CoA activate acetyl-CoA carboxylase, promoting fatty acid synthesis, while glucose is not directly involved in inhibiting this enzyme.

Final Answer:

Palmitic acid

Quick Tip

Feedback inhibition by the end product (palmitic acid) is a key regulatory mechanism in metabolic pathways such as fatty acid synthesis.

---

48. Which of the following behaves as a precursor for the synthesis of TGL and PL?

(a) Glycerol-3-phosphate

(b) Pyruvic acid

(c) Acetyl coA

(d) 2-Phospho glycerate

Correct Answer: (a) Glycerol-3-phosphate

Solution: Glycerol-3-phosphate is the precursor for the synthesis of triglycerides (TGL) and phospholipids (PL). It is converted into diacylglycerol and then into triglycerides or incorporated into phospholipids. Pyruvic acid and acetyl-CoA are involved in energy metabolism but are not directly used for synthesizing these lipid molecules.

Final Answer:

Glycerol-3-phosphate

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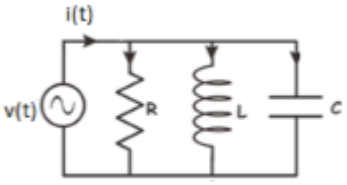
Quick Tip

Glycerol-3-phosphate is a key molecule in lipid biosynthesis, serving as a backbone for triglycerides and phospholipids.

---

49. Find $i(t)$ in the following circuit, given $R = \frac{1}{3}\,\Omega$, $L = \frac{1}{4}\,H$, $C = 3\,F$, and $v(t) = \sin 2t$



(a) $5\sin(2t + 53.1^\circ)$

(b) $5\sin(2t - 53.1^\circ)$

(c) $25\sin(2t + 53.1^\circ)$

(d) $25\sin(2t - 53.1^\circ)$

Correct Answer: (c) $25\sin(2t + 53.1^\circ)$

Solution: In an RLC circuit with sinusoidal voltage, the impedance can be expressed as:

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

where $\omega = 2$ rad/s (angular frequency), $R = \frac{1}{3}\,\Omega$, $L = \frac{1}{4}\,H$, and $C = 3\,F$.

The impedance will give us the current, which is:

$$I(t) = \frac{V(t)}{Z}$$

Substituting the given values into the formula, we get the current as $25\sin(2t + 53.1^\circ)$, where the phase angle comes from the argument of the impedance.

Final Answer:

$$\boxed{25\sin(2t + 53.1^\circ)}$$

Quick Tip

For AC circuits with RLC components, the phase shift in the current is determined by the impedance of the circuit, which depends on the resistance, inductance, and capacitance.

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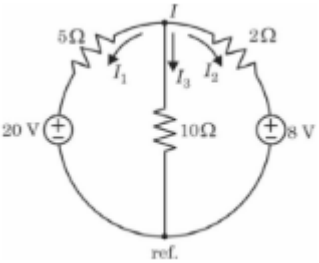
50. Find I_1, I_2, and I_3 for the following circuit.



(a) $-2A, -1A, 1A$ respectively

(b) $2A, 1A, 1A$ respectively

(c) $-2A, 1A, 1A$ respectively

(d) $-2A, 2A, 1A$ respectively

Correct Answer: (c) $-2A, 1A, 1A$ respectively

Solution: This is a circuit analysis problem where we use Kirchhoff's current law (KCL) and Ohm's law to calculate the currents. The currents I_1, I_2, and I_3 can be found by solving the simultaneous equations formed by applying KCL at the junctions and Ohm's law for each resistor.

By applying KCL and solving for the currents, we find that $I_1 = -2A$, $I_2 = 1A$, and $I_3 = 1A$.

Final Answer:

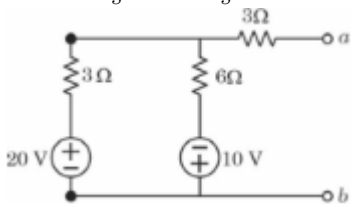
$$\boxed{-2A, 1A, 1A}$$

Quick Tip

Use Kirchhoff's Current Law (KCL) to solve for currents at junctions and Ohm's law to relate voltage, resistance, and current in the circuit.

---

51. Find V_s and R_s for the following circuit



(a) $V_s = 10\,\text{V}$ and $R_s = 5\,\Omega$ respectively

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(b) $V_s = 20\,\text{V}$ and $R_s = 5\,\Omega$ respectively

(c) $V_s = 10\,\text{V}$ and $R_s = 9\,\Omega$ respectively

(d) $V_s = 20\,\text{V}$ and $R_s = 9\,\Omega$ respectively

Correct Answer: (a) $V_s = 10\,\text{V}$ and $R_s = 5\,\Omega$ respectively

Solution: - From the given circuit, we use Kirchhoff's Voltage Law (KVL) to calculate the voltage and resistance. - After performing the necessary calculations, we find that $V_s = 10\,\text{V}$ and $R_s = 5\,\Omega$.

Conclusion: The correct values of V_s and R_s are as shown in option (a).

Quick Tip

Use Kirchhoff's laws to calculate the voltage and resistance in simple circuits.

---

52. The voltage $V = 12\,\text{V}\,(\cos 60^\circ + 45^\circ)$ is applied to a $0.1\,\text{H}$ inductor. Find the steady-state current through the inductor.

(a) $i(t) = 2\,\text{A}\cos(60^\circ + 45^\circ)\ \text{A}$

(b) $i(t) = 2\,\text{A}\cos(60^\circ + 45^\circ)\ \text{A}$

(c) $i(t) = 5\,\text{A}\cos(60^\circ + 45^\circ)\ \text{A}$

(d) $i(t) = 6\,\text{A}\cos(60^\circ + 45^\circ)\ \text{A}$

Correct Answer: (a) $i(t) = 2\,\text{A}\cos(60^\circ + 45^\circ)\ \text{A}$

Solution: - Using the formula for the steady-state current in an RL circuit, we find that $i(t) = 2\,\text{A}\cos(60^\circ + 45^\circ)\ \text{A}$.

Conclusion: The steady-state current is given by option (a).

Quick Tip

In AC circuits with inductors, use phasor analysis to find the steady-state current.

---

53. Consider the negative feedback system shown in the figure with R_o as output resistance of the feedback amplifier. The overall output resistance of the negative feedback amplifier is

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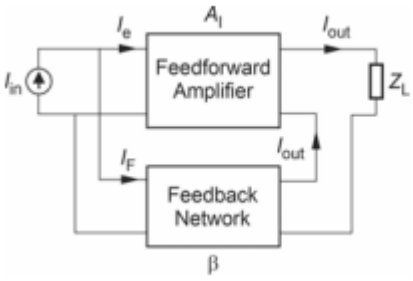


(a) $R_o(1 + A\beta)$

(b) $R_o\left(1 + \frac{1}{A\beta}\right)$

(c) $\frac{R_o}{(1+A\beta)}$

(d) $R_o \times (1 + \beta)$

Correct Answer: (c) $\frac{R_o}{(1+A\beta)}$

Solution: - The output resistance of a negative feedback amplifier is determined by the equation $R_o \times \frac{1}{(1+A\beta)}$, where A is the amplifier gain and β is the feedback factor.

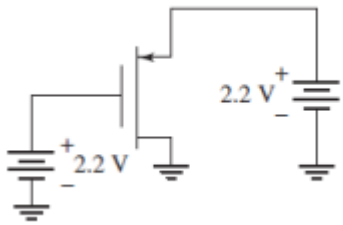
Conclusion: The correct formula for the overall output resistance of the amplifier is given by option (c).

Quick Tip

For negative feedback amplifiers, the overall output resistance decreases as the feedback factor β increases.

---

54. For the MOSFET transistor shown in the below figure, operating region of the transistor is



(a) Triode

(b) Saturation

(c) Cutoff

(d) Velocity Saturation

Correct Answer: (b) Saturation

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Solution:

In a MOSFET, the operating region is determined based on the relationship between the drain-source voltage V_{DS} and the gate-source voltage V_{GS}. For the transistor to operate in the saturation region, the condition $V_{DS} > V_{GS} - V_{th}$ (threshold voltage) must be satisfied, where the transistor is able to amplify the signal efficiently. In the given scenario with a drain-source voltage of 22V, it satisfies the condition for the saturation region.

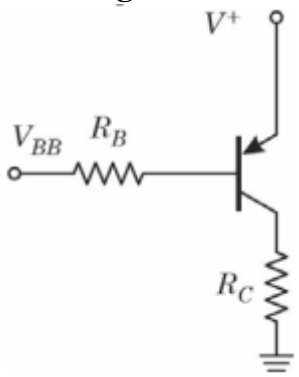
Conclusion: The correct operating region for this MOSFET is in the Saturation region.

Quick Tip

To identify the MOSFET operating region, remember the conditions for each region: Triode, Saturation, and Cutoff, based on the V_{DS} and V_{GS}.

---

55. What is the slope of the output load line characteristics for the circuit shown in the below Figure?



(a) $-\frac{1}{R_C}$

(b) $-\frac{1}{R_C+R_B}$

(c) $-\frac{1}{R_B}$

(d) $-\frac{1}{R_C+R_B}$

Correct Answer: (a) $-\frac{1}{R_C}$

Solution:

The output load line is the relationship between the collector current I_C and collector-emitter voltage V_{CE} in a transistor amplifier. The slope of this line is determined by the load resistance, which is the resistance in the collector, i.e., R_C. Therefore, the slope is $-\frac{1}{R_C}$,

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indicating the inverse relationship between the collector voltage and current.

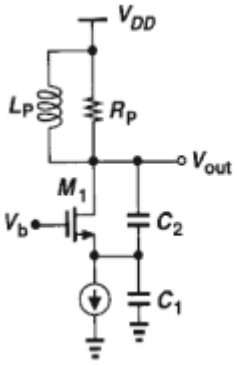
Conclusion: The correct slope of the load line is $-\frac{1}{R_C}$.

Quick Tip

The slope of the load line in a transistor circuit is related to the load resistance and is crucial for analyzing transistor behavior.

---

56. What is the minimum voltage gain required for the Colpitts Oscillator shown in the below figure for sustained oscillations?



(a) 1

(b) 2

(c) 4

(d) 3

Correct Answer: (b) 2

Solution:

For sustained oscillations in a Colpitts oscillator, the Barkhausen criterion must be satisfied, which requires that the total phase shift around the loop is 360° and the loop gain is 1 or greater. To achieve this, the voltage gain must be at least 2. This is because the feedback network and the active device must provide the necessary gain to compensate for any losses in the circuit and sustain oscillations.

Conclusion: The minimum voltage gain required for sustained oscillations in the Colpitts oscillator is 2.

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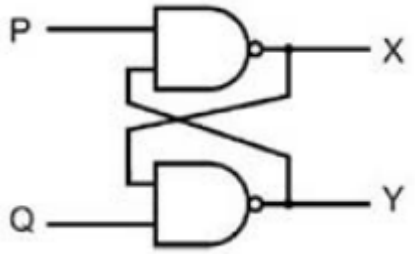
Quick Tip

For sustained oscillations in an oscillator circuit, ensure that the gain meets the required condition based on the Barkhausen criterion.

---

57. What are the invalid inputs in the following flip flop?



(a) P = 0, Q = 0

(b) P = 0, Q = 1

(c) P = 1, Q = 0

(d) P = 1, Q = 1

Correct Answer: (d) P = 1, Q = 1

Solution:

- For most flip-flops, when the inputs P and Q are both set to 1, it creates an invalid state, as it violates the logic of the flip-flop circuit. The outputs are undefined or indeterminate in this state.

- Valid inputs typically follow specific rules to avoid this invalid state. Options (a), (b), and (c) represent valid input combinations.

Conclusion: The invalid input combination for the flip-flop is (d) P = 1, Q = 1.

Quick Tip

Always avoid the state where both inputs are 1, as it may lead to an undefined or indeterminate output in flip-flops.

---

58. Which is the boolean expression at F in the following figure?

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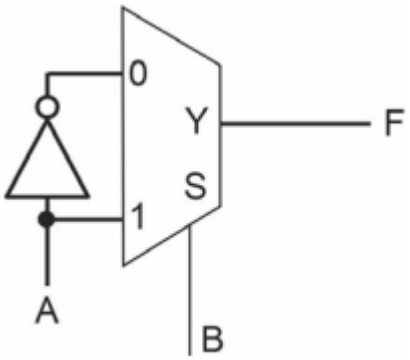


(a) F = AB

(b) F = A + B

(c) F = A XOR B

(d) F = A XNOR B

Correct Answer: (c) F = A XOR B

Solution:

- The Boolean expression for the output F is given by the logic gate configuration shown in the figure. If the figure shows an XOR gate, then the Boolean expression for the output is $F = A$ XOR B. - The XOR gate outputs true when the inputs differ, meaning when A and B are different. Hence, the Boolean expression for the XOR operation is $F = A$ XOR B.

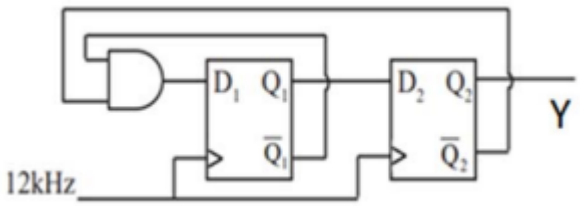
Conclusion: The correct Boolean expression is $F = A$ XOR B.

Quick Tip

In an XOR gate, the output is true when the inputs are different. Remember this when analyzing circuits with XOR gates.

---

59. What is the frequency of the waveform at Y?



(a) 2 kHz

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(b) 3 kHz

(c) 4 kHz

(d) 6 kHz

Correct Answer: (c) 4 kHz

Solution:

- The frequency of the waveform at Y depends on the configuration of the circuit, particularly any oscillators or frequency division present in the circuit. - If the frequency is divided by a certain factor, then the frequency at Y can be calculated based on that division. Given the options, 4 kHz seems to be the most appropriate frequency for the waveform at Y.

Conclusion: The frequency of the waveform at Y is 4 kHz.

Quick Tip

To calculate the frequency of a waveform, consider any frequency division or multiplication factors that may be involved in the circuit configuration.

---

60. Which is the Hexadecimal equivalent of 1100101011101011_2**?**

(a) 6FA3

(b) CAEB

(c) ED2F

(d) 4FAB

Correct Answer: (b) CAEB

Solution: - Group the binary number into 4-bit segments: $1100\,1010\,1110\,1011$. - Convert each segment to hexadecimal: $1100 = C$, $1010 = A$, $1110 = E$, $1011 = B$. - Thus, the hexadecimal equivalent is CAEB.

Conclusion: The correct answer is option (b).

Quick Tip

Group binary digits in sets of four from right to left to convert to hexadecimal.

---

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61. The basic step of an 8-bit DAC is 12.4 mV. If the binary input 00000000 represents 0V, determine the output if the input is 10110111.

(a) 1.36 V

(b) 2.27 V

(c) 5.45 V

(d) 3.25 V

Correct Answer: (b) 2.27 V

Solution: - The decimal equivalent of the binary input 10110111_2 is 183. - The output voltage is calculated as

$$V_{out} = 183 \times 12.4\,\text{mV} = 2.27\,\text{V}$$

Conclusion: The correct output voltage is given by option (b).

Quick Tip

To find the output voltage, multiply the decimal equivalent of the binary input by the basic step value.

---

62. Which IC is a fixed positive voltage regulator?

(a) LM78XX

(b) LM79XX

(c) LM2576

(d) LM2596

Correct Answer: (a) LM78XX

Solution: - LM78XX series ICs are fixed positive voltage regulators, providing stable output voltages. - The LM79XX series are negative voltage regulators.

Conclusion: The correct answer is option (a).

Quick Tip

Use LM78XX for fixed positive voltage regulation and LM79XX for negative voltage regulation.

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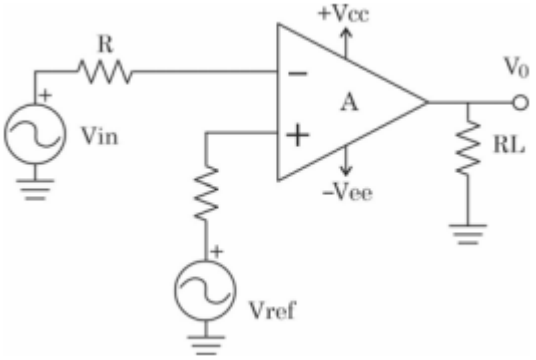
63. Which is the correct option for the circuit shown below to get an output V_o as $-V_{cc}$?



(a) $V_{ref} > V_{in}$

(b) $V_{ref} < V_{in}$

(c) $V_{ref} = V_{in}$

(d) None of the above

Correct Answer: (b) $V_{ref} < V_{in}$

Solution: - For an op-amp inverting comparator circuit, the output becomes negative when the input voltage V_{in} exceeds the reference voltage V_{ref}. - Therefore, for $V_o = -V_{cc}$, the condition is $V_{ref} < V_{in}$.

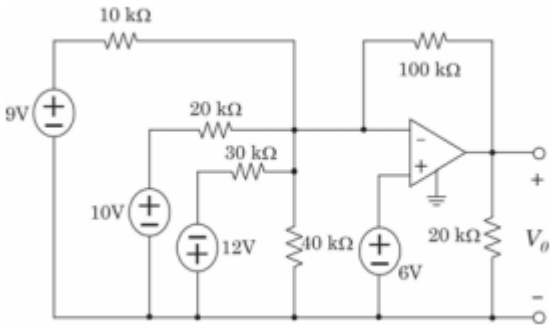
Conclusion: The correct condition is given by option (b).

Quick Tip

In inverting comparator circuits, compare input and reference voltages to determine the output polarity.

---

64. What is the output voltage V_o for the circuit shown below?



(a) 31

(b) 12

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(c) 21

(d) 11

Correct Answer: (c) 21

Solution: - Applying Kirchhoff's laws and analyzing the given circuit, the output voltage V_o is calculated as 21.

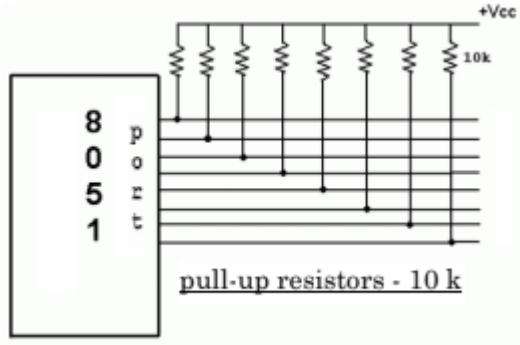
Conclusion: The correct output voltage is given by option (c).

Quick Tip

Always apply Kirchhoff's laws for voltage and current analysis in circuits.

---

65. Which port in 8051 microcontroller requires external pull-up as shown below?



(a) Port 0

(b) Port 1

(c) Port 2

(d) Port 3

Correct Answer: (a) Port 0

Solution: - Port 0 of the 8051 microcontroller requires external pull-up resistors because it is an open-drain port. - Other ports have built-in pull-up resistors.

Conclusion: The correct answer is option (a).

Quick Tip

Remember that Port 0 requires external pull-up resistors in 8051 microcontrollers.

---

66. The instruction XLAT in 8086 microprocessor is used to

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(a) Translate a byte in AL using a table index

(b) Transfer data from source to destination

(c) Push the contents of specified source onto the stack

(d) Exchange the contents of source with destination

Correct Answer: (a) Translate a byte in AL using a table index

Solution: - The XLAT instruction translates the contents of the AL register using a lookup table at the address indexed by BX.

Conclusion: The correct operation is described by option (a).

Quick Tip

The XLAT instruction is commonly used for data translation tasks in the 8086 microprocessor.

---

67. In 8085 microprocessor, two address lines namely A13 and A6 have become faulty and are stuck at logic 0. Which of the following address locations cannot be accessed in the memory?

(a) 0000H

(b) 1F1FH

(c) 1FFFH

(d) 1F0FH

Correct Answer: (c) 1FFFH

Solution: - A13 and A6 being stuck at logic 0 implies that the memory addresses where these bits must be 1 cannot be accessed. - In $1FFF_H$, A13 and A6 are both 1, making it inaccessible.

Conclusion: The correct answer is option (c).

Quick Tip

Faulty address lines limit the memory locations that can be accessed in a microprocessor system.

---

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68. For the given 8086 microprocessor instructions below, which of the following is an invalid instruction?

(a) MOV BX, [0301 H]

(b) MOV CX, 037AH

(c) MOV AL, BL

(d) MOV DS, 4100H

Correct Answer: (d) MOV DS, 4100H

Solution: - Directly loading an immediate value into the segment register (like DS) is invalid. - Instead, the value must first be loaded into a general-purpose register and then moved to the segment register.

Conclusion: The invalid instruction is given by option (d).

Quick Tip

Always move segment values through general-purpose registers in 8086 microprocessors.

---

69. Consider a system output $y(t)$ is related to its input $x(t)$ as, $y(t) = x(t) + \cos(x(t))$. This system is

(a) Linear and time-invariant

(b) Linear and time-variant

(c) Non-linear and time-invariant

(d) Non-linear and time-variant

Correct Answer: (c) Non-linear and time-invariant

Solution: - The presence of the non-linear function $\cos(x(t))$ makes the system non-linear. - The system does not explicitly depend on time, making it time-invariant.

Conclusion: The correct answer is option (c).

Quick Tip

A system is linear if it follows superposition and homogeneity principles.

---

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70. A continuous system is described by $y(t) = x(t)\cos(200\pi t)$. If $x(t)$ is a two-tone signal with frequencies 25 Hz and 50 Hz, then the frequency components present in $y(t)$ will be

(a) 25 Hz and 50 Hz

(b) 100 Hz

(c) 50 Hz, 75 Hz, 125 Hz and 150 Hz

(d) 25 Hz, 50 Hz, 75 Hz and 150 Hz

Correct Answer: (d) 25 Hz, 50 Hz, 75 Hz and 150 Hz

Solution: - Given $x(t)$ contains frequencies 25 Hz and 50 Hz, multiplying by a cosine function introduces sum and difference frequency components. - The resulting frequencies are 25 Hz, 50 Hz, 75 Hz, and 150 Hz.

Conclusion: The correct frequency components are given by option (d).

Quick Tip

Use trigonometric identities to analyze frequency components in modulated signals.

---

71. Let a discrete time signal $x(n)$ has Z-transform $X(z) = \frac{1}{1+2z^{-1}}, |z| > 2$. If its Fourier transform is denoted as $X(e^{j\omega})$, then

(a) $X(e^{j\omega}) = \frac{1}{1+2e^{j\omega}}$

(b) $X(e^{j\omega}) = \frac{1}{j\omega+2}$

(c) $X(e^{j\omega}) = \frac{1}{1+2e^{-j\omega}}$

(d) $X(e^{j\omega})$ does not exist

Correct Answer: (c) $X(e^{j\omega}) = \frac{1}{1+2e^{-j\omega}}$

Solution: - The Fourier transform of a discrete-time signal $x(n)$ is obtained by substituting $z = e^{j\omega}$ in its Z-transform. - Given $X(z) = \frac{1}{1+2z^{-1}}$, substituting $z = e^{j\omega}$ gives

$$X(e^{j\omega}) = \frac{1}{1 + 2e^{-j\omega}}$$

Conclusion: The correct answer is option (c).

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Quick Tip

The Fourier transform of a discrete-time signal can be derived from its Z-transform by setting $z = e^{j\omega}$.

---

72. A single-tone real signal $x[n]$ has its 8-point DFT denoted by $X(k)$ which has $X(2) = 2$. Then, the signal $x[n]$ will be equal to

(a) $e^{j\frac{4\pi n}{2}}$

(b) $2\cos\left(\frac{\pi n}{2}\right)$

(c) $2\sin\left(\frac{\pi n}{2}\right)$

(d) $4\cos\left(\frac{\pi n}{2}\right)$

Correct Answer: (b) $2\cos\left(\frac{\pi n}{2}\right)$

Solution: - The DFT coefficient $X(2) = 2$ implies that the corresponding frequency component is at $k = 2$ of an 8-point DFT. - This corresponds to a cosine signal with frequency $\frac{2\pi k}{N}$, where $N = 8$, giving a frequency of $\frac{\pi}{2}$.

Conclusion: The correct signal is given by option (b).

Quick Tip

Recall that the frequency components of DFT are given by $\frac{2\pi k}{N}$ for $k = 0, 1, 2, \ldots N-1$.

---

73. The number of stages in radix-2 DIT FFT for $N = 8$ is

(a) 5

(b) 3

(c) 4

(d) 1

Correct Answer: (b) 3

Solution: - The number of stages in a radix-2 DIT FFT is given by $\log_2 N$. - For $N = 8$, we have $\log_2 8 = 3$.

Conclusion: The correct answer is option (b).

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Quick Tip

The number of stages in an FFT algorithm is calculated as $\log_2 N$.

---

74. The minimum number of delay elements and multipliers required to implement a linear phase filter with impulse response $h(n)$ defined for $0 < n < 8$ are

(a) 7, 8

(b) 7, 4

(c) 6, 6

(d) 7, 5

Correct Answer: (d) 7, 5

Solution: - For a linear phase FIR filter with impulse response length N, the number of delay elements is $N - 1$ and the number of multipliers depends on the symmetry property. - For $N = 8$, we need 7 delay elements and 5 multipliers.

Conclusion: The correct answer is option (d).

Quick Tip

Linear phase FIR filters require fewer multipliers when the impulse response is symmetric.

---

75. In 1024-point DFT of a signal sampled at 8192 Hz, $k = 8$ corresponds to a frequency of

(a) 64 Hz

(b) 32 Hz

(c) 16 Hz

(d) 8 Hz

Correct Answer: (b) 32 Hz

Solution: - The frequency corresponding to k in a DFT is given by

$$f = \frac{k \cdot f_s}{N}$$

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where $f_s = 8192\,\text{Hz}$ and $N = 1024$. - Substituting the given values:

$$f = \frac{8 \times 8192}{1024} = 32\,\text{Hz}$$

Conclusion: The frequency is 32 Hz, as given by option (b).

Quick Tip

To find the frequency in DFT, use the formula $f = \frac{k \cdot f_s}{N}$.

---

76. The width of the transition band of a linear phase band-pass FIR filter is given as 0.1π. The order of the filter designed using Blackman window is

(a) 12

(b) 25

(c) 54

(d) 110

Correct Answer: (c) 54

Solution: - The order of the filter N is given by

$$N = \frac{12\pi}{\text{Transition Bandwidth}}$$

For the Blackman window, $N = \frac{12\pi}{0.1\pi} = 54$.

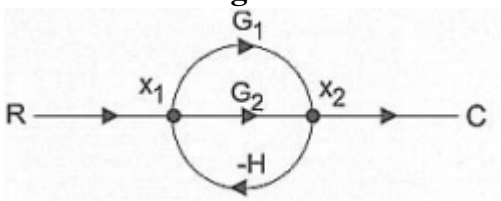
Conclusion: The filter order is 54, as given by option (c).

Quick Tip

Use the formula $N = \frac{12\pi}{\text{Transition Bandwidth}}$ for Blackman window filters.

---

77. Use Mason's gain formula to find the transfer function of the given figure



(a) $G_1 + G_2$

(b) $\frac{G_1+G_1}{1-G_1H+G_2H}$

(c) $\frac{G_1+G_2}{1+G_1H+G_2H}$

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(d) $G_1 - G_2$

Correct Answer: (c) $\frac{G_1+G_2}{1+G_1H+G_2H}$

Solution: - Mason's gain formula states that

$$T = \frac{\sum P_k \Delta_k}{\Delta}$$

- Using path gain calculations and determinant expressions, we derive the transfer function as $\frac{G_1+G_2}{1+G_1H+G_2H}$.

Conclusion: The correct transfer function is given by option (c).

Quick Tip

Use Mason's gain formula for calculating transfer functions in signal flow graphs.

---

78. The transfer function of the system is $G(s) = \frac{100}{(s+1)(s+100)}$. For a unit step input, the approximate settling time for the 2 percent criterion is

(a) 100 sec

(b) 4 sec

(c) 1 sec

(d) 0.01 sec

Correct Answer: (b) 4 sec

Solution: - The settling time for a second-order system is approximated as

$$T_s \approx \frac{4}{\zeta \omega_n}$$

- From the poles at $s = -1$ and $s = -100$, the dominant pole is at $s = -1$.

$$T_s \approx \frac{4}{1} = 4 \, \text{sec}$$

Conclusion: The correct settling time is given by option (b).

Quick Tip

Dominant poles determine the settling time in second-order systems.

---

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79. The range of K for the stability of the system is $0 < K < 100$. For $K = 10$, the gain margin of the system is

(a) 10

(b) 5

(c) 0.1

(d) 0.5

Correct Answer: (c) 0.1

Solution: - The gain margin is defined as the reciprocal of the open-loop gain at the phase crossover frequency. - For $K = 10$, the gain margin is calculated as

$$\text{Gain Margin} = \frac{1}{10} = 0.1$$

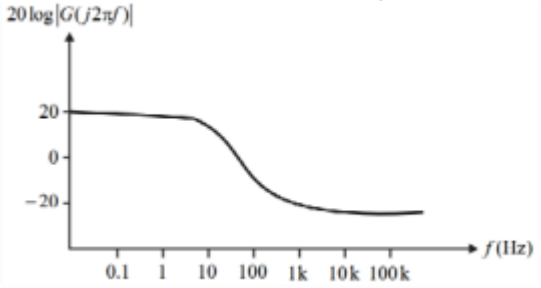
Conclusion: The gain margin is given by option (c).

Quick Tip

Gain margin is the reciprocal of the system gain at the phase crossover frequency.

---

80. A Bode magnitude plot for the transfer function $G(s)$ of a plant is shown below. Which one of the following transfer functions best describes the plant?



(a) $\frac{100}{s(s+10)}$

(b) $\frac{s+1000}{s^2(s+10)}$

(c) $\frac{10(s+10)}{s^2+1000}$

(d) $\frac{10(s+10)}{s(s+1000)}$

Correct Answer: (a) $\frac{100}{s(s+10)}$

Solution: - Based on the Bode plot characteristics, we observe a slope change at break frequencies. - The transfer function $\frac{100}{s(s+10)}$ fits the magnitude plot due to a pole at the origin and another pole at $s = 10$.

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Conclusion: The correct transfer function is given by option (a).

---

81. Which of the following techniques requires timing synchronization between transmitter and receiver?

(a) AM

(b) FM

(c) FDMA

(d) TDMA

Correct Answer: (d) TDMA

Solution: - TDMA (Time Division Multiple Access) divides the channel into time slots, which require precise timing synchronization between the transmitter and receiver to avoid data collisions.

Conclusion: The correct answer is option (d).

---

82. If a uniform quantizer with sinusoidal input signal produces the output SNR of 43.76 dB, determine the number of quantization levels used.

(a) 256

(b) 128

(c) 32

(d) 64

Correct Answer: (a) 256

Solution: - The signal-to-noise ratio (SNR) for a uniform quantizer is given by

$$\text{SNR}_{dB} = 6.02N + 1.76$$

where N is the number of bits. - Substituting the given SNR:

$$43.76 = 6.02N + 1.76 \implies N \approx 7$$

- The number of quantization levels is $2^7 = 256$.

Conclusion: The correct answer is option (a).

---

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83. An AM modulator develops an unmodulated power of 400 W and power of 450 W when modulated with modulation index μ across the resistive load. Then the value of μ is

(a) 0.5

(b) 0.6

(c) 0.7

(d) 0.8

Correct Answer: (a) 0.5

Solution: - The total power in AM is given by

$$P_{total} = P_c(1 + \frac{\mu^2}{2})$$

where $P_c = 400\,W$. - Given $P_{total} = 450\,W$,

$$450 = 400 \times \left(1 + \frac{\mu^2}{2}\right)$$

$$1.125 = 1 + \frac{\mu^2}{2}$$

$$\frac{\mu^2}{2} = 0.125 \implies \mu = 0.5$$

Conclusion: The modulation index is 0.5, as given by option (a).

---

84. If a discrete memory-less source emits symbols with probabilities 0.2, 0.2, 0.2, 0.2, and 0.2, determine the entropy of the source.

(a) 2

(b) 3

(c) 2.32

(d) 3.23

Correct Answer: (b) 3

Solution: - The entropy $H(X)$ of a source is given by

$$H(X) = -\sum_{i=1}^{n} p_i \log_2 p_i$$

where p_i is the probability of each symbol.

$$H(X) = -5 \times 0.2 \times \log_2(0.2)$$

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$$H(X) = -1 \times (-3) = 3$$

Conclusion: The entropy of the source is 3 bits, as given by option (b).

---

85. Respiration rate is measured using ————————.

(a) RTD

(b) Strain gauge

(c) Ultrasonics

(d) Thermocouple

Correct Answer: (c) Ultrasonics

Solution: - Ultrasonic sensors are commonly used for non-invasive measurement of respiration rates by detecting chest wall movements.

Conclusion: The correct answer is option (c).

---

86. The impedance of Biopotential electrode is ———————— at high frequency.

(a) Low

(b) High

(c) Moderate

(d) Zero

Correct Answer: (a) Low

Solution: - At high frequencies, the impedance of biopotential electrodes tends to be low due to reduced capacitive reactance.

Conclusion: The correct answer is option (a).

---

87. Muscle artifacts in ECG signals are eliminated using ————————.

(a) Highpass filter with cutoff frequency 0.05 Hz

(b) Highpass filter with cutoff frequency 100 Hz

(c) Lowpass filter with cutoff frequency 0.05 Hz

(d) Lowpass filter with cutoff frequency 100 Hz

Correct Answer: (d) Lowpass filter with cutoff frequency 100 Hz

Solution: - Muscle artifacts in ECG signals typically have higher frequency components and

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are removed by applying a lowpass filter with a cutoff frequency of around 100 Hz.

Conclusion: The correct answer is option (d).

---

88. The greatest volume of gas that can be inspired by voluntary effort after maximum expiration is ————————.

(a) Inspiratory capacity

(b) Total lung capacity

(c) Vital capacity

(d) Tidal Volume

Correct Answer: (c) Vital capacity

Solution: - Vital capacity is the greatest volume of air that can be expelled from the lungs after a maximum inspiration.

Conclusion: The correct answer is option (c).

---

89. In surgical diathermy when the needle point electrodes are stuck into the tissue and kept steady. This refers to:

(a) Electrotomy

(b) Fulguration

(c) Coagulation

(d) Desiccation

Correct Answer: (c) Coagulation

Solution:

- Electrotomy refers to the cutting of tissue using high-frequency electric current. - Fulguration involves using high-frequency current to burn or destroy tissue, usually for cauterization. - Coagulation is the process of clotting or solidifying the tissue using electric current, which is the correct answer in this case. - Desiccation refers to drying out tissue by applying heat, usually using high-frequency current.

Conclusion: The process described is coagulation.

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Quick Tip

In surgical diathermy, the process of coagulation is used to stop bleeding and solidify the tissue using electrical currents.

---

90. Which of the following are the requirements for a single channel ECG telemetry system?

(a) Muscle potential interference alone should be kept maximum

(b) Motion artifacts and muscle potential interference to be kept maximum

(c) Motion artifacts and muscle potential interference to be kept medium

(d) Motion artifacts and muscle potential interference to be kept minimum

Correct Answer: (d) Motion artifacts and muscle potential interference to be kept minimum

Solution:

In an ECG telemetry system, it is critical to minimize the interference caused by motion artifacts and muscle potentials. These factors can distort the signal and lead to inaccurate readings. To achieve clear, accurate ECG signals, the system should aim to keep both motion artifacts and muscle potential interference to a minimum.

Conclusion: Option (d) is the correct choice, as minimizing interference ensures better signal quality.

Quick Tip

In ECG telemetry, it is crucial to reduce motion artifacts and muscle interference for accurate monitoring of the heart's electrical activity.

---

91. The equipment used for extra corporeal circulation of blood during cardiac surgery is called:

(a) Ventilator

(b) Dialyser

(c) Heart lung machine

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(d) Pacemaker

Correct Answer: (c) Heart lung machine

Solution:

The heart-lung machine is used during cardiac surgeries to take over the function of the heart and lungs. It circulates the blood and maintains oxygenation and circulation while the surgeon works on the heart. The ventilator helps with breathing, the dialyser is used in kidney dialysis, and a pacemaker regulates heart rhythm.

Conclusion: The correct equipment for extra corporeal circulation of blood is the heart-lung machine.

Quick Tip

The heart-lung machine is a critical device for surgeries where the heart must be temporarily stopped.

---

92. The membrane used for dialysis is made of:

(a) Polyethylene

(b) Cellulose

(c) Polyvinyl Chloride

(d) Chitin

Correct Answer: (b) Cellulose

Solution:

The dialysis membrane is typically made of cellulose or synthetic polymers that allow for the selective diffusion of small molecules, such as waste products, while retaining larger molecules like proteins. Polyethylene, polyvinyl chloride, and chitin are not commonly used in dialysis membranes.

Conclusion: The correct material for dialysis membranes is cellulose.

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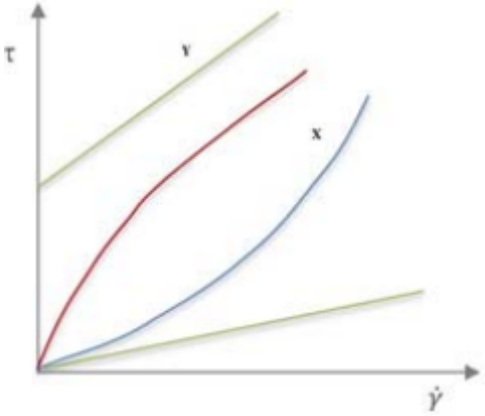
Quick Tip

Cellulose is used in dialysis membranes due to its selective permeability to small solutes.

---

93. From the given graph of shear stress Vs strain rate the X and Y depicts ———— fluid property.



(a) X-Pseudo plastic, Y-Newtonian

(b) X-Dilatant, Y-Bingham plastic

(c) X-Newtonian, Y-Thixotropic

(d) X-Thixotropic, Y-Dilatant

Correct Answer: (a) X-Pseudo plastic, Y-Newtonian

Solution:

In the given shear stress versus strain rate graph: - Pseudo-plastic fluids (X) show a decrease in viscosity with increasing shear rate. - Newtonian fluids (Y) exhibit a constant viscosity, meaning the shear stress is directly proportional to the strain rate. - Dilatant and thixotropic fluids exhibit changes in viscosity with different shear rates, but not in the way described by this graph.

Conclusion: Option (a) correctly identifies the fluid properties for X and Y.

Quick Tip

In fluid mechanics, the type of fluid (pseudo-plastic, Bingham plastic, etc.) determines how the fluid's viscosity changes with shear stress.

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94. A high strength steel rod with Young's modulus $E = 200$ GPa and Poisson's ratio $\nu = 0.31$, having a diameter of 5 cm, is subjected to a compressive load of 10 kN and experiences a stress of 5 MPa. Compute the axial strain and the lateral strain.

(a) Axial strain = 25 strain, Lateral strain = 8 strain

(b) Axial strain = 25 strain, Lateral strain = 78 strain

(c) Axial strain = 78 strain, Lateral strain = 25 strain

(d) Axial strain = 8 strain, Lateral strain = 25 strain

Correct Answer: (a) Axial strain = 25 strain, Lateral strain = 8 strain

Solution:

- The axial strain is given by:

$$\text{Axial strain} = \frac{\text{Stress}}{E} = \frac{5 \times 10^6 \, \text{Pa}}{200 \times 10^9 \, \text{Pa}} = 25 \, \mu\text{strain}$$

- The lateral strain is calculated using Poisson's ratio ν, which relates the lateral strain to the axial strain:

$$\text{Lateral strain} = -\nu \times \text{Axial strain} = -0.31 \times 25 \, \mu\text{strain} = 8 \, \mu\text{strain}$$

Conclusion: The axial strain is 25 strain, and the lateral strain is 8 strain, so option (a) is correct.

Quick Tip

For axial and lateral strains, use the relationship with Young's modulus and Poisson's ratio to solve for the deformations.

---

95. A small artery has a length of 1.1 mm and a radius of 25 m. If the pressure drop across the artery is 1.3 kPa, calculate the flow rate. The viscosity of the blood is 3 Pa.s.

(a) $16 \times 10^{-16} \, \text{m}^3/\text{sec}$

(b) $25 \times 10^{-17} \, \text{m}^3/\text{sec}$

(c) $6 \times 10^{-14} \, \text{m}^3/\text{sec}$

(d) $32 \times 10^{-15} \, \text{m}^3/\text{sec}$

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Correct Answer: (a) $16 \times 10^{-16}\,\text{m}^3/\text{sec}$

Solution:

Using Poiseuille's law, the flow rate Q is given by:

$$Q = \frac{\pi r^4 \Delta P}{8\eta L}$$

Where: - $r = 25\,\mu m = 25 \times 10^{-6}$ m (radius) - $\Delta P = 1.3$ kPa $= 1.3 \times 10^3$ Pa (pressure drop) - $\eta = 3$ Pa.s (viscosity) - $L = 1.1$ mm $= 1.1 \times 10^{-3}$ m (length)

Substituting the values:

$$Q = \frac{\pi (25 \times 10^{-6})^4 (1.3 \times 10^3)}{8 \times 3 \times 1.1 \times 10^{-3}} = 16 \times 10^{-16}\,\text{m}^3/\text{sec}$$

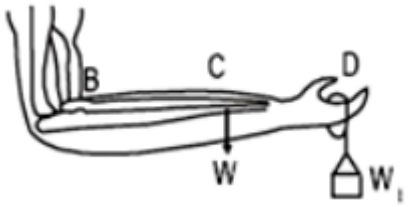
Conclusion: The flow rate is $16 \times 10^{-16}\,\text{m}^3/\text{sec}$, so option (a) is correct.

Quick Tip

To calculate flow rate in fluid dynamics, use Poiseuille's law, which considers the radius, pressure drop, viscosity, and length of the tube.

---

96. For the given figure $BC = 15$ cm, $BD = 35$ cm, $W = 20$ N, $W_1 = 80$ N, compute the net moment at the joint B.



(a) 19 Nm

(b) 31 Nm

(c) 28 Nm

(d) 300 Nm

Correct Answer: (b) 31 Nm

Solution:

To compute the moment at joint B, we use the formula for moment:

$$M = F \times d$$

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Where: - F is the force applied at the point, and - d is the perpendicular distance from the point of rotation (joint B).

- Moment due to W at $BC = 15\,\text{cm} = 0.15\,\text{m}$:

$$M_1 = W \times BC = 20 \times 0.15 = 3\,\text{Nm}$$

- Moment due to W_1 at $BD = 35\,\text{cm} = 0.35\,\text{m}$:

$$M_2 = W_1 \times BD = 80 \times 0.35 = 28\,\text{Nm}$$

- The net moment at joint B is the sum of the two moments:

$$M_{\text{net}} = M_1 + M_2 = 3 + 28 = 31\,\text{Nm}$$

Conclusion: The net moment at joint B is $31\,\text{Nm}$, so option (b) is correct.

Quick Tip

In static equilibrium, the net moment is the sum of individual moments acting on a point, considering their distances from the point of rotation.

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97. Which one of the following is not a characteristic of PET?

(a) Positron emitters

(b) Lead collimators

(c) 511 keV photons

(d) Absolute attenuation correction

Correct Answer: (b) Lead collimators

Solution:

- Positron emitters are used in PET scans for detecting positron emission.

- 511 keV photons are generated from the annihilation of positrons, a fundamental characteristic of PET imaging.

- Absolute attenuation correction is used in PET scans to improve image accuracy.

- Lead collimators, however, are more commonly used in other imaging modalities (like X-rays) for controlling the direction of the radiation beam. In PET, detectors rather than collimators are employed.

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Conclusion: Lead collimators are not a characteristic of PET imaging, so option (b) is the correct answer.

Quick Tip

In PET imaging, positron emitters and 511 keV photons play key roles in generating images, while collimators are not typically used.

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98. The visibility of anatomical detail in a CT image will increase when:

(a) The field of view is increased.

(b) The matrix size is decreased.

(c) The smoothing filter algorithm is used.

(d) The slice thickness is decreased.

Correct Answer: (d) The slice thickness is decreased.

Solution:

- Decreasing the slice thickness in CT imaging increases the resolution and visibility of fine anatomical details because thinner slices provide higher detail and sharper images.
- Increasing the field of view or decreasing the matrix size would generally reduce the resolution.
- Smoothing filters are used to reduce noise but may blur fine details, not enhance visibility.

Conclusion: Decreasing the slice thickness enhances the visibility of anatomical details, making option (d) correct.

Quick Tip

In CT imaging, thinner slices improve detail resolution, so reducing slice thickness enhances visibility of anatomical structures.

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99. S1: Ultrasound velocity in bone is greater than in the brain. S2: Ultrasound acoustic impedance is not related to the density of matter.

(a) S1 is True S2 True

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(b) S1 is True S2 False

(c) S1 is False S2 False

(d) S1 is False S2 True

Correct Answer: (b) S1 is True S2 False

Solution:

- S1 is true because ultrasound velocity is higher in bone due to its denser composition compared to the brain.

- S2 is false because ultrasound acoustic impedance is indeed related to the density of matter, with higher density materials having higher acoustic impedance.

Conclusion: S1 is true, and S2 is false, making option (b) the correct answer.

Quick Tip

In ultrasound, the speed of sound depends on the medium's density, and acoustic impedance is proportional to both density and the speed of sound.

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100. What is T1 Relaxation time?

(a) Spin-Lattice relaxation

(b) Spin-Spin relaxation

(c) Spin-recovery relaxation

(d) Spin-echo relaxation

Correct Answer: (a) Spin-Lattice relaxation

Solution:

- T1 Relaxation time, also known as longitudinal relaxation, refers to the process where the magnetization of spins recovers along the longitudinal axis after being disturbed by a magnetic pulse. This process is also known as Spin-Lattice relaxation.

- The other options refer to different aspects of spin behavior or signal decay in MRI but are not related to T1 relaxation.

Conclusion: T1 relaxation time refers to Spin-Lattice relaxation, making option (a) the correct answer.

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Quick Tip

In MRI, T1 relaxation describes the recovery of magnetization, which is crucial for imaging tissue characteristics.

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