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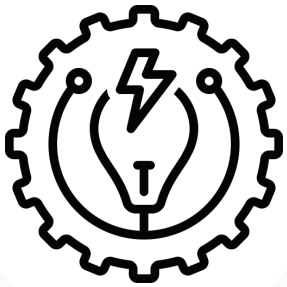
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ENGINEERING MATHEMATICS

SECTION 1

SYLLABUS

MATRIX THEORY, EIGEN VALUES & EIGEN VECTORS, SYSTEM OF LINEAR EQUATIONS, NUMERICAL METHODS FOR SOLUTION OF NON-LINEAR ALGEBRAIC EQUATIONS AND DIFFERENTIAL EQUATIONS, INTEGRAL CALCULUS, PARTIAL DERIVATIVES, MAXIMA AND MINIMA, LINE, SURFACE AND VOLUME INTEGRALS. FOURIER SERIES, LINEAR, NON-LINEAR AND PARTIAL DIFFERENTIAL EQUATIONS, INITIAL AND BOUNDARY VALUE PROBLEMS, COMPLEX VARIABLES, TAYLOR'S AND LAURENT'S SERIES, RESIDUE THEOREM, PROBABILITY AND STATISTICS FUNDAMENTALS, SAMPLING THEOREM, RANDOM VARIABLES, NORMAL AND POISSON DISTRIBUTIONS, CORRELATION AND REGRESSION ANALYSIS



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ESE ELECTRICAL ENGINEERING: NUMBER OF QUESTIONS ASKED IN PREVIOUS EXAMS (2017-2025)										
ENGINEERING MATHEMATICS		**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
1.1	**Linear Algebra**	2	2	2	2	2	1	2	-	1
1.2	**Calculus**	-	-	2	1	3	3	1	-	2
1.3	**Complex Variables**	2	1	4	1	3	-	2	1	2
1.4	**Ordinary Differential Equation**	2	2	1	2	-	1	1	3	1
1.5	**Partial Differential Equation**	1	1	1	1	-	2	2	1	4
1.6	**Fourier Series**	2	-	-	-	-	-	1	-	1
1.7	**Numerical Methods**	-	-	1	2	-	-	1	-	-
1.8	**Probability & Statistics**	5	2	2	3	4	6	2	7	1

CHAPTER-1 ENGINEERING MATHEMATICS

Unit 1.1: Linear Algebra

Previous Year Exam Questions

[ESE-2017]

1. Which of the following statements are correct regarding dot product of vectors?

(1) Dot product is less than or equal to the product of magnitudes of two vectors.

(2) When two vectors are perpendicular to each other, then their dot product is non-zero.

(3) Dot product of two vectors is positive or negative depending whether the angle between the vectors is less than or greater than $\pi/2$

(4) Dot product is equal to the product of one vector and the projection of the vector on the first one.

Select the correct answer using the codes given below.

(a) 1, 2 and 3 only (b) 1, 3 and 4 only

(c) 1, 2 and 4 only (d) 2, 3 and 4 only

[ESE-2017]

2. If a square matrix of order 100 has exactly 15 distinct eigen values, the degree of the minimal polynomial is

(a) At least 15 (b) At most 15

(c) Always 15 (d) Exactly 100

[ESE-2018]

3. Eigen values of the matrix $\begin{bmatrix} 3 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{bmatrix}$ **are**

(a) 1,1,1 (b) 1,1,2

(c) 1,4,4 (d) 1,2,4

[ESE-2018]

4. If the system

$2x - y + 3z = 2$

$x + y + 2z = 2$

$5x - y + az = b$

has infinitely many solutions, then the values of a and b, respectively, are

(a) -8 and 6 (b) 8 and 6

(c) -8 and -6 (d) 8 and -6

[ESE-2019]

5. What are the value of k for which the system of equations:

$$(3k-8)x + 3y + 3z = 0$$
$$3x + (3k-8)y + 3z = 0$$
$$3x + 3y + (3k-8)z = 0$$

has a not-trivial solution?

(a) $k = \frac{2}{3}, \frac{11}{3}, \frac{10}{3}$ (b) $k = \frac{2}{3}, \frac{10}{3}, \frac{11}{3}$

(c) $k = \frac{11}{3}, \frac{11}{3}, \frac{11}{3}$ (d) $k = \frac{2}{3}, \frac{11}{3}, \frac{11}{3}$

[ESE-2019]

6. If $\mathbf{A} = \begin{bmatrix} 2+i & 3 & -1+3i \\ -5 & i & 4-2i \end{bmatrix}$**, then $\mathbf{AA}^*$ will be (where, $\mathbf{A}^*$ is the conjugate transpose of A)**

(a) Unitary matrix

(b) Orthogonal matrix

(c) Hermitian matrix

(d) Skew Hermitian matrix

[ESE-2020]

7. If λ is eigenvalues of A, and A is idempotent matrix then

(a) $\lambda \neq 0$ (b) $\lambda \neq 1$

(c) Either $\lambda = 0$ or $\lambda = 1$ (d) $\lambda \neq 0$ and $\lambda = 1$

[ESE-2020]

8. The eigenvalues of the matrix $\begin{bmatrix} 5 & 4 \\ 1 & 2 \end{bmatrix}$ **are**

(a) 5 and 2 (b) 1 and 4

(c) 1 and 6 (d) 7 and 5

[ESE-2021]

9. In which matrix are eigen vectors corresponding to different eigen values orthogonal?

(a) Singular matrix

(b) Non-singular matrix

(c) Symmetric matrix

(d) Non-symmetric matrix

[ESE-2021]

10. '0' is a characteristic root of a matrix, if and only if, the matrix is

(a) Idempotent matrix (b) Periodic matrix

(c) Nilpotent matrix (d) Singular matrix

[ESE-2022]

11. A and B are real non-zero 3×3 matrices and satisty the equation $(AB)^{\top} + B^{-1}A = 0$. It B is orthogonal, then A is

(a) symmetric (b) antisymmetric

(c) Hermitian (d) anti-Hermitian

[ESE-2023]

12. The general solution of the system

$$6x_1 - x_2 + x_3 = 0$$
$$x_1 - x_4 + 2x_5 = 0$$
$$x_1 - 2x_5 = 0$$

(a) $x = \alpha \begin{pmatrix} -\frac{1}{9} \\ -\frac{2}{3} \\ \frac{2}{3} \\ 1 \\ 0 \end{pmatrix} + \beta \begin{pmatrix} -\frac{11}{9} \\ -\frac{13}{3} \\ \frac{1}{3} \\ 0 \\ 1 \end{pmatrix}$

(b) $X = \alpha \begin{pmatrix} -\frac{1}{9} \\ -\frac{2}{3} \\ \frac{2}{3} \\ 1 \\ 0 \end{pmatrix} + \beta \begin{pmatrix} -\frac{11}{9} \\ -\frac{13}{3} \\ \frac{1}{3} \\ 0 \\ 1 \end{pmatrix} + \gamma \begin{pmatrix} -\frac{11}{9} \\ -\frac{13}{3} \\ 0 \\ \frac{1}{3} \\ 1 \end{pmatrix}$

(c) $X = \alpha \begin{pmatrix} -\frac{1}{9} \\ -\frac{2}{3} \\ \frac{2}{3} \\ 1 \\ 0 \end{pmatrix} + \beta \begin{pmatrix} -\frac{11}{9} \\ -\frac{13}{3} \\ \frac{1}{3} \\ 0 \\ 1 \end{pmatrix} + \gamma \begin{pmatrix} -\frac{11}{9} \\ 1 \\ 0 \\ \frac{1}{3} \\ 1 \end{pmatrix}$

(d) $x = \alpha \begin{pmatrix} -\frac{1}{9} \\ 0 \\ \frac{2}{3} \\ 1 \\ 0 \end{pmatrix} + \beta \begin{pmatrix} -\frac{11}{9} \\ -\frac{13}{3} \\ \frac{1}{3} \\ 1 \\ 1 \end{pmatrix}$

[ESE-2023]

13. If the eigen values of the matrix $A = \begin{pmatrix} 5 & -2 \\ m & -6 \end{pmatrix}$ are 3 and -4, then what is the value of m ?

(a) 6 (b) 4

(c) 8 (d) 9

[ESE-2025]

14. What is the value of b such that the system of homogeneous equations

$$2x + y + 2z = 0$$
$$x + y + 3z = 0$$
$$4x + 3y + bz = 0$$

has non-trivial solution?

(a) 4 (b) 6

(c) 8 (d) 10

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(b)	(a)	(c)	(b)	(d)	(c)	(c)	(c)	(c)	(d)
11	**12**	**13**	**14**						
(b)	*	(d)	(c)						

EXPLANATIONS

1. Explanation: (b) The correct statements regarding the dot product of vectors are:

(1) True: The dot product is $|a||b|\cos\theta$, so its absolute value is less than or equal to the product of the magnitudes.

(2) False: When two vectors are perpendicular ($\theta = \frac{\pi}{2}$), $\cos\theta = 0$, so their dot product is zero, not non-zero.

(3) True: The dot product is positive if the angle is less than $\frac{\pi}{2}$, negative if greater than $\frac{\pi}{2}$.

(4) True: The dot product equals the product of one vector's magnitude and the projection of the other vector onto it.

Correct answer: (b) 1, 3 and 4 only

2. Explanation: (a) If a square matrix of order 100 has exactly 15 distinct eigenvalues, the degree of its minimal polynomial is at least 15. This is because the minimal polynomial must have each distinct eigenvalue as a root, so its degree cannot be less than the number of distinct eigenvalues.

3. Explanation: (c) Given,

$$A = \begin{bmatrix} 3 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{bmatrix}$$

Characteristic equation is,

$|A - \lambda I| = 0$

$$\begin{vmatrix} 3-\lambda & -1 & -1 \\ -1 & 3-\lambda & -1 \\ -1 & -1 & 3-\lambda \end{vmatrix} = 0$$

$(3-\lambda)((3-\lambda)^2 - 1) + 1(-3+\lambda-1) - 1(1+3-\lambda) = 0$

$(3-\lambda)(\lambda^2 - 6\lambda + 9 - 1) + -4 + \lambda - 4 + \lambda = 0$

$(3-\lambda)(\lambda^2 - 6\lambda + 8) - 8 + 2\lambda = 0$

$3\lambda^2 - 18\lambda + 24 - \lambda^3 + 6\lambda^2 - 8\lambda - 8 + 2\lambda = 0$

$-\lambda^3 + 9\lambda^2 - 24\lambda + 16 = 0$

$\lambda^3 - 9\lambda^2 + 24\lambda - 16 = 0$

$\lambda^3 - 9\lambda^2 + 24\lambda - 16 = (\lambda - 1)(\lambda - 4)^2$

Set each factor equal to 0:

1. $\lambda - 1 = 0 \Rightarrow \lambda = 1$
2. $(\lambda - 4)^2 = 0 \Rightarrow \lambda = 4,4$

4. Explanation: (b) Write the augmented matrix:

$$\begin{bmatrix} 2 & -1 & 3 & | & 2 \\ 1 & 1 & 2 & | & 2 \\ 5 & -1 & a & | & b \end{bmatrix}$$

$R_1 = R_1 - 2R_2$

$[2,-1,3|2] - 2 \cdot [1,1,2|2] = [0,-3,-1|-2]$

$R_3 = R_3 - 5R_2$

$[5,-1,a|b] - 5 \cdot [1,1,2|2] = [0,-6,a-10|b-10]$

Now the system becomes:

$$\begin{bmatrix} 0 & -3 & -1 & | & -2 \\ 1 & 1 & 2 & | & 2 \\ 0 & -6 & a-10 & | & b-10 \end{bmatrix}$$

Multiply Row 1 by 2:

$2 \cdot [0,-3,-1|-2] = [0,-6,-2|-4]$

Now subtract:

$R_3 = R_3 - 2 \cdot R_1 = [0, -6, a-10 | b-10]$
$- [0, -6, -2 | -4]$
$= [0,0, a-8 | b-6]$
For infinitely many solutions
The third row must reduce to [0, 0, 0 | 0]:
$a - 8 = 0 \Rightarrow a = 8 \qquad b - 6 = 0 \Rightarrow b = 6$
Final Answer: (b) 8 and 6

5. Explanation: (c)
For non-trivial solution,
$|A| = 0$
$C_1 \to C_1 + C_2 + C_3$
$$\begin{vmatrix} 3k-8+3+3 & 3 & 3 \\ 3+3k-8+3 & 3k-8 & 3 \\ 3+3+3k-8 & 3 & 3k-8 \end{vmatrix} = 0$$
$$\begin{vmatrix} 3k-2 & 3 & 3 \\ 3k-2 & 3k-8 & 3 \\ 3k-2 & 3 & 3k-8 \end{vmatrix} = 0$$
$$(3k-2)\begin{vmatrix} 1 & 3 & 3 \\ 1 & 3k-8 & 3 \\ 1 & 3 & 3k-8 \end{vmatrix} = 0$$
$R_2 - R_1 \cdot R_3 - R_1$
$$(3k-2)\begin{vmatrix} 1 & 3 & 3 \\ 0 & 3k-11 & 0 \\ 0 & 0 & 3k-11 \end{vmatrix} = 0$$
$(3k-2)(3k-11)^2 = 0$
$k = \frac{2}{3}, \frac{11}{3}, \frac{11}{3}$

6. Explanation: (c)
Given A is a complex matrix, AA^* (where A^* is the conjugate transpose) is always a **Hermitian matrix**, because the product of a matrix and its conjugate transpose is Hermitian and positive semi-definite, regardless of whether A is square or not.

7. Explanation: (c) We are given that:
A is an **idempotent matrix**, i.e.,
$A^2 = A$
If λ is an eigenvalue of A, then by definition:
$A\vec{v} = \lambda\vec{v}$ for some $\vec{v} \neq 0$
Apply A again:
$A^2\vec{v} = A(A\vec{v}) = A(\lambda\vec{v}) = \lambda A\vec{v} = \lambda^2\vec{v}$
But since A is idempotent:
$A^2\vec{v} = A\vec{v} = \lambda\vec{v}$
So:
$\lambda^2\vec{v} = \lambda\vec{v} \Rightarrow (\lambda^2 - \lambda)\vec{v} = 0 \Rightarrow \lambda(\lambda-1)\vec{v} = 0$
Since $\vec{v} \neq 0$, this implies:
$\lambda(\lambda-1) = 0 \Rightarrow \lambda = 0$ or $\lambda = 1$
Final Answer: (c) Either $\lambda = 0$ or $\lambda = 1$

8. Explanation: (c) We are given the matrix:
$A = \begin{bmatrix} 5 & 4 \\ 1 & 2 \end{bmatrix}$
The characteristic equation is:
$\det(A - \lambda I) = 0$
$\Rightarrow \det\begin{bmatrix} 5-\lambda & 4 \\ 1 & 2-\lambda \end{bmatrix} = 0$
$(5-\lambda)(2-\lambda) - 4 \cdot 1 = 0$
$(5-\lambda)(2-\lambda) - 4 = 0$
$= (10 - 5\lambda - 2\lambda + \lambda^2) - 4 = \lambda^2 - 7\lambda + 6 = 0$
Solve the quadratic:
$\lambda^2 - 7\lambda + 6 = 0 \Rightarrow (\lambda-6)(\lambda-1) = 0 \Rightarrow \lambda = 1,6$
Final Answer: (c) 1 and 6

9. Explanation: (c) Eigenvectors corresponding to distinct eigenvalues of a matrix are **orthogonal** if the matrix is **symmetric**. This is a fundamental property of symmetric matrices in linear algebra.

- If **A** is a symmetric matrix, then for any two distinct eigenvalues λ_i and λ_j, their corresponding eigenvectors v_i and v_j satisfy:
  $Av_i = \lambda_i v_i, Av_j = \lambda_j v_j$
- Taking the dot product and using symmetry ($A^T = A$), it can be shown that v_i and v_j are orthogonal.

Thus, the correct answer is **(c) Symmetric matrix**.

10. Explanation: (d) A matrix has a characteristic root (eigenvalue) of 0 if and only if it is singular.

11. Explanation: (b)
$(AB)^\top + B^{-1}A = 0$
$B^\top A^\top + B^{-1}A = 0$
Since B is orthogonal: $B^\top = B^{-1}$
$B^{-1}A^\top + B^{-1}A = 0 \Rightarrow B^{-1}(A^\top + A) = 0$
Multiply both sides on the left by B (which is invertible):
$A^\top + A = 0 \Rightarrow A^\top = -A$
This means: **Antisymmetric**

12. Explanation: (*)
Let $x_3 = \alpha$ and $x_5 = \beta$
Then, we have,
$x_1 = 2x_5 = 2\beta$
$x_2 = 6x_1 + x_3 = \alpha + 12\beta$
$x_3 = \alpha$
$x_4 = x_1 + 2x_5 = 4\beta$
$x_5 = \beta$
$$\therefore \vec{x} = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{pmatrix} = \begin{pmatrix} 2\beta \\ \alpha + 12\beta \\ \alpha \\ 4\beta \\ \beta \end{pmatrix} = \alpha\begin{pmatrix} 0 \\ 1 \\ 1 \\ 0 \\ 0 \end{pmatrix} + \beta\begin{pmatrix} 2 \\ 12 \\ 0 \\ 4 \\ 1 \end{pmatrix}$$
None of the options is correct.

13. Explanation: (d) Given:

$A = \begin{bmatrix} 5 & -2 \\ m & -6 \end{bmatrix}$

$\det(A - \lambda I) = 0$

$\begin{vmatrix} 5-\lambda & -2 \\ m & -6-\lambda \end{vmatrix} = 0$

$(5-\lambda)(-6-\lambda) - (-2)m = 0$

$(5-\lambda)(-6-\lambda) + 2m = 0$

$(5-\lambda)(-6-\lambda) + 2m = 0$

$\lambda_1 + \lambda_2 = 3 + (-4) = -1$

Trace of A is $5 + (-6) = -1$

$\lambda_1\lambda_2 = 3 \times (-4) = -12$

Determinant of A is:

$\det(A) = (5)(-6) - (m)(-2) = -30 + 2m$

Set equal to -12:

$-30 + 2m = -12$

$2m = -12 + 30 = 18$

$m = 9$

14. Explanation: (c)

We are given a homogeneous system of equations:

$\begin{cases} 2x + y + 2z = 0 \ (1) \\ x + y + 3z = 0 \ (2) \\ 4x + 3y + bz = 0 \ (3) \end{cases}$

For the system to have a non-trivial solution, the determinant of the coefficient matrix must be zero.

The coefficient matrix

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

We want to compute $\det(A) = 0$.

Use cofactor expansion along the first row:

$\det(A) = 2 \cdot \begin{vmatrix} 1 & 3 \\ 3 & b \end{vmatrix} - 1 \cdot \begin{vmatrix} 1 & 3 \\ 4 & b \end{vmatrix} + 2 \cdot \begin{vmatrix} 1 & 1 \\ 4 & 3 \end{vmatrix}$

$\det(A) = 2(b-9) - (b-12) + 2(-1)$

$= 2b - 18 - b + 12 - 2$

$= b - 8$

Set determinant $= 0$ for non-trivial solution

$b - 8 = 0 \Rightarrow b = 8$

Final Answer: (c) 8

Unit 1.2 Calculus

Previous Year Exam Questions

[ESE-2019]

1. The volume of the solid surrounded by the surface $\left(\frac{x}{a}\right)^{2/3} + \left(\frac{y}{b}\right)^{2/3} + \left(\frac{z}{c}\right)^{2/3} = 1$ is

(a) $\frac{4\pi abc}{35}$ (b) $\frac{abc}{35}$

(c) $\frac{2\pi abc}{35}$ (d) $\frac{\pi abc}{35}$

[ESE-2019]

2. The area between the parabolas $y^2 = 4ax$ and $x^2 = 4ay$ is

(a) $\frac{2}{3}a^2$ (b) $\frac{14}{3}a^2$

(c) $\frac{16}{3}a^2$ (d) $\frac{17}{3}a^2$

[ESE-2020]

3. The first four terms of the Taylor series expansion of $f(z) = \frac{z+1}{(z-3)(z-4)}$ when $z = 2$ is

(a) $\frac{11}{4}(z-2) + \frac{27}{8}(z-2)^2 + \frac{59}{16}(z-2)^3 + \cdots$

(b) $\frac{11}{4}(z+2) - \frac{27}{8}(z-2)^2 - \frac{59}{16}(z+2)^3 + \cdots$

(c) $\frac{3}{2} + \frac{11}{4}(z-2) + \frac{27}{8}(z-2)^2 + \frac{59}{16}(z-2)^3 + \cdots$

(d) $\frac{3}{2} - \frac{11}{4}(z-2) - \frac{27}{8}(z-2)^2 - \frac{59}{16}(z-2)^3 + \cdots$

[ESE-2021]

4. If a force $\vec{F} = 2x^2y\hat{\imath} + 3xy\hat{\jmath}$ displaces a particle in the xy-plane from $(0,0)$ to $(1,4)$ along a curve $y = 4x^2$, what is the work done?

(a) $\frac{102}{5}$ (b) $\frac{5}{104}$

(c) $\frac{104}{5}$ (d) $\frac{5}{102}$

[ESE-2021]

5. The value of $\int_0^{\pi/6} \cos^4 3\theta \sin^3 6\theta c\theta$ is

(a) $\frac{1}{15}$ (b) $\frac{8}{3}$

(c) $\frac{7}{3}$ (d) $\frac{7}{15}$

[ESE-2021]

6. The simplified value of $\int x^2 \cos ax dx$ is

(a) $\frac{1}{a^3}(2ax\cos ax - 2\sin ax + a^2x^2\sin ax)$

(b) $\frac{1}{a^2}(2ax\cos ax - 2\sin ax + a^2x\sin ax)$

(c) $\frac{1}{a}(2ax\cos ax - 2\sin ax + ax\sin ax)$

(d) $\frac{1}{a}(2ax\cos ax - 2\sin ax + a^2x^2\sin ax)$

[ESE-2022]

7. The value of $\int x^2 e^{ax} dx$ is

(a) $\frac{e^{ax}}{a}(a^2x^2 + 3ax - 2)$

(b) $\frac{e^{ax}}{a^4}(a^3x^2 - a^2x + 2ax + 1)$

(c) $\frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2)$

(d) $\frac{e^{ax}}{a^2}(a^3x^2 - 2a^2x + 4)$

[ESE-2022]

8. The distances of the variable point P, which has coordinates x, y, z from the flixed points $(0,0,1)$ and $(0,0,-1)$ are denoted by u and v respectively. New variables ξ, η, ϕ are defined by $\xi = \frac{1}{2}(u + v), n = \frac{1}{2}(u - v)$ and ϕ is the angle between the plane $y = 0$ and the plane containing the three points, i.e., $\phi = \tan^{-1}\left(\frac{y}{x}\right)$ over $\leq \xi < \infty, -1 \leq \eta <$

$1, 0 \le \phi < 2\pi$. The Jacobian of $\frac{\partial(\xi,\eta,\phi)}{\partial(x,y,z)}$ has the value $(\xi^2 - \eta^2)^{-1}$, then

$$\iiint_{\text{all space}} \frac{(u-v)^2}{UV} \exp\left(-\frac{U+V}{2}\right) dxdy\,dz =$$

(a) $\frac{16\pi}{e}$ (b) $\frac{8\pi}{30}$
(c) $\frac{16\pi}{3e}$ (d) $\frac{8\pi}{e}$

[ESE-2022]

9. The function $f(x,y) = x^3 - 12xy + 48x + by^2$, $b \neq 0$ has two, one of zero stationary points. according to whether $|b|$ is

(a) less than, equal to or greater than 3
(b) less than, equal to or greater than 4
(c) less than, equal to or greater than 8
(d) less than, equal to or greater than 2

[ESE-2023]

10. The volume of the solid enclosed between the paraboloids $z = 5x^2 + 5y^2$ and $z = 6 - 7x^2 - y^2$ is

(a) $\frac{3\pi}{2\sqrt{2}}$ (b) $\frac{3\pi}{\sqrt{2}}$
(c) $\frac{3\pi^2}{\sqrt{2}}$ (d) $\frac{3\pi^3}{\sqrt{2}}$

[ESE-2025]

11. The value of the integral $\int_C x^2 y dS$, where C is the curve defined by

$x = 3\cos t, y = 3\sin t, 0 \le t \le \frac{\pi}{2}$ is

(a) 20 (b) 24
(c) 27 (d) 31

[ESE-2025]

12. Let D be the region bounded by the closed cylinder $x^2 + y^2 = 16, z = 0, z = 4$, and $v = 3x^2 i + 6y^2 j + zk$, then by divergence theorem

$$\iiint_D (\nabla \cdot v) dV$$

is

(a) 46π (b) 64π
(c) 84π (d) 96π

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(a)	(c)	(c)	(c)	(a)	(a)	(c)	(c)	(a)	(b)
11	**12**								
(c)	(b)								

EXPLANATIONS

1. Explanation: (a)

$$\left(\frac{x}{a}\right)^{2/3} + \left(\frac{y}{b}\right)^{2/3} + \left(\frac{z}{c}\right)^{2/3} = 1$$

Put $\left(\frac{x}{a}\right)^{1/3} = u \Rightarrow x = au^3 \Rightarrow dx = 3au^2 du$

$$\left(\frac{y}{b}\right)^{1/3} = v \Rightarrow y = bv^3 \Rightarrow dy = 3bv^2 dv$$

$$\left(\frac{z}{c}\right)^{1/3} = w \Rightarrow z = cw^3 \Rightarrow dz = 3cw^2 dw$$

The equation of solid becomes,

$v^2 + v^2 + w^2 = 1$……(1)

$v = \iiint_V dxdydx$ ……(2)

On putting, the values of dx, dy and dz, we get

$$V = \iiint_V 27abaw^2v^2w^2 dudvdw$$

Equation (i) represents a sphere,

By taking spherical co-ordinates

$u = r\sin\theta\cos\phi, v = r\sin\theta\sin\phi, w = r\cos\theta$

$dudvdw = r^2\sin\theta dr d\theta d\phi$

Substituting in equation (iii),

$$V = 27abc \int_{r=0\theta}^{1} \int_{-0\phi=0}^{\pi} \int_{2}^{2\pi} r^2 \sin^2\theta \cdot \cos^2\phi \cdot$$

$$= r^2\sin^2\theta \sin^2\phi \cdot r^2\cos^2\theta r^2 \sin\theta dr d\theta d\phi$$

$$= 216\,abc \int_{r=0}^{1} r^8 dr \int_{\theta=0}^{\pi/2} \sin^2\phi d\phi$$

$$\int_{\theta=0}^{\pi/2} \sin^5\theta . cos^2\theta d\theta$$

$$= 216abc \left[\frac{r^9}{9}\right]_0^1 \left[\frac{1\times 1}{4\times 2} \times \frac{\pi}{2}\right] \times \left[\frac{(4\times 2)1)}{7\times 5\times 3\times 1}\right]$$

$$= \frac{4}{35} abc\pi$$

2. Explanation: (c) To find the area bounded between the parabolas $y^2 = 4ax$ and $x^2 = 4ay$:

Set $y^2 = 4ax$ and $x^2 = 4ay$

- From $x^2 = 4ay$, $y = \frac{x^2}{4a}$
- Substitute into $y^2 = 4ax$:

$$\left(\frac{x^2}{4a}\right)^2 = 4ax \implies \frac{x^4}{16a^2} = 4ax \implies x^4 = 64a^3x$$

$$\implies x(x^3 - 64a^3) = 0$$

So, $x = 0$ or $x = 4a$. Corresponding y values are $y = 0$ and $y = 4a$. Thus, intersection points are $(0,0)$ and $(4a, 4a)$.

The area between the curves from $x = 0$ to $x = 4a$ is:

$$A = \int_{x=0}^{x=4a} \left[\sqrt{4ax} - \frac{x^2}{4a}\right] dx$$

- $y = \sqrt{4ax}$ is from $y^2 = 4ax$
- $y = \frac{x^2}{4a}$ is from $x^2 = 4ay$

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

Calculate each term:

1. $\int_0^{4a} 2\sqrt{ax}dx = 2a^{1/2}\int_0^{4a} x^{1/2}dx = 2a^{1/2}\left[\frac{2}{3}x^{3/2}\right]_0^{4a} = 2a^{1/2}\cdot\frac{2}{3}(4a)^{3/2}$
- $(4a)^{3/2} = 8a^{3/2}$
- So, $2a^{1/2}\cdot\frac{2}{3}\cdot 8a^{3/2} = \frac{32}{3}a^2$

2. $\int_0^{4a}\frac{x^2}{4a}dx = \frac{1}{4a}\int_0^{4a} x^2dx = \frac{1}{4a}\left[\frac{x^3}{3}\right]_0^{4a} = \frac{1}{4a}\cdot\frac{(4a)^3}{3} = \frac{1}{4a}\cdot\frac{64a^3}{3} = \frac{16}{3}a^2$

Subtract:

$A = \frac{32}{3}a^2 - \frac{16}{3}a^2 = \frac{16}{3}a^2$

The area between the parabolas $y^2 = 4ax$ and $x^2 = 4ay$ is $\frac{16}{3}a^2$

3. Explanation: (c)

$f(z) = \frac{z+1}{(z-3)(z-4)}$

centered at $z = 2$.

First, express $f(z)$ as a sum of partial fractions:

$\frac{z+1}{(z-3)(z-4)} = \frac{A}{z-3} + \frac{B}{z-4}$

Multiply both sides by $(z-3)(z-4)$:

$z+1 = A(z-4) + B(z-3)$

To find A and B, choose values:

Let $z = 4$: $4+1 = A(0) + B(1) \Rightarrow B = 5$

Let $z = 3$: $3+1 = A(-1) + B(0) \Rightarrow A = -4$

So:

$f(z) = \frac{-4}{z-3} + \frac{5}{z-4}$

Expand Each Term About $z = 2$

Let $w = z-2$ (to expand around $z = 2$). Then:

- $z - 3 = w - 1$
- $z - 4 = w - 2$

So:

$f(z) = -\frac{4}{w-1} + \frac{5}{w-2}$

Now expand $\frac{1}{w-a}$ using geometric series (valid for $|w| < |a|$):

$\frac{1}{w-a} = -\frac{1}{a}\cdot\sum_{n=0}^{\infty}\left(\frac{w}{a}\right)^n$ (if $|w| < |a|$)

So:

First term:

$-\frac{4}{w-1} = \frac{4}{1-w} = 4\sum_{n=0}^{\infty} w^n$

$= 4(1 + w + w^2 + w^3 + \cdots)$

Second term:

$\frac{5}{w-2} = \frac{5}{-2\left(1-\frac{w}{2}\right)} = -\frac{5}{2}\sum_{n=0}^{\infty}\left(\frac{w}{2}\right)^n$

$= -\frac{5}{2}\left(1 + \frac{w}{2} + \frac{w^2}{4} + \frac{w^3}{8} + \cdots\right)$

Add Terms

Let's compute up to $w^3 = (z-2)^3$:

First term:

$4(1 + w + w^2 + w^3) = 4 + 4w + 4w^2 + 4w^3$

Second term:

$-\frac{5}{2}\left(1 + \frac{w}{2} + \frac{w^2}{4} + \frac{w^3}{8}\right) = -\frac{5}{2} - \frac{5}{4}w - \frac{5}{8}w^2 - \frac{5}{16}w^3$

Combine

$f(z) = (4 - \frac{5}{2}) + (4 - \frac{5}{4})w + (4 - \frac{5}{8})w^2 + (4 - \frac{5}{16})w^3 + \cdots$

$= \frac{3}{2} + \frac{11}{4}(z-2) + \frac{27}{8}(z-2)^2 + \frac{59}{16}(z-2)^3 + \cdots$

4. Explanation: (c)

The curve is given by $y = 4x^2$. We can parameterize it using x as the parameter:

$\vec{r}(x) = x\,\hat{\imath} + 4x^2\,\hat{\jmath}$, where $x \in [0,1]$.

The differential displacement $d\vec{r}$ is:

$d\vec{r} = \frac{d\vec{r}}{dx}dx = (\hat{\imath} + 8x\,\hat{\jmath})dx$

Substitute $y = 4x^2$ into $\vec{F}$:

$\vec{F} = 2x^2(4x^2)\,\hat{\imath} + 3x(4x^2)\,\hat{\jmath} = 8x^4\,\hat{\imath} + 12x^3\,\hat{\jmath}$.

$\vec{F}\cdot d\vec{r} = (8x^4\,\hat{\imath} + 12x^3\,\hat{\jmath})\cdot(\hat{\imath} + 8x\,\hat{\jmath})dx$

$= 8x^4 + 96x^4 = 104x^4$.

The work W is the integral of $\vec{F}\cdot d\vec{r}$ from $x = 0$ to $x = 1$:

$W = \int_0^1 104x^4\,dx = 104\left[\frac{x^5}{5}\right]_0^1 = 104\cdot\frac{1}{5} = \frac{104}{5}$

5. Explanation: (a) Reduction formulae is given by

$\int_0^{\pi}\sin^m x\cdot\cos^n x\,dx$

$= \frac{(m-1)(m-3)\cdots(n-1)(n-3)\cdots}{(m+n)(m+n-2)(m+n-4)}$

Calculation:

Given:

$I = \int_0^{\pi/6}\cos^4 3\theta\cdot\sin^3 6\theta\,d\theta$

Since, $\sin 6\theta = \sin(2\times 3\theta)$

Hence:

$I = \int_0^{\frac{\pi}{6}}\cos^4 3\theta(2^3\sin^3 3\theta\cdot\cos^3 3\theta)d\theta$

(since $\sin 2\theta = 2\sin\theta\cos\theta$)

Simplifies to:

$I = 8\int_0^{\frac{\pi}{6}}\cos^7 3\theta\sin^3 3\theta\,d\theta$

Substitute $3\theta = x$:

$\Rightarrow d\theta = \frac{dx}{3}$

Change limits accordingly:

- When $\theta = 0 \Rightarrow x = 0$
- When $\theta = \frac{\pi}{6} \Rightarrow x = \frac{\pi}{2}$

So:

$I = \frac{8}{3}\int_0^{\frac{\pi}{2}} \cos^7 x \sin^3 x \, dx$

Further, the integral is evaluated as:

$I = \frac{8}{3} \times \frac{2 \times (6 \times 4 \times 2)}{10 \times 8 \times 6 \times 4 \times 2} = \frac{1}{15}$

6. Explanation: (a)

Let:

$u = x^2 \Rightarrow du = 2x\,dx,$

$dv = \cos(ax)\,dx \Rightarrow v = \frac{1}{a}\sin(ax).$

Applying integration by parts:

$\int x^2 \cos(ax)\,dx$

$= x^2\left(\frac{1}{a}\sin(ax)\right) - \int \frac{1}{a}\sin(ax) \cdot 2x\,dx.$

Simplify:

$= \frac{x^2}{a}\sin(ax) - \frac{2}{a}\int x\sin(ax)\,dx.$

Now, evaluate $\int x\sin(ax)\,dx$ using integration by parts again.

Let:

$u = x \Rightarrow du = dx,$

$dv = \sin(ax)\,dx \Rightarrow v = -\frac{1}{a}\cos(ax)$

Applying integration by parts:

$\int x\sin(ax)\,dx = x\left(-\frac{1}{a}\cos(ax)\right) - \int -\frac{1}{a}\cos(ax)\,dx.$

Simplify:

$= -\frac{x}{a}\cos(ax) + \frac{1}{a}\int \cos(ax)\,dx.$

$= -\frac{x}{a}\cos(ax) + \frac{1}{a^2}\sin(ax).$

Substitute the result back into the first integration by parts:

$\int x^2 \cos(ax)\,dx$

$= \frac{x^2}{a}\sin(ax) - \frac{2}{a}\left(-\frac{x}{a}\cos(ax) + \frac{1}{a^2}\sin(ax)\right)$

$= \frac{x^2}{a}\sin(ax) + \frac{2x}{a^2}\cos(ax) - \frac{2}{a^3}\sin(ax)$

$= \frac{1}{a^3}(a^2x^2\sin(ax) + 2ax\cos(ax) - 2\sin(ax))$

Final Simplified Form:

$\int x^2 \cos(ax)\,dx$

$= \frac{1}{a^3}(2ax\cos(ax) - 2\sin(ax) + a^2x^2\sin(ax))$

7. Explanation: (c) We are asked to evaluate the integral:

$\int x^2 e^{ax}\,dx$

Let:

- $u = x^2 \Rightarrow du = 2x\,dx$
- $dv = e^{ax}\,dx \Rightarrow v = \frac{e^{ax}}{a}$

Now apply integration by parts:

$\int x^2 e^{ax}\,dx = x^2 \cdot \frac{e^{ax}}{a} - \int 2x \cdot \frac{e^{ax}}{a}\,dx$

$= \frac{x^2e^{ax}}{a} - \frac{2}{a}\int xe^{ax}\,dx$

Now compute $\int xe^{ax}\,dx$ again using integration by parts:

- $u = x \Rightarrow du = dx$
- $dv = e^{ax}dx \Rightarrow v = \frac{e^{ax}}{a}$

So:

$\int xe^{ax}dx = \frac{xe^{ax}}{a} - \int \frac{e^{ax}}{a}dx = \frac{xe^{ax}}{a} - \frac{e^{ax}}{a^2}$

Back to the original expression:

$\int x^2e^{ax}dx = \frac{x^2e^{ax}}{a} - \frac{2}{a}\left(\frac{xe^{ax}}{a} - \frac{e^{ax}}{a^2}\right)$

$\int x^2e^{ax}dx = \frac{e^{ax}}{a}\left(x^2 - \frac{2x}{a} + \frac{2}{a^2}\right)$

Multiply numerator and denominator by a^2 to match options:

$= \frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2)$

8. Explanation: (c) We're asked to evaluate:

$\iiint_{\text{all space}} \frac{(u-v)^2}{uv} e^{-\frac{u+v}{2}}\,dx\,dy\,dz$

Now change variables to (ξ, η, ϕ):

- $u = \xi + \eta$
- $v = \xi - \eta$

Thus,

- $u - v = 2\eta \Rightarrow (u-v)^2 = 4\eta^2$
- $uv = (\xi+\eta)(\xi-\eta) = \xi^2 - \eta^2$
- $u + v = 2\xi \Rightarrow e^{-(u+v)/2} = e^{-\xi}$

So, the integrand becomes:

$\frac{4\eta^2}{\xi^2 - \eta^2}e^{-\xi}$

Including the Jacobian:

$$\left|\frac{\partial(x,y,z)}{\partial(\xi,\eta,\phi)}\right| = \left(\frac{\partial(\xi,\eta,\phi)}{\partial(x,y,z)}\right)^{-1} = \xi^2 - \eta^2$$

So the volume element becomes:

$dx\,dy\,dz = (\xi^2 - \eta^2)\,d\xi\,d\eta\,d\phi$

Thus, the integral becomes:

$$\iiint \frac{4\eta^2}{\xi^2 - \eta^2} e^{-\xi} \cdot (\xi^2 - \eta^2) d\xi\,d\eta\,d\phi$$

$$= 4 \iiint \eta^2 e^{-\xi}\,d\xi\,d\eta\,d\phi$$

Now integrate over the specified limits:

- $\xi \in [1, \infty)$
- $\eta \in [-1,1]$
- $\phi \in [0,2\pi]$

So:

$$4\int_0^{2\pi} d\phi \int_{-1}^{1} \eta^2 d\eta \int_1^{\infty} e^{-\xi} d\xi$$

Now compute each integral:

- $\int_0^{2\pi} d\phi = 2\pi$
- $\int_{-1}^{1} \eta^2 d\eta = \left[\frac{\eta^3}{3}\right]_{-1}^{1} = \frac{1}{3} - (-\frac{1}{3}) = \frac{2}{3}$
- $\int_1^{\infty} e^{-\xi} d\xi = [-e^{-\xi}]_1^{\infty} = 0 - (-e^{-1}) = \frac{1}{e}$

Now multiply:

$$4 \cdot 2\pi \cdot \frac{2}{3} \cdot \frac{1}{e} = \frac{16\pi}{3e}$$

9. Explanation: (a) We are given the function:

$f(x,y) = x^3 - 12xy + 48x + by^2, b \neq 0$

Stationary points occur when partial derivatives are zero:

$f_x = \frac{\partial f}{\partial x} = 3x^2 - 12y + 48 = 0$ ..... (1)

$f_y = \frac{\partial f}{\partial y} = -12x + 2by = 0$ (2)

Solve the system

From equation (2):

$$-12x + 2by = 0 \Rightarrow y = \frac{6x}{b} \quad (3)$$

Substitute (3) into (1):

$$3x^2 - 12\left(\frac{6x}{b}\right) + 48 = 0 \Rightarrow 3x^2 - \frac{72x}{b} + 48 = 0$$

Multiply through by b to eliminate the denominator:

$$3bx^2 - 72x + 48b = 0 \quad (4)$$

The number of real solutions (stationary points) depends on the discriminant:

Discriminant $D = (-72)^2 - 4 \cdot 3b \cdot 48b$

$$= 5184 - 576b^2$$

So:

- If $D > 0 \Rightarrow$ two stationary points
- If $D = 0 \Rightarrow$ one stationary point
- If $D < 0 \Rightarrow$ no real (zero) stationary points

Solve $D = 0$:

$$5184 - 576b^2 = 0 \Rightarrow b^2 = \frac{5184}{576} = 9 \Rightarrow |b| = 3$$

(a) less than, equal to or greater than 3

10. Explanation: (b) To find the volume of the solid enclosed between the two paraboloids:

$z = 5x^2 + 5y^2$ (lower surface)

$z = 6 - 7x^2 - y^2$ (upper surface)

we follow these steps:

Set the two equations equal to each other to find where the surfaces meet:

$5x^2 + 5y^2 = 6 - 7x^2 - y^2$

$5x^2 + 7x^2 + 5y^2 + y^2 = 6$

$12x^2 + 6y^2 = 6$

$2x^2 + y^2 = 1$

Divide by 1 to express the ellipse in standard form:

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

This represents an ellipse with semi-axes:

- $a = \frac{1}{\sqrt{2}}$ (along the x-axis)
- $b = 1$ (along the y-axis)

The volume V of the solid is given by the double integral over the region D (the ellipse) of the difference between the upper and lower surfaces:

$$V = \iint_D [(6 - 7x^2 - y^2) - (5x^2 + 5y^2)]\,dA$$

$$V = \iint_D (6 - 12x^2 - 6y^2)\,dA$$

$$V = 6\iint_D (1 - 2x^2 - y^2)\,dA$$

To simplify the integral, we use the substitution:

$$x = \frac{r\cos\theta}{\sqrt{2}}, y = r\sin\theta$$

The Jacobian determinant for this transformation is:

$$J = \frac{\partial(x,y)}{\partial(r,\theta)} = \frac{r}{\sqrt{2}}$$

The ellipse equation $2x^2 + y^2 = 1$ becomes:

$$2\left(\frac{r^2\cos^2\theta}{2}\right) + r^2\sin^2\theta = 1$$

$r^2\cos^2\theta + r^2\sin^2\theta = 1$

$r^2(\cos^2\theta + \sin^2\theta) = 1 \implies r^2 = 1 \implies r \in [0,1]$

The integrand transforms as:

$$1 - 2x^2 - y^2 = 1 - 2\left(\frac{r^2\cos^2\theta}{2}\right) - r^2\sin^2\theta$$

$= 1 - r^2\cos^2\theta - r^2\sin^2\theta = 1 - r^2$

Thus, the volume integral becomes:

$$V = 6\int_0^{2\pi} \int_0^1 (1 - r^2) \cdot \frac{r}{\sqrt{2}}\,dr\,d\theta$$

$$V = \frac{6}{\sqrt{2}} \int_0^{2\pi} d\theta \int_0^1 (r - r^3)\,dr$$

Compute the inner integral:

$$\int_0^1 (r - r^3)\, dr = \left[\frac{r^2}{2} - \frac{r^4}{4}\right]_0^1 = \frac{1}{2} - \frac{1}{4} = \frac{1}{4}$$

Compute the outer integral:

$$\int_0^{2\pi} d\theta = 2\pi$$

Multiply the results:

$$V = \frac{6}{\sqrt{2}} \cdot 2\pi \cdot \frac{1}{4} = \frac{12\pi}{4\sqrt{2}} = \frac{3\pi}{\sqrt{2}}$$

11. Explanation: (c)

Let's solve the given integral: $\int_C x^2 y\, dS$

where the curve C is defined by:

$x = 3\cos t, y = 3\sin t, 0 \le t \le \frac{\pi}{2}$

Compute dS:

$$dS = \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}\, dt$$

$\frac{dx}{dt} = -3\sin t, \frac{dy}{dt} = 3\cos t$

$dS = \sqrt{9\sin^2 t + 9\cos^2 t}\, dt = \sqrt{9}\, dt = 3\, dt$

The integrand $x^2 y$:

$x^2 = (3\cos t)^2 = 9\cos^2 t, y = 3\sin t \Rightarrow x^2 y = 27\cos^2 t \sin t$

Set up the integral:

$\int_0^{\pi/2} x^2 y\, dS = \int_0^{\pi/2} 27\cos^2 t \sin t \cdot 3\, dt =$

$81 \int_0^{\pi/2} \cos^2 t \sin t\, dt$

Substitute:

Let $u = \cos t \Rightarrow du = -\sin t\, dt$

When $t = 0, u = 1$; when $t = \pi/2, u = 0$

$81 \int_0^{\pi/2} \cos^2 t \sin t\, dt = 81 \int_1^0 u^2(-du) =$

$81 \int_0^1 u^2\, du = 81 \cdot \frac{1}{3} = 27$

Final Answer: (c) 27

12. Explanation: (b) Given:

- Vector field: $\vec{v} = 3x^2\, \hat{\imath} + 6y^2\, \hat{\jmath} + z\, \hat{k}$
- Region D: solid cylinder bounded by $x^2 + y^2 \le 16, \quad 0 \le z \le 4$

  Compute divergence

  $\nabla \cdot \vec{v} = \frac{\partial}{\partial x}(3x^2) + \frac{\partial}{\partial y}(6y^2) + \frac{\partial}{\partial z}(z) = 6x + 12y + 1$

  Use symmetry

  $\iiint_D (6x + 12y + 1)\, dV = \iiint_D 6x\, dV + \iiint_D 12y\, dV + \iiint_D 1\, dV$
- First two integrals are zero (odd functions over symmetric region)
- Only $\iiint_D 1\, dV$ remains

  Volume of cylinder $= \pi r^2 h = \pi(4^2)(4)$

  $= 16\pi \cdot 4 = 64\pi$

  Final Answer: (b) 64π

Unit 1.3 Complex Variables

Previous Year Exam Questions

[ESE-2017]

1. Evaluate: $\int_c \frac{dz}{z\sin z}$, where c is $x^2 + y^2 = 1$.

(a) 1 (b) 2

(c) 0 (d) -1

[ESE-2017]

2. The sum of residues of $f(z) = \frac{2z}{(z-1)^2(z-2)}$ at its singular point is

(a) -8 (b) -4

(c) 0 (d) 4

[ESE-2018]

3. If $= e^{ax+bt}\, F(ax - by)$; the value of $b \cdot \frac{\partial Z}{\partial x} + a \cdot \frac{\partial Z}{\partial y}$ is

(a) $2Z$ (b) $2a$

(c) $2b$ (d) $2abz$

[ESE-2019]

4. Evaluate $\oint_c \frac{1}{(z-1)^3 \cdot (z-3)} dz$ where c is the rectangular region defined by $x = 0, x = 4, y = -1$ and $y = 1$

(a) 1 (b) 0

(c) $\frac{\pi}{2} i$ (d) $\pi(3 + 2i)$

[ESE-2019]

5. The complex number $\left(\frac{2+i}{3-i}\right)^2$ is

(a) $\frac{1}{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$ (b) $\frac{1}{2}\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right)$

(c) $\frac{1}{2}(\cos\pi + i\sin\pi)$ (d) $\frac{1}{2}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

[ESE-2019]

6. If n is a positive integer then, $(\sqrt{3} + i)^n + (\sqrt{3} - i)^n$ is

(a) $2^n \sin\frac{n\pi}{6}$ (b) $2^n \cos\frac{n\pi}{6}$

(c) $2^{n+1}\cos\frac{n\pi}{6}$ (d) $2^{n+1}\sin\frac{7\pi}{6}$

[ESE-2019]

7. The nature of singularity of function $f(z) = \frac{1}{\cos z - \sin z}$ at $z = \frac{\pi}{4}$ is

(a) Removable singularity (b) Isolated singularity

(c) Simple pole (d) Essential singularity

[ESE-2020]

8. If the imaginary part $v = e^x(x\sin y + y\cos y)$ is part of analytic function $f(z) = u + iv$, then $f(z)$ is

(a) $(1 + z)e^z + c$ (b) $ze^z + c$

(c) $ze^{2z} + c$ (d) $(1 - z)e^2 + c$

[ESE-2021]

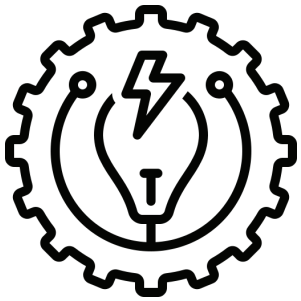
9. The residue at the singular point $z = -2$ of $f(z) = \frac{1+z+z^2}{(z-1)^2(z+2)}$ is

ELECTRIC CIRCUITS & FIELDS

SECTION 3

SYLLABUS

CIRCUIT ELEMENTS, NETWORK GRAPH, KCL, KVL, NODE AND MESH ANALYSIS, IDEAL CURRENT AND VOLTAGE SOURCES, THEVENIN'S, NORTON'S, SUPERPOSITION AND MAXIMUM POWER TRANSFER THEOREMS, TRANSIENT RESPONSE OF DC AND AC NETWORKS, SINUSOIDAL STEADY STATE ANALYSIS, BASIC FILTER CONCEPTS, TWO-PORT NETWORKS, THREE PHASE CIRCUITS, MAGNETICALLY COUPLED CIRCUITS, GAUSS THEOREM, ELECTRIC FIELD AND POTENTIAL DUE TO POINT, LINE, PLANE AND SPHERICAL CHARGE DISTRIBUTIONS, AMPERE'S AND BIOT SAVART'S LAWS; INDUCTANCE, DIELECTRICS, CAPACITANCE; MAXWELL'S EQUATIONS.



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ESE ELECTRICAL ENGINEERING:
NUMBER OF QUESTIONS ASKED IN PREVIOUS EXAMS (2001-2025)

ELECTRIC CIRCUITS & FIELDS		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
3.1	Network Elements & Basics	3	7	4	3	2	1	2	5	7	6	6	5	6	4	-	8	-	9	6	4	5	-	-	2	4
3.2	Network Theorems and Steady State Analysis	7	6	4	7	4	5	2	8	10	7	3	2	6	6	9	6	-	2	-	-	1	4	1	2	2
3.3	Transient Response of DC & AC Networks	6	3	2	2	2	5	3	4	4	3	4	3	-	4	2	3	-	1	-	-	1	2	1	2	1
3.4	Resonance	2	4	1	3	2	2	3	-	1	7	2	6	4	2	3	3	1	2	1	-	-	3	-	-	-
3.5	Two Ports and Network Functions	3	1	3	2	2	1	-	3	2	3	5	4	5	-	2	1	-	2	1	-	-	-	-	1	2
3.6	Magnetically Coupled Circuits	5	3	4	4	5	1	5	1	3	4	4	2	1	-	-	3	-	-	1	-	-	-	-	2	-
3.7	Graph Theory & Duality	2	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1	1	2	-	1	1	-	-	-	1
3.8	Three Phase Circuit & Filters	-	1	-	3	1	-	1	-	-	-	-	1	-	2	2	-	1	1	1	1	-	-	-	-	2
3.9	Network Synthesis	2	-	1	1	1	3	1	2	4	2	4	1	1	2	-	-	-	-	-	-	-	-	-	-	-
3.10	Coordinate System & Vector Calculus	1	2	3	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
3.11	Electrostatic Fields	5	4	5	6	2	7	5	3	1	1	2	6	2	5	2	5	-	2	-	3	1	2	-	-	-
3.12	Magneto static Fields	3	3	3	1	1	5	2	3	5	1	2	2	-	2	4	2	-	2	-	2	-	1	-	1	-
3.13	Time Varying Electromagnetic Fields	4	4	2	2	-	-	2	1	3	-	-	-	4	-	2	-	1	-	-	-	-	-	-	-	-
3.14	EM Waves and Transmission Lines	7	6	7	9	13	4	5	7	7	4	11	5	5	1	3	-	-	-	-	-	-	-	-	-	-

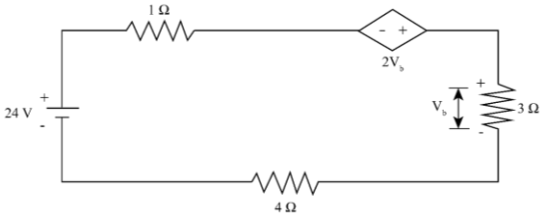
CHAPTER-3 ELECTRIC CIRCUITS AND FIELDS

Unit 3.1: Network Elements & Basics

Previous Year Exam Questions

[ESE-2001]

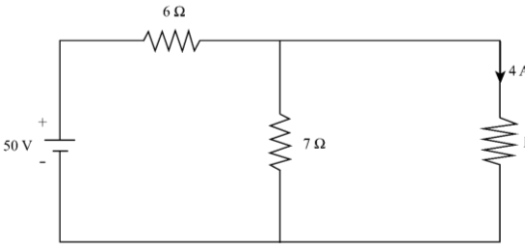
1. The current in the given circuit with a dependent voltage source is



(a) 10 A (b) 12 A
(c) 14 A (d) 16 A

[ESE-2001]

2. The value of resistance ' R ' shown in the given figure is



(a) 3.5Ω (b) 2.5Ω
(c) 1Ω (d) 4.5Ω

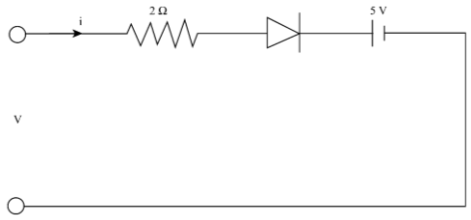
[ESE-2001]

3. Assertion (A): Equivalent network obtained from $\Delta - Y$ transformation relationships in general is valid only for one frequency.
Reason (R): The impedances involved in $\Delta - Y$ vary with frequency.

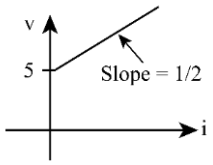
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

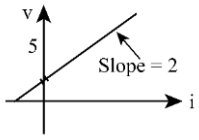
[ESE-2002]

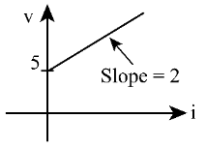
4. The figure shows a network in which the diode is an ideal one.

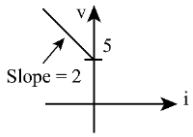


the terminal v -i characteristics of the network is given by

(a)


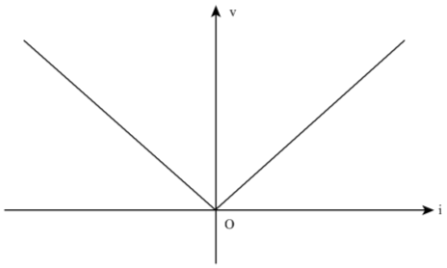
(b)


(c)


(d)


[ESE-2002]

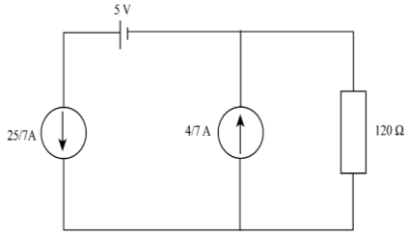
5. The v-i characteristic of an element is shown in the figure given below. The element is



(a) non-linear, active, non-bilateral
(b) linear, active, non-bilateral
(c) non-linear, passive, non-bilateral
(d) non-linear, active, bilateral

[ESE-2002]

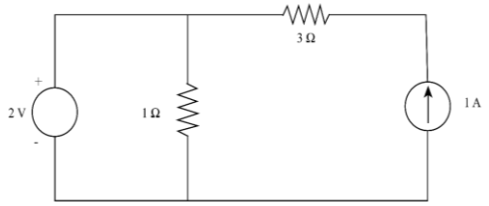
6. The current through 120 ohm resistor in the circuit shown in the figure below is



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

[ESE-2002]

7. For the circuit given in figure below the power delivered by the 2 volt source is given by



(a) 4 W (b) 2 W
(c) -2 W (d) -4 W

[ESE-2002]

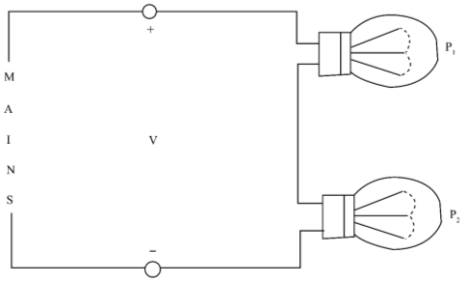
8. Assertion (A): Node-voltage analysis of networks is a method that uses Kirchhoff's current law to obtain a set of simultaneous equations that, when solved, will provide information concerning the magnitudes and phase angles of the voltages across each branch.
Reason (R): The ideal generator maintains a constant voltage amplitude and wave-shape regardless of the amount of current it supplies to the circuit.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2002]

9. Assertion (A): All networks made up of passive, linear time invariant elements are reciprocal.
Reason (R): Passivity and time-invariance of elements do not guarantee reciprocity of the network.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2002]

10. The incandescent bulbs rated respectively as P_1 and P_2 for operation at a specified mains voltage are connected in series across the mains as shown in the above figure. Then the total power supplied by the mains to the two bulbs are



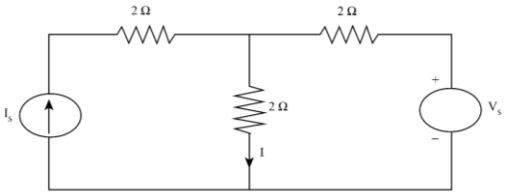
(a) $\frac{P_1P_2}{P_1+P_2}$ (b) $\sqrt{P_1^2+P_2^2}$
(c) (P_1+P_2) (d) $\sqrt{P_1 \times P_2}$

[ESE-2003]

11. A certain network consists of a large number of ideal linear resistances, one of which is designated as R and two constant ideal sources. The power consumed by R is P_1 when only the first source is active, and P_2 when only the second source is active. If both sources are active simultaneously, then the power consumed by R is
(a) $P_1 \pm P_2$ (b) $\sqrt{P_1} \pm \sqrt{P_2}$
(c) $\left(\sqrt{P_1} \pm \sqrt{P_2}\right)^2$ (d) $(P_1 \pm P_2)^2$

[ESE-2003]

12. For the circuit shown below, the value of V_s is 0 when $I = 4$ A. The value of I when $V_s = 16$ V, is



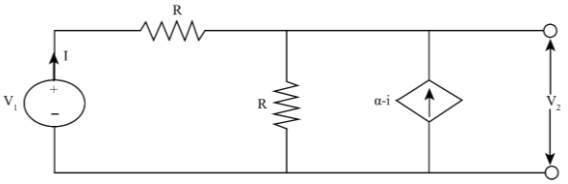
(a) 6 A (b) 8 A
(c) 10 A (d) 12 A

[ESE-2003]

13. In a network made up of linear resistors and ideal voltage sources, values of all resistors are doubled. Then the voltage across each resistor is
(a) Doubled (b) Halved
(c) Decreases four times (d) Not changed

[ESE-2003]

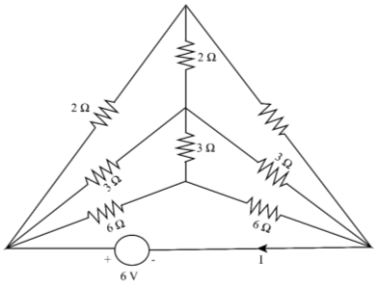
14. Consider the circuit as shown below which has a current-dependent current source. The value V_2/V_1 is



(a) 1 (b) 2
(c) $\frac{1+\alpha}{2+\alpha}$ (d) $\frac{\alpha}{2+\alpha}$

[ESE-2004]

15. Consider the following circuit:

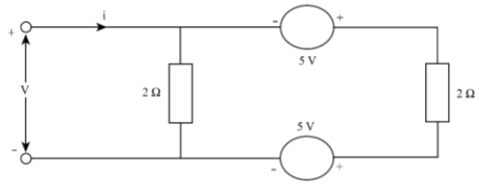


What is the value of the current-I in the above circuit?

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

[ESE-2004]

16. Consider the following circuit:



Which one of the following statements is correct? The circuit shown above is

(a) passive and linear
(b) active and linear
(c) passive and non-linear
(d) active and non-linear

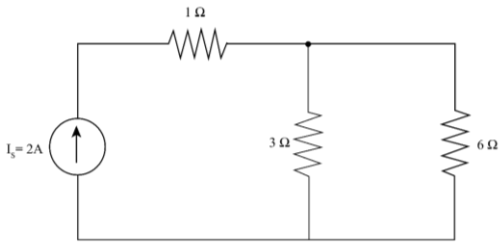
[ESE-2004]

17. Three parallel resistive branches are connected across a d. c supply. What will be the ratio of the branch currents $I_1 : I_2 : I_3$ if the branch resistances are in the ratio $R_1 : R_2 : R_3 :: 2 : 4 : 6$?

(a) 3: 2: 6 (b) 2: 4: 6
(c) 6: 3: 2 (d) 6: 2: 4

[ESE-2005]

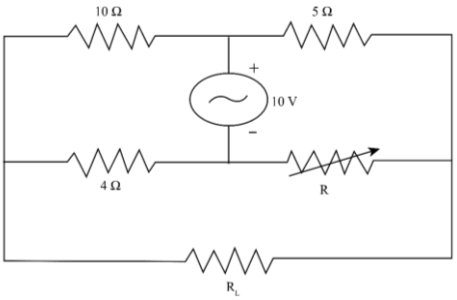
18. For the circuit shown below, what is the voltage across the current source I_s ?



(a) 0 (b) 2 V
(c) 3 V (d) 6 V

[ESE-2005]

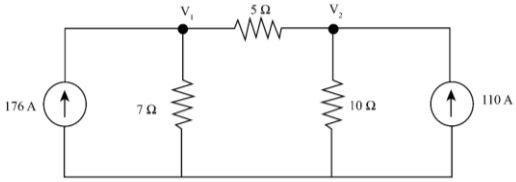
19. For the circuit shown below, the value of R is adjusted, so as to make the current in R_L equal to zero. What is the value of R?



(a) 1Ω (b) 2Ω
(c) 3Ω (d) 4Ω

[ESE-2006]

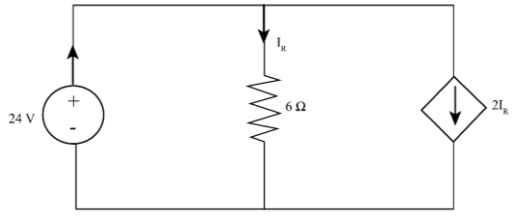
20. In the circuit shown below, what is the voltage across 5Ω resistor?



(a) -30 V (b) 30 V
(c) 1250 V (d) -1250 V

[ESE-2007]

21. Consider the circuit in the below figure. What is the power delivered by the 24 V source?



(a) 96 W (b) 144 W
(c) 192 W (d) 288 W

[ESE-2007]

22. Consider the following statements on mesh and nodal analysis:

1. Networks that contain many series-connected elements, voltage sources or meshes having common current sources (super meshes) are more suitable for mesh analysis than for nodal analysis.

2. Networks with parallel connected elements, current sources or nodes connected by voltage sources are more suitable for nodal analysis than mesh analysis.

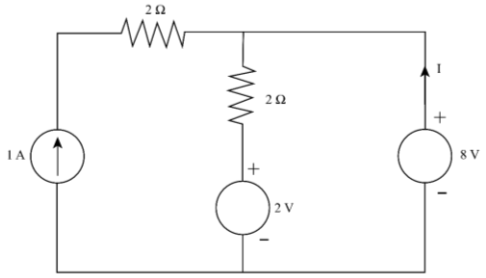
3. A circuit with fewer nodes than meshes is better analyzed using mesh analysis, while a circuit with fewer meshes, than nodes is better analyzed using nodal analysis.

Which of the statements given above are correct?

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1,2 and 3

[ESE-2008]

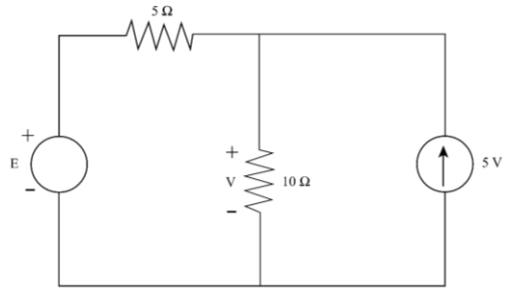
23. In the circuit shown below, what is the value of the current-I?



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

[ESE-2008]

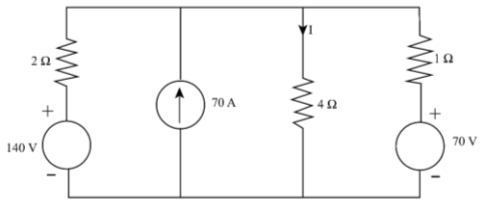
24. If the voltage V across 10Ω resistance is 10 V, what is the voltage E of the voltage source in the circuit shown below?



(a) -50 V (b) -10 V
(c) +10 V (d) +50 V

[ESE-2008]

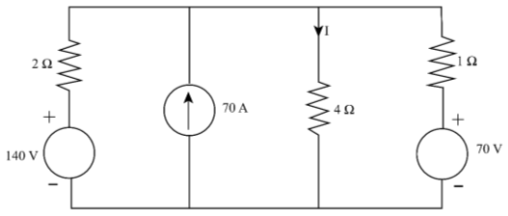
25. What is the value of the current I in the circuit shown below?



(a) 20 A (b) 25 A
(c) 30 A (d) 36 A

[ESE-2008]

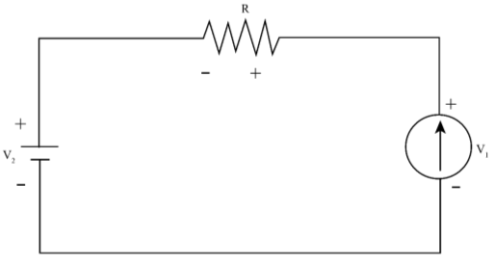
26. For the network shown in the figure below, what is the voltage across the current source?



(a) V – RI (b) V + RI
(c) Zero (d) RI – V

[ESE-2008]

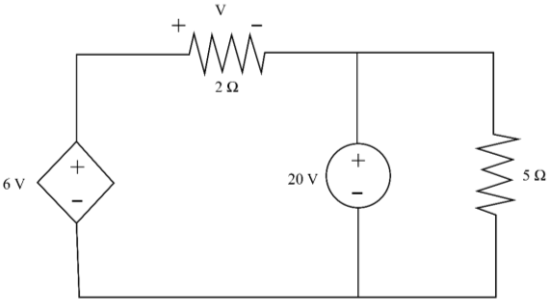
27. For the circuit shown, what is the voltage V if the source voltage is reduced by 50 % ?



(a) IR + E (b) E – IR
(c) 2IR – (E/2) (d) (E/2) – IR

[ESE-2009]

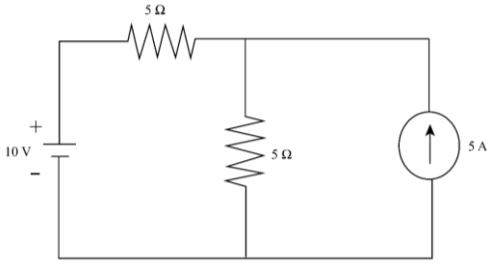
28. What is the current through the 2Ω resistance for the circuit as shown below?



(a) 5 A (b) 4 A
(c) 3 A (d) 2 A

[ESE-2009]

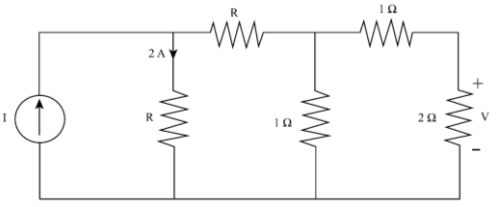
29. What is the voltage across the current source for the below shown circuit?



(a) 5.0 V (b) 7.5 V
(c) 12.5 V (d) 17.5 V

[ESE-2009]

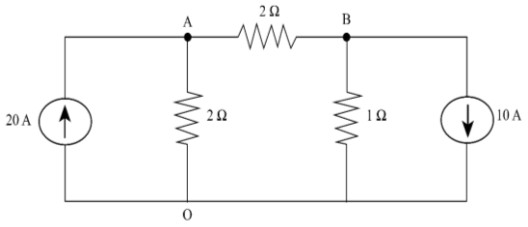
30. What is the value of I for the below shown circuit, if V = 2 volts?



(a) 2 A (b) 4 A
(c) 6 A (d) 8 A

[ESE-2009]

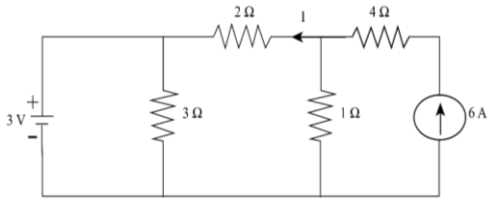
31. Find the voltage of the node A with respect to ' O ' for the circuit as shown in below.



(a) 40 V (b) 20 V
(c) 50 V (d) 60 V

[ESE-2009]

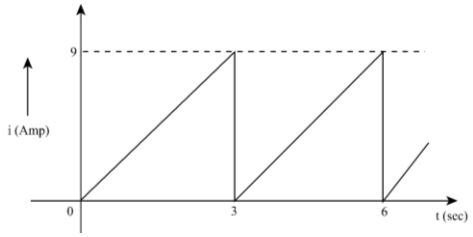
32. For the circuit as shown below, what is the value of I?



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

[ESE-2009]

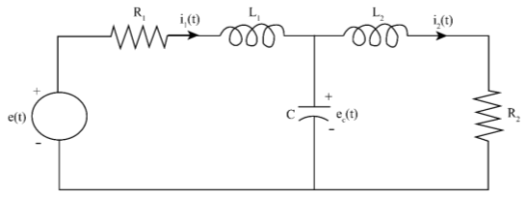
33. The current waveform as shown below, is applied in a pure resistor of 10Ω. What is the power dissipated in the resistor?



(a) 270 W (b) 135 W
(c) 52 W (d) 7 W

[ESE-2009]

34. Consider the following equations with respect to the below network:



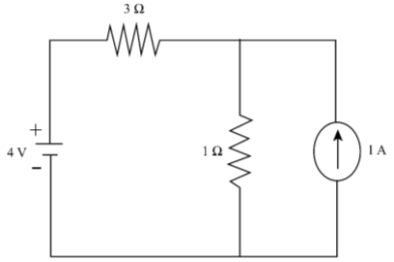
1. $\mathbf{L_1\frac{di_1(t)}{dt} = R_1 i_1(t) - e_c(t) + e(t)}$
2. $\mathbf{L_1\frac{di_1(t)}{dt} = -R_1 i_1(t) - e_c(t) + e(t)}$
3. $\mathbf{L_2\frac{di_2(t)}{dt} = -R_2 i_2(t) + e_c(t)}$
4. $\mathbf{C\frac{de_c(t)}{dt} = i_1(t) - i_2(t)}$

Which of the above statements is/are correct?

(a) 1 only (b) 2, 3 and 4
(c) 1, 3 and 4` (d) 1,2 and 4

[ESE-2010]

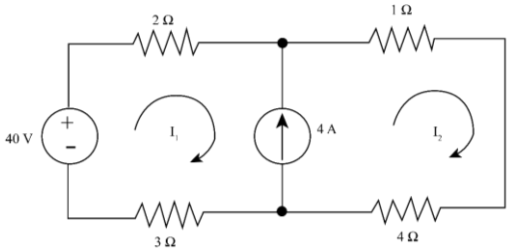
35. For the circuit shown in the figure below, the voltage across the 1 ohm resistor is given by



(a) $7/4$ V (b) $5/4$ V
(c) $7/3$ V (d) $2/3$ V

[ESE-2010]

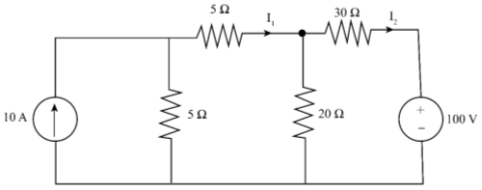
36. The currents $\mathbf{I_1}$ and $\mathbf{I_2}$ in the below circuit are respectively.



(a) 4 A; 4 A (b) 3 A; 5 A
(c) 2 A; 6 A (d) 6 A; 2 A

[ESE-2010]

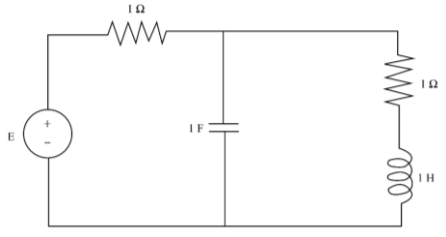
37. The currents $\mathbf{I_1}$ and $\mathbf{I_2}$ in the below circuit are respectively



(a) 1.818 A; -0.4545 A (b) 2.451 A; -1.568 A
(c) 0.4545 A; -1.818 A (d) 1.56 A; -2.45 A

[ESE-2010]

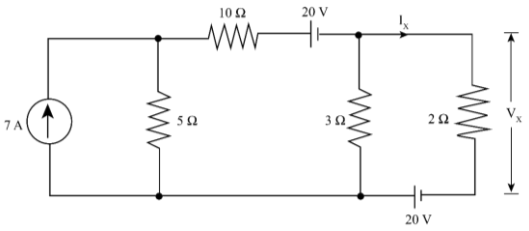
38. If the power dissipated in the circuit shown below is 8 W , then the value of E will be



(a) 2 V (b) 4 V
(c) 8 V (d) 16 V

[ESE-2010]

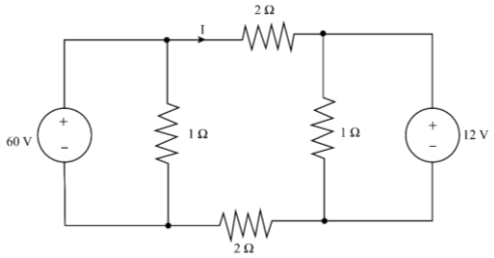
39. The currents I_x and V_x in the below circuit are respectively



(a) 5 A; 10 V (b) 10 A; 20 V
(c) 6 A; 12 V (d) 4 A; 8 V

[ESE-2010]

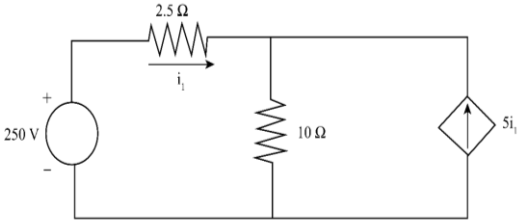
40. For the circuit shown in figure below, the value of current, I is



(a) 2 A (b) 3 A
(c) 6 A (d) 12 A

[ESE-2011]

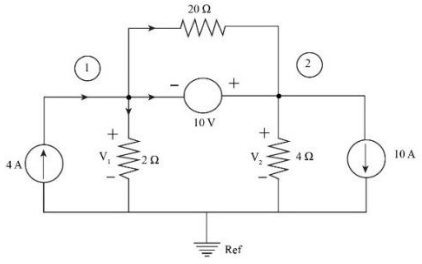
41. In the circuit shown, the current i_1 is



(a) 4 A (b) 2 A
(c) 4.76 A (d) 20 A

[ESE-2011]

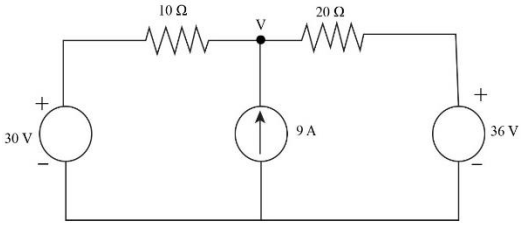
42. When KCL is applied at the super node in the below circuit, the current equation in terms of node voltages V_1 and V_2 is



(a) $-6 = \frac{V_1}{2} + \frac{V_2}{4}$ (b) $4 = \frac{V_1 - V_2}{2} + \frac{V_1 - V_2}{20}$
(c) $4 = \frac{V_1}{2} + \frac{V_1 - V_2}{20}$ (d) $4 = \frac{V_1}{2} + \frac{V_2}{4}$

[ESE-2011]

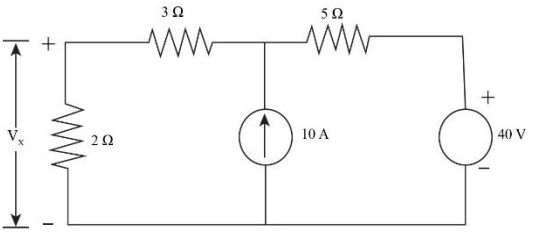
43. The node voltage V in the circuit is



(a) 6 V (b) 30 V
(c) 36 V (d) 92 V

[ESE-2011]

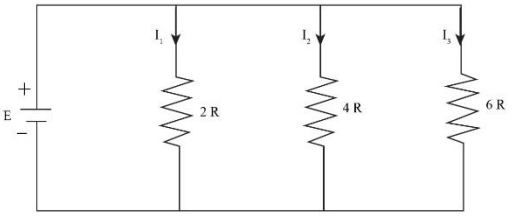
44. The voltage V_x across the 2Ω resistance in the circuit is



(a) 16 V (b) 60 V
(c) 18 V (d) 10 V

[ESE-2011]

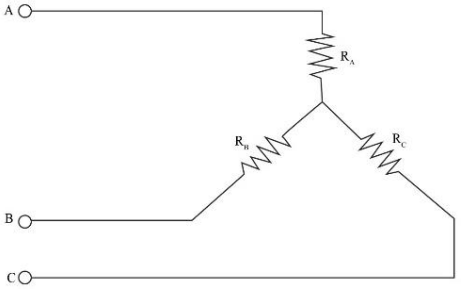
45. Three parallel branches of resistors are connected across a d.c. source as shown in the figure. What is $I_1 : I_2 : I_3$?



(a) 3: 2: 6 (b) 2: 4: 6
(c) 6: 3: 2 (d) 6: 2: 4

[ESE-2011]

46. The following are the results of tests conducted on the below star-connected load:



The resistance between B and C with A open : 22Ω
The resistance between C and A with B open : 18Ω

The individual resistance of R_A, R_B and R_C are respectively,

(a) $8\Omega, 14\Omega$ and 4Ω (b) $10\Omega, 2\Omega$ and 8Ω

(c) $4\Omega, 8\Omega$ and 14Ω (d) $6\Omega, 6\Omega$ and 8Ω

[ESE-2012]

47. Match List-I with List-II and select the correct answer using the code given below the lists:

List - I	List - II
A. Resistance	1. Number of node pairs
B. Inductance	2. Conductance
C. Loop current	3. Capacitance
D. Numbers of loops	4. Node pair voltage

Codes:

	A	B	C	D
(a)	1	3	4	2
(b)	2	3	4	1
(c)	1	4	3	2
(d)	2	4	3	1

[ESE-2012]

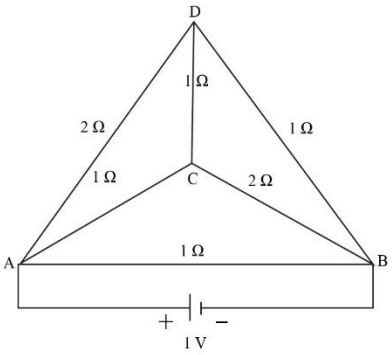
48. The number of independent KVL and KCL equations for a network with n-nodes and l links are respectively

(a) l and n (b) l and $n-1$

(c) n-1 and l (d) $n-1$ and $l-1$

[ESE-2012]

49. A triangular pyramid, built up of six wires whose resistances are shown in the figure, is fed from a 1 V battery at the terminals A and B. The current through the branch DB is



(a) $\frac{1}{7}$ A (b) $\frac{2}{7}$ A

(c) $\frac{3}{7}$ A (d) $\frac{4}{7}$ A

[ESE-2012]

50. For a series and a parallel circuit, the equivalent total value of certain parameter X is given by $x_e = x_1 + x_2 + x_3 + X_4 + \cdots + x_n$ where X_i is the ith value of the parameter and X_e is the equivalent value, and n is the number of elements.

The parameter X can be

(a) resistance (b) current

(c) voltage (d) power

[ESE-2012]

51. Consider the following statements:

Any element connected in

1. series with a voltage source is redundant.

2. parallel with a voltage source is redundant.

3. series with a current source is redundant.

4. parallel with a current source is redundant.

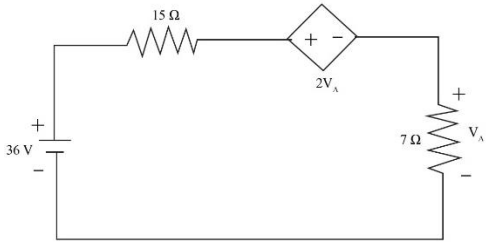
The correct statements are

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

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

[ESE-2013]

52. The power dissipated in the controlled source of the network shown below is

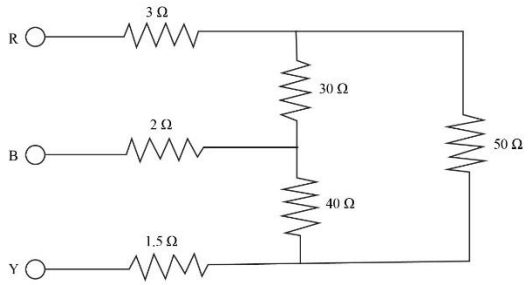


(a) 36 W (b) 15 W

(c) 07 W (d) 14 W

[ESE-2013]

53. A 3-phase distribution network is as shown below. The resistance across the terminals RB, BY and RYare



(a) $25.5\Omega, 31.2\Omega$ and 33.6Ω

(b) $27.5\Omega, 30.17\Omega$ and 33.67Ω

(c) $28.5\Omega, 32.3\Omega$ and 34.5Ω

(d) $21.2\Omega, 42.3\Omega$ and 45.6Ω

[ESE-2013]

54. A network N consists of resistors, independent voltage and current sources. The value of its determinant based on the loop analysis:

1. cannot be negative

2. cannot be zero

3. is independent of the values of voltage and current sources.

4. dependent on the values of the resistances and the voltage and current sources

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

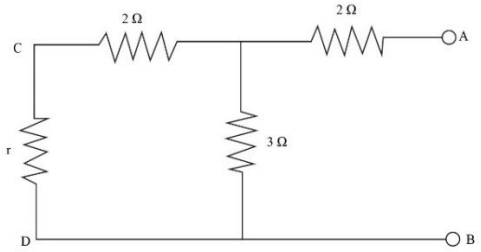
[ESE-2013]

55. The number of $2\mu F, 300\ V$ capacitors needed to obtain a capacitance value of $2\mu F$ rated for 1200 V is

(a) 16 (b) 12
(c) 10 (d) 8

[ESE-2013]

56. For the circuit shown below the value of r connected between C and D is such that the aquivalent resistance of the circuit by looking into circuit through terminals A and B is r only. Then the value of r is



(a) 2Ω (b) 4Ω
(c) 3Ω (d) 6Ω

[ESE-2013]

57. If an ideal voltage source and ideal current source are connected in series, the combination

(a) has the same properties as a current source alone.
(b) has the same properties as a voltage source alone.
(c) has the same properties as the source which has a higher value.
(d) results in the branch being redundant.

[ESE-2014]

58. A conductor of diameter d, length l consumes a power of W when a current I flows through it. What will be the power consumed if d is doubled, l is halved and current is tripled?

(a) 18 W (b) 36 W
(c) 48 W (d) 72 W

[ESE-2014]

59. Consider the following statements:
Any element connected in

1. **Series with an ideal current source is redundant.**
2. **Parallel with an ideal current source is redundant.**
3. **Series with an ideal voltage source is redundant.**
4. **Parallel with an ideal voltage source is redundant.**

Which of the above statements is/are correct?

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

[ESE-2014]

60. Consider the following two types of non-identical sources:

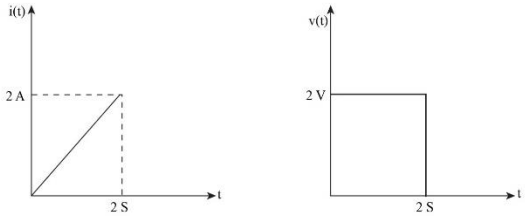
1. **Voltage source $e_1(t)$ and $e_2(t)$**
2. **Current sources i_1 and $i_2(t)$**

Regarding the mode of their connection in a circuit.

(a) 1 cannot be connected in parallel, and 2 cannot be connected in series.
(b) 1 cannot be connected in series, and 2 cannot be connected in parallel.
(c) Both 1 and 2 cannot be connected in parallel.
(d) Both 1 and 2 cannot be connected in parallel

[ESE-2014]

61. The voltage and current waveforms for an element are shown in the figures.



The circuit element and its value are

(a) capacitor and 2 F
(b) inductor and 1 H
(c) inductor and 2 H
(d) resistor and 1Ω

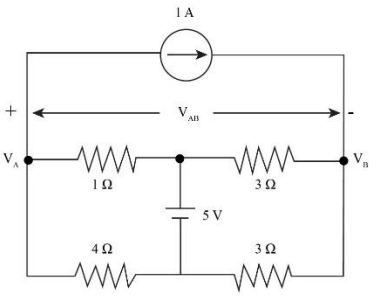
[ESE-2016]

62. In resistors each of resistance R when connected in series offer an equivalent resistance of 50Ω and when reconnected in parallel the effective resistance is 2Ω. The value of R is

(a) 2.5Ω (b) 5Ω
(c) 7.5Ω (d) 10Ω

[ESE-2016]

63. The potential difference V_{AB} in the circuit is



(a) 0.8 V (b) -0.8 V
(c) 1.8 V (d) -1.8 V

[ESE-2016]

64. Two bulbs of $100\ W/250\ V$ and $150\ W/250\ V$ are connected in series across a supply of 250 V. The power consumed by the circuit is

(a) 30 W (b) 60 W
(c) 100 W (d) 250 W

[ESE-2016]

65. Three 30 Ω resistors are connected in parallel across an ideal 40 V source. What would be the equivalent Resistance seen by the load connected across this circuit?

(a) 0 Ω (b) 10 Ω
(c) 20 Ω (d) 30 Ω

[ESE-2016]

66. In a parallel resistive circuit, opening a branch results in

1. increase in total resistance
2. decrease in total power
3. no changes in total voltage and branch voltage
Which of the above is/are correct?

(a)1 only (b) 2 only
(c) 3 only (d)1, 2 and 3

[ESE-2016]

67. In nodal analysis , the preferred reference node is a node that is connected to is a node that is connected to

1. ground
2. many parts of the network
3. the highest voltage source
Which of the above is/are correct?

(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

[ESE-2016]

68. The mesh-current method

1. Works with both planar and non-planar circuits.
2. Uses Kirchhoffs voltage law.
Which of the above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

[ESE-2016]

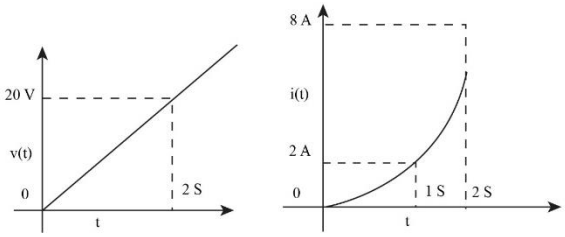
69. A short in any type of circuit (series, parallel or combination) causes the total circuit

1. resistance to decrease
2. power to decrease
3. current to increase
4. voltage to increase
Which of the above are correct?

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

[ESE-2018]

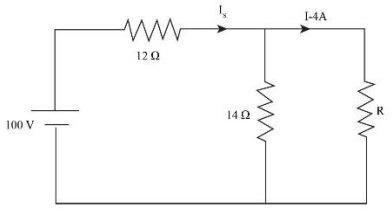
70. The voltage and current characteristic of an element is as shown in figure. The nature and value of the element are



(a) Capacitor of 3.3μ F
(b) Inductor of 2.5 H
(c) Capacitor of 6.7μ F
(d) Inductor of 500 H

[ESE-2018]

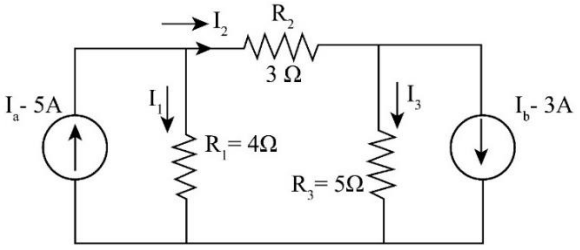
71. In the circuit shown, what value of R will result in $I = 4$ A ?



(a) 9Ω (b) 7Ω
(c) 5.5Ω (d) 3.5Ω

[ESE-2018]

72. In the circuit as shown, the currents I_1, I_2 and I_3 through three resistors are, respectively



(a) 2 · 08 A, 2 · 92 A and -0·08 A
(b) 3 · 08 A, 2 · 5 A and -0·06 A
(c) 2 · 08 A, 2 · 5 A and -0·08 A
(d) 3 · 08 A, 2 · 92 A and -0·06 A

[ESE-2018]

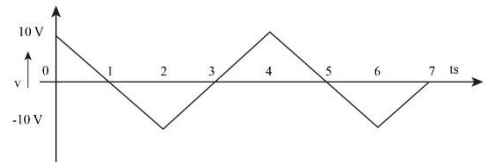
73. The $v - i$ relationship for a circuit containing R and C and a battery of voltage E, all in series is

1. $\frac{1}{C}\int idt + iR = E$
2. $\frac{1}{RC}i + \frac{di}{dt} - 0$
3. $\frac{1}{C}t + R\int idt = E$
Which of the above relationships are correct?

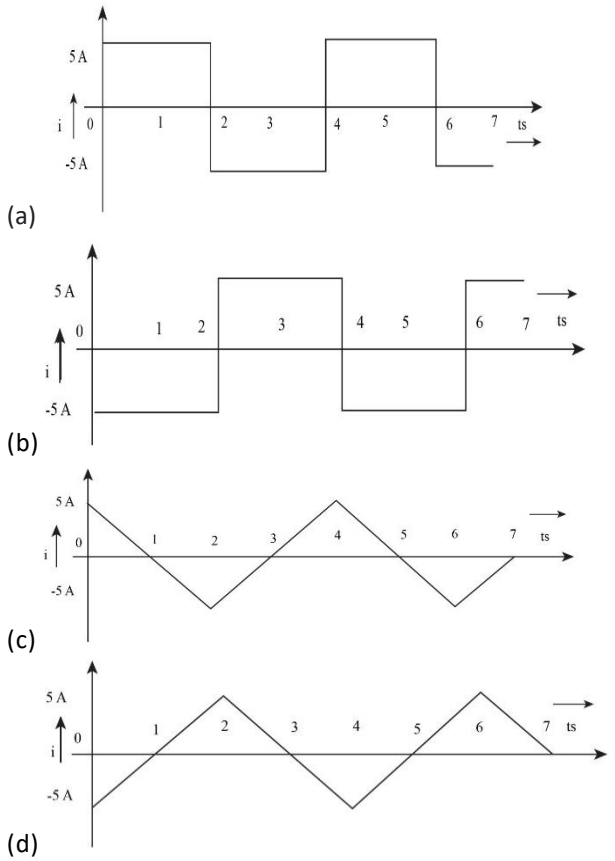
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1,2 and 3

[ESE-2018]

74.



A triangular wave voltage, as shown in figure, is applied across the terminals of a $0 \cdot 5\,F$ pure capacitor at time $t = 0$. The corresponding current-wave is



[ESE-2018]

75. Consider the following statements for Norton's theorem:

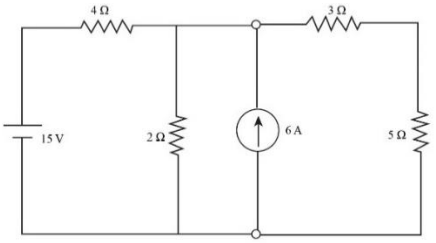
1. **Short the branch resistance through which current is to be calculated**
2. **Obtain the current through this short-circuited branch, using any of the network simplification tech-niques**
3. **Develop Norton's equivalent circuit by connecting current source IN with the resistance Ry in series with it**

Which of the above statements are correct?

(a) 1, 2 and 3
(b) 1 and 3 only
(c) 1 and 2 only
(d) 2 and 3 only

[ESE-2018]

76.

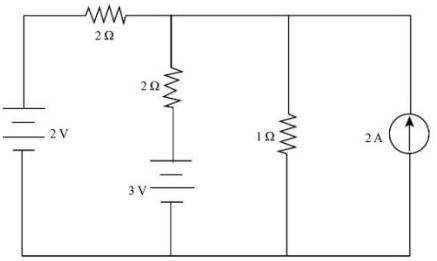


For the network shown in the figure, the current flowing through the 5Ω resistance will be

(a) $\frac{37}{25}$ A
(b) $\frac{40}{28}$ A
(c) $\frac{39}{28}$ A
(d) $\frac{41}{28}$ A

[ESE-2018]

77.



The current in the 1Ω resistor in the network as shown is

(a) $2 \cdot 00\,A$
(b) $2 \cdot 25\,A$
(c) $2 \cdot 50\,A$
(d) $2 \cdot 75\,A$

[ESE-2018]

78. A pulse of +10 V in magnitude and 2 s in duration is applied to the terminals of a lossless inductor of 1.0 H. The current through the inductor would

(a) be a pulse of +20 A for the duration of 2 s
(b) be a pulse of -20 A for the duration of 2 s
(c) increase linearly from zero to 20 A in 2 s , and in the positive direction, and, from thereon, it remains constant at+20 A
(d) increase linearly from zero to -20 A in 2 s , and in the negative direction, and, from thereon, it remains constant at -20 A

[ESE - 2019]

79. If the voltage across an element in a circuit is linearly proportional to the current through it, then it is a

(a) Capacitor
(b) Transformer
(c) Resistor
(d) Inductor

[ESE - 2019]

80. Thevenin's equivalent circuit consists of

(a) Current source and series impedance
(b) Voltage source and series impedance
(c) Voltage source and shunt impedance
(d) Current source and shunt impedance

[ESE - 2019]

81. When the voltage sources are replaced with short circuits and current sources are replaced with open circuits, leaving dependent sources in the circuit, the theorem applied is

(a)Superposition (b) Thevenin
(c) Norton (d) Millman

[ESE - 2019]

82. The maximum power is delivered from a source to a load when the source resistance is

(a) Greater than the load resistance
(b) Equal to zero
(c) Less than the load resistance
(d) Equal to the load resistance

[ESE - 2019]

83. A network delivers maximum power to the Load resistance when it is

(a) Greater than Norton's equivalent resistance of the network
(b) Equal to Thevenin's equivalent resistance of the network
(c) Less than source resistance
(d) Less than Norton's equivalent resistance of the network

[ESE - 2019]

84. consider the following statements:

1. The rules for series and parallel combinations of capacitors are opposite to those for resistors.
2. The rules foe series and parallel combinations of inductors are same as those for resistors.
3. An inductor is a short circuit to dc currents.

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

85. Statement (I): When a non-linear resistor, in series with a linear resistor, both being non-inductive, is connected to a voltage source, the current in the circuit cannot be determined by using Ohm's law.
Statement (II): If the current-voltage characteristic of the non-linear resistor is known, current-voltage characteristic of the series.circuit can be obtained by graphical solution

[ESE 2020]

86. A voltage source-series resistance combination is equivalent to a current source- parallel resistance combination if and only if their.

1. Respective open- circuit voltages are equal.
2. Respective short=circuit currents are equal.
3. Resistance remains same in both cases.
Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

[ESE 2020]

87. The resistance R of a conductor is

(a) $\frac{EA}{JI}$ (b) $\frac{EJ}{AI}$
(c) $\frac{EI}{JA}$ (d) $\frac{JA}{EI}$

[ESE 2020]

88. Which of the following statements are correct for an ideal constant voltage source?

1. Its output voltage remains absolutely constant whatever the change in load current.
2. It possesses zero internal resistance so that internal voltage drop in the source is zero.
3. Output voltage provided by the source would remain constant irrespective of the amount of current drawn from it.
4. Output voltage provided by the source varies with the amount of current drawn from it.

(a) 1, 2 and 4 only (b) 1, 3 and 4 only
(c) 2, 3 and 4 only (d) 1, 2 and 3

[ESE 2020]

89. An uncharged capacitor of 0.01 F is charged first by a current of 2 mA for 30s and then by a current of 4 mA for 30s. The final voltage in it will be

(a) 12V (b) 18V
(c) 24V (d) 30V

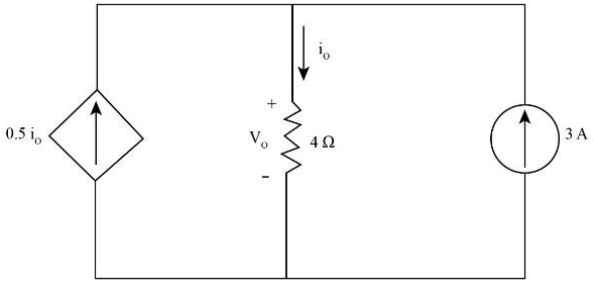
[ESE 2021]

90. A generator develops 250 V and has an internal resistance of 100 ohm . If the load resistance is 100 ohm , then what is the efficiency of the generator?

(a) 80% (b) 50%
(c) 60% (d) 70%

[ESE 2021]

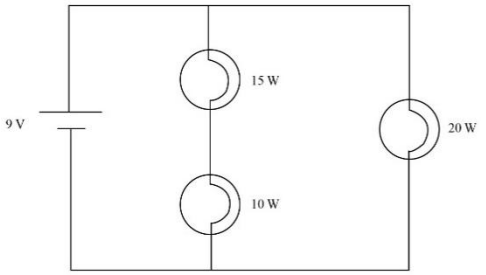
91. What is the value of v_0 in the given circuit?



(a) 12 V (b) 6 V
(c) 24 V (d) 15 V

[ESE 2021]

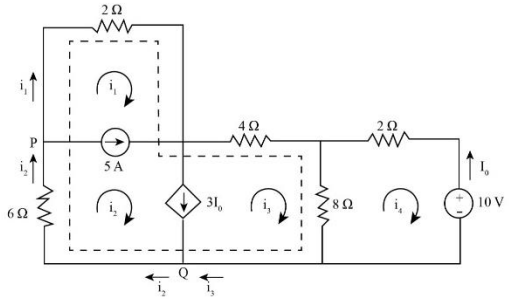
92. Three light bulbs are connected to a 9 V battery as shown in the figure. What are the values of the resistance of 20 W, 15 W, 10 W bulbs respectively?



(a) $4.05\Omega, 1.945\Omega, 1.297\Omega$
(b) $6.02\Omega, 3.762\Omega, 3.162\Omega$
(c) $7.672\Omega, 4.887\Omega, 4.223\Omega$
(d) $8.345\Omega, 6.893\Omega, 5.634\Omega$

[ESE 2021]

93. For the circuit in figure, the values of i_1 and i_4 are respectively,



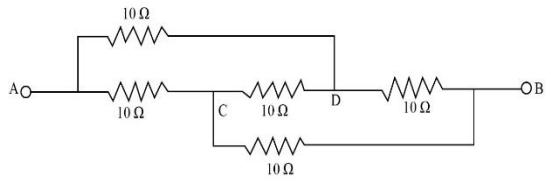
(a) -7.5 A, $2 \cdot 143$ A
(b) -2.5 A, 3.93 A
(c) 3.4 A, -6.5 A
(d) $7 \cdot 1$ A, $-3 \cdot 5$ A

[ESE 2021]

94. An energy source forces a constant current of 2 A for 10 s to flow through a light bulb. If 2.3 kJ is given off in the form of light and heat energy, what is the voltage drop across the bulb?
(a) 120 V
(b) 115 V
(c) 110 V
(d) 105 V

[ESE 2024]

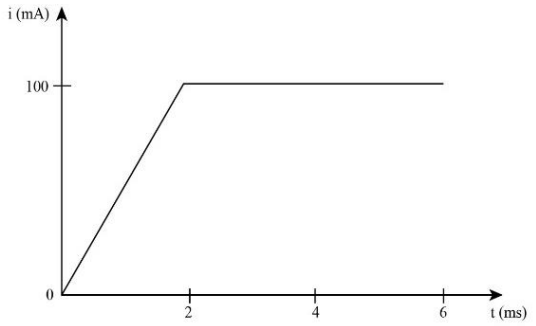
95. Five resistances of 10Ω each are connected between terminals A and B as shown in the figure. What is the total resistance between terminals A and B?



(a) 5Ω
(b) 10Ω
(c) 15Ω
(d) 20Ω

[ESE 2024]

96. An initially uncharged 1 mF capacitor has the current shown in the figure. What is the voltage across it at $= 2$ ms ?



(a) 50 mV
(b) 100 mV
(c) 200 mV
(d) 250 mV

[ESE-2025]

97. Three capacitors of capacitances 10μ F, 20μ F and 40μ F are connected in series across 280 V . The charge of each capacitor will be
(a) 0.6×10^{-3}C
(b) 1.6×10^{-3}C
(c) 2.6×10^{-3}C
(d) 3.6×10^{-3}C

[ESE-2025]

98. Which one of the following never dissipates energy but only stores it?
(a) Pure capacitor
(b) Pure resistor
(c) Conductor
(d) Ideal diode

[ESE-2025]

99. An ideal voltage source is defined as energy source whose terminal voltage (V) is
(a) proportional to load with infinite internal resistance
(b) dependent on the output current
(c) independent of the output current
(d) proportional to load with finite internal resistance

[ESE-2025]

100. An ideal voltage source is a two-terminal element in which the
(a) current i_s is completely independent of the voltage
(b) voltage v_s is completely independent of the current i_s through its terminals
(c) current i_s is completely independent through its terminals
(d) voltage v_s is completely dependent on current i_s through its terminals

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(b)	(a)	(d)	(c)	(a)	(c)	(b)	(b)	(c)	(a)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(c)	(b)	(d)	(c)	(c)	(a)	(c)	(d)	(b)	(b)
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
(d)	(a)	(b)	(b)	(c)	(b)	(*)	(d)	(d)	(c)
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
(b)	(d)	(a)	(b)	(a)	(c)	(c)	(b)	(a)	(d)
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
(a)	(a)	(d)	(c)	(c)	(c)	(b)	(b)	(c)	(d)
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
(b)	(d)	(b)	(a)	(a)	(b)	(a)	(*)	(d)	(a)
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
(c)	(d)	(b)	(b)	(a)	(d)	(b)	(b)	(d)	(b)
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
(b)	(a)	(a)	(c)	(c)	(d)	(b)	(c)	(c)	(b)
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
(a)	(b)	(b)	(d)	(a)	(d)	(c)	(d)	(b)	(b)
91	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
(c)	(a)	(a)	(b)	(b)	(b)	(b)	(a)	(c)	(b)

EXPLANATIONS

1. Explanation: (b)

We Applying KVL in the loop

$24 - 1I + 2V_b - V_b - 4I = 0$

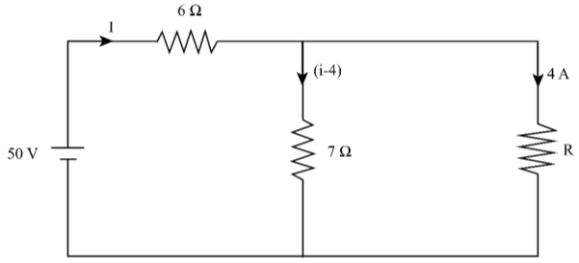
Where, $V_b = 3I$

$\Rightarrow$ 24 – 5I + V = 0

$\Rightarrow$ 24 – 5I + 3I = 0

I = 12A

2. Explanation: (a)



When we applying KVL in 1st loop

50 = 6i + 7(i-4)

13i = 78

i =6A

Now by applying KVL in 2nd loop

7×2 = 4 × R

R = 3.5Ω

3. Explanation: (d)

Assertion (A) is **false** because Δ-Y transformations are algebraically exact and valid at all frequencies.

Reason (R) is **true**, as impedances involving inductors and capacitors vary with frequency ($Z_L = j\omega L, Z_C = \frac{1}{j\omega C}$).

Hence, the correct choice is **(d): A is false, but R is true**.

4. Explanation: (c)

Applying KVL

The terminal v-i characteristic is V = 2i +5

5. Explanation: (a)

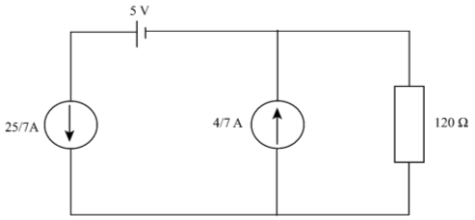
The given element is **non-linear** since its v-i characteristic isn't a straight line.

It is **active**, capable of supplying energy, indicated by operation in the 2nd and 4th quadrants.

It is **non-bilateral** because its characteristic isn't symmetrical about the origin.

Hence, the correct answer is **(a) non-linear, active, non-bilateral**.

6. Explanation: (c)

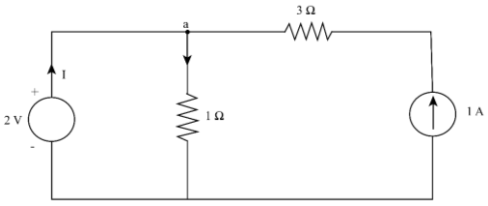


By applying KCL at node a

$$i = \frac{25}{7} - \frac{4}{7} = 3\ A$$

Voltage source in series with constant current source will behave like short circuit.

7. Explanation: (b)



From figure, i = $\frac{2}{1}$ = 2 Amp

By applying KCL at node a

I = i – 1 = 2 – 1 = 1 Amp

i.e. the current delivered by voltage source = 1 A

∴ Power delivered by voltage source

= 2 × 1 = 2 W

8. Explanation: (b)

Assertion (A): Node-voltage analysis uses Kirchhoff's Current Law to solve for voltage magnitudes and phase angles.

Reason (R): The ideal generator maintains constant voltage and wave-shape regardless of current.

Both are true, but Reason (R) does not explain Assertion (A).

9. Explanation: (c)

Other requirements for reciprocity

(i) Network should have only single – source.

(ii) Networks should not have dependent sources.

10. Explanation: (a)

$R_1 = \frac{v^2}{P_1}$ and $R_2 = \frac{V^2}{P_2}$

Bulbs are connected in series

$R_{eq} = R_1 + R_2$

$= V^2 \left[\frac{1}{p_1} + \frac{1}{P_2}\right] = v^2 \left[\frac{p_{1+} P_2}{P_{1P_2}}\right]$

Total power = $\frac{V^2}{R_{eq}} = \frac{P_{1P_2}}{P_{1+} P_2}$

11. Explanation: (c)

$$i_1 = \sqrt{\frac{P_1}{R}} \text{ and } i2 = \sqrt{\frac{P_2}{R}}$$

When both source are active

$$i = i_1 \neq i_2 = \sqrt{\frac{P_1}{R}} \pm \sqrt{\frac{P_2}{R}}$$

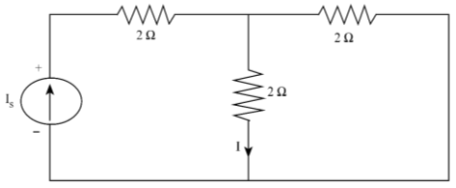
Total power = i^2R

$$= \left(\sqrt{\frac{P_1}{R}} \pm \sqrt{\frac{P_2}{R}}\right)^2 R$$

$$= \left(\sqrt{P_1} \pm \sqrt{P_2}\right)^2$$

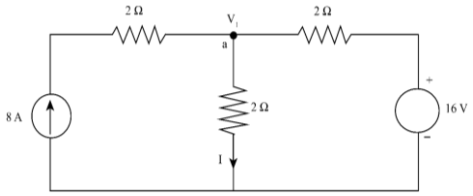
12. Explanation: (b)

When, $V_s = 0$



$$I = \frac{I_s}{2}$$

$$\Rightarrow I_S = 2I = 2 \times 4 = 8A$$



When $V_s = 16$ v

Applying KCL node a,

$-8 + \frac{V_1}{2} + \frac{V_{1-16}}{2} = 0$

$v_1 = 16v$

$I = \frac{V_1}{2} = \frac{16}{2} = 8$ A

Alternate solution :

By superposition,

$v_s = 0$, $I_s = 8$ A , $I_1 = 4A$

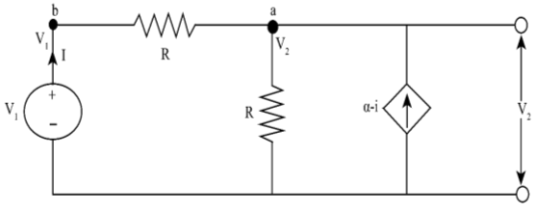
When, $v_s = 16$ V, $I_s = 0$, $I_2 = 4$

So, I = 4+4 = 8 A

13. Explanation: (d)

Ideal voltage source keeps the terminal voltage constant so accordingly current will change and the voltage Across each resistor is unchanged following superposition principle.

14. Explanation: (c)



$\frac{V_1 - V_2}{R} = i$ ……(i)

By applying KCL at node a

$(1+a)\, i = \frac{V_2}{R}$ …….. (ii)

From equation (i),

$(1+ a) \left(\frac{V_1 - V_2}{R}\right) = \frac{V_2}{R}$

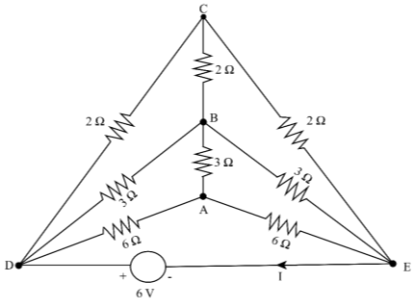
$\therefore \quad \left(\frac{V_1}{V_2} - 1\right) = \frac{1}{1+a}$

$\frac{V_1}{V_2} = \frac{2+a}{1+a}$

$\therefore \quad \frac{V_2}{V_1} = \frac{1+a}{2+a}$

15. Explanation: (c)

DCEB and DBEA are two balanced wheatstone's bridges hence these will not be any current in branch CB And BA.



$I = \frac{6}{2+2} + \frac{6}{3+3} + \frac{6}{6+6} = 3$ A

16. Explanation: (a)

In the given circuit there are only resistor/ inductor or capacitor and a voltage source, of V=5-5=0 V.

As these are passive elements and follow the superposition theorem. The circuit is passive and linear.

17. Explanation: (c)

As all the resistive branches are in parallel.

∴ Voltage across each branch will be constant and will be equal to the dc supply voltage

∴ V = IR = constant

$\Longrightarrow \quad I \propto \frac{1}{R}$

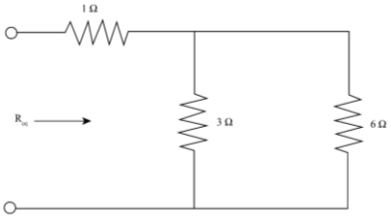
$I_1 : I_2 : I_3 = \frac{1}{R_1} : \frac{1}{R_2} : \frac{1}{R_3}$

$= R_2R_3 : R_1R_3 : R_1R_2$

= 24 : 12 : 8

= 6 : 3 : 2

18. Explanation: (d)



R_{eq} = 1 + (3||6) = 3Ω

Voltage across current source

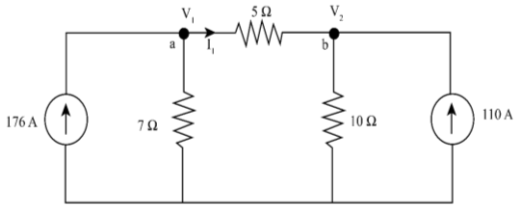
I_sR_{eq} = 2× 3 = 6 V

19. Explanation: (b)

Using wheatstone's bridge balance equation,

$\frac{10}{5} = \frac{4}{R} \Longrightarrow$ R = 2Ω

20. Explanation: (b)



Applying superposition theorem,

I, due to 176 A source = $\frac{7}{22} \times 176$ = 56 A

From node a to node b,

I_2 due to 110 A source = $\frac{10}{22} \times 110$ = 50 A

From node b to node a

∴ Voltage across 5Ω resistor = $(v_1 - V_2)$

= (56 – 50) 5 = 30 V

21. Explanation: (d)

$I_R = \frac{24}{6}$ = 4 A

Current delivered by the voltage source.

$I = I_R + 2I_R = 3I_R = 3 \times 4 = 12$ A

Power delivered by the voltage source

= 24 × 12 = 288 W

22. Explanation: (a)

Fewer nodes will give lesser nodal equation than mesh equations hence better analyzed by node analysis.

So point 3 is not correct.

23. Explanation: (b)

Applying KCL, $-1+\frac{8-2}{2} - I = 0 \Longrightarrow I = 2$ A

24. Explanation: (b)

Applying KCL,

$-5 + \frac{V}{10} + \frac{V-E}{5} = 0$

$\Rightarrow -5 + \frac{10}{10} + \frac{10-E}{5} = 0$

$\Rightarrow$ E = -10 V

25. Explanation: (c)

Assuming voltage of the node V

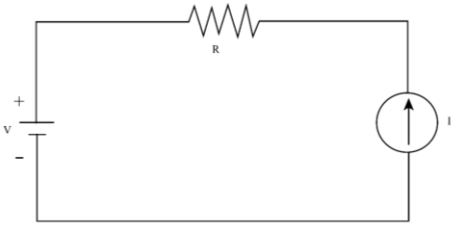
Applying KCL,

$\frac{V-140}{2} - 70 + \frac{V}{4} + \frac{V-70}{1} = 0$

$\Rightarrow$ V = 120 V

$I = \frac{V}{4} = \frac{120}{4}$ =30 A

26. Explanation: (b)



Assuming voltage across current source is V_1

Applying KVL,

$V + IR - V_1 = 0$

$\Rightarrow \quad V_1 = V + IR$

27. Explanation: (*)

By KVL Source voltage,

$V_s = E + IR$

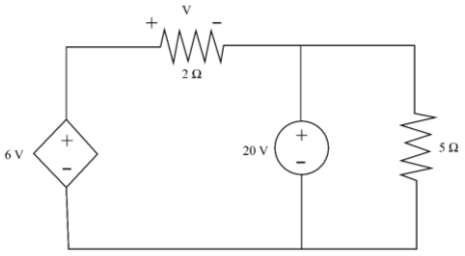
So new source voltage = $\frac{E+IR}{2}$

Hence again by KVL,

$E - V - \frac{E+IR}{2} = 0$

So, $V = \frac{E-IR}{2}$

28. Explanation: (d)

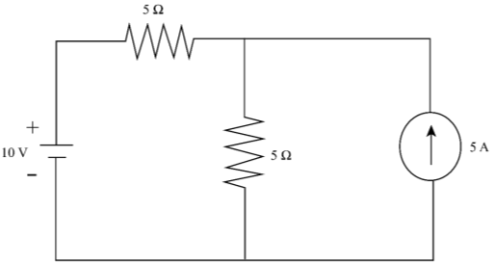


6 V – V – 20 = 0

V = 4 V

Current through 2 Ω resistor = $\frac{V}{2} = \frac{4}{2}$ = 2 A

29. Explanation: (d)



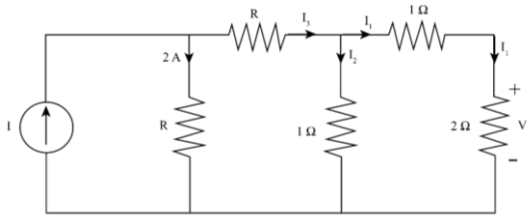
Applying Nodal Analysis,

$\frac{10-V}{5} + 5 = \frac{V}{5}$

$\therefore$ 10 – V + 25 = V

$\therefore$ V = 17.5 V

30. Explanation: (c)



V = 2 V

$\therefore \quad I_1 = \frac{V}{2}$ = 1 A

and $I_1 = \left(\frac{1}{1+3}\right) I_3$

$\frac{1}{I} = \frac{1}{4} I_3$

$\therefore \quad I_3$ = 4 A

and I = 4 + 2 = 6 A

31. Explanation: (b)

Applying Nodal Analysis

$20 = \frac{V_A}{2} + \frac{V_A - V_B}{2}$

$40 = 2V_A - V_B$ ... (i)

and $\frac{V_A + V_B}{2} = \frac{V_B}{1} + 10$

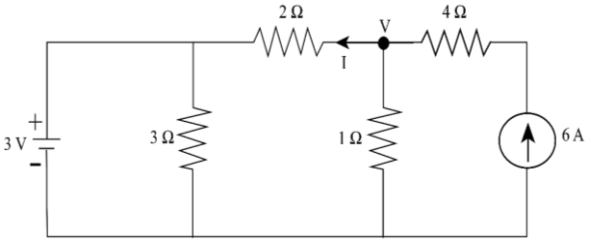
$V_A - V_B = 2V_B + 20$

$\therefore \quad V_A - 3V_B = 20$ ... (ii)

Solving (i) and (ii),

V_A = 20 V

32. Explanation: (d)



Applying Nodal Analysis ,

$6 = \frac{V-3}{2} + \frac{V}{1}$

12 = V – 3 + 2 V

$\therefore \quad$ V = 5 V

$I = \frac{5-3}{2}$ = 1 A

33. Explanation: (a)

$i_{rms}^2 = \frac{1}{T}\int_0^T (i_{avg})^2 . dt$

$\therefore \quad i_{avg} = \left(\frac{9-0}{3-0}\right) \times t = 3t$

$\therefore \quad i_{rms}^2 = \frac{1}{3}\int_0^3 (3t)^2 \times dt$

$= \frac{1}{3} \times 9 \times \left[\frac{t^3}{3}\right]_0^3 = 27$

And $P = i_{rms}^2 \times R$

= 27 × 10 = 270 W

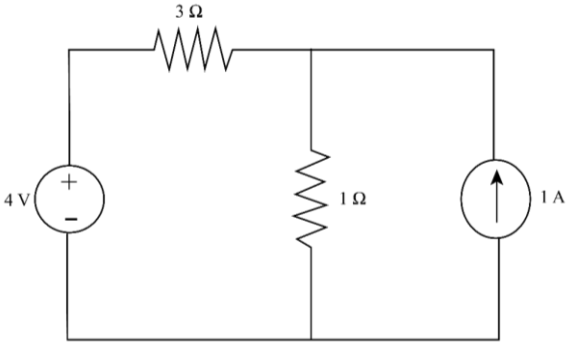
34. Explanation: (b)

2. $L_1 \frac{di_1(t)}{dt} = -R_1 i_1(t) - e_c(t) + e(t)$

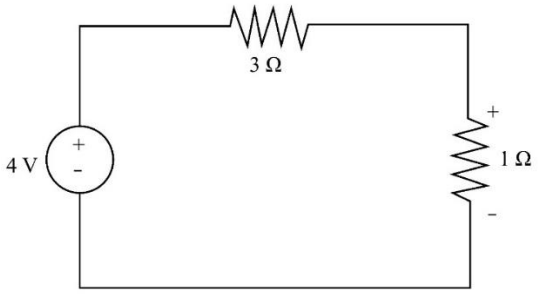
3. $L_2 \frac{di_2(t)}{dt} = -R_2 i_2(t) + e_c(t)$

4. $C \frac{de_c(t)}{dt} = i_1(t) - i_2(t)$

35. Explanation: (a)

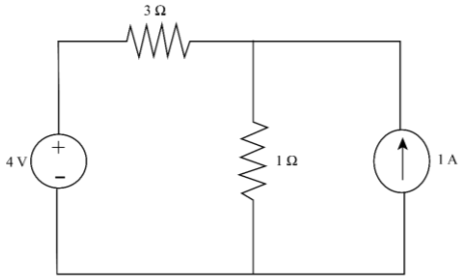


1. By O. C . the 1 A current source.



$V'_{1\Omega} = \frac{4 \times 1}{4} = 1$ V

2. By S.C. the voltage source.



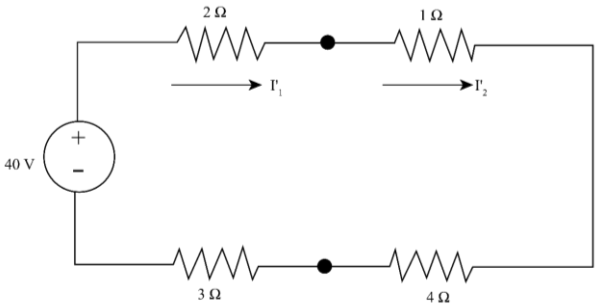
$V''_{1\Omega} = \frac{3 \times 1}{4} = \frac{3}{4}$ V

By superposition theorem,

$= V_{1\Omega}^{total} = V'_{1\Omega} + V''_{1\Omega} = 1 + \frac{3}{4} = \frac{7}{4}$ V

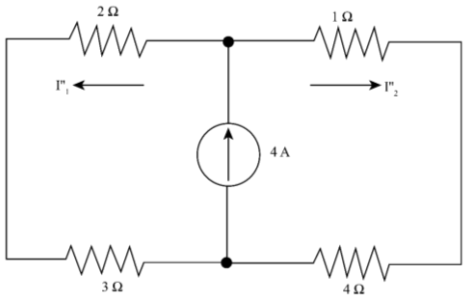
36. Explanation: (c)

By open circuiting the 4 A current source.



$I'_1 = I'_2 = 4$ A

Applying short-circuiting 40 V voltage source.



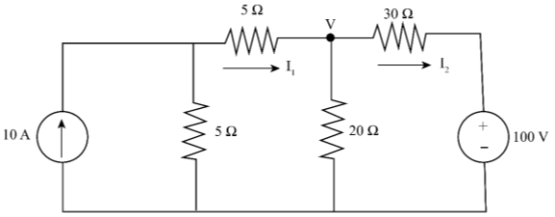
$I''_1 = I''_2 = 2$ A

By superposition theorem

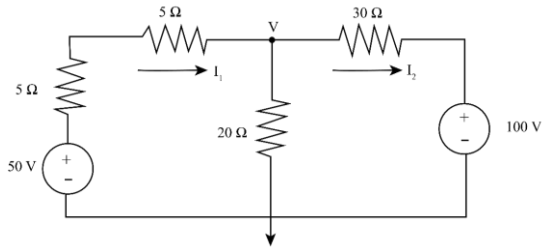
$I_1 = I'_1 - I''_1 = 2$ A

$I_2 = I'_2 - I''_2 = 6$ A

37. Explanation: (c)



By applying source transformation,



By applying KCL

$\frac{V-50}{10} + \frac{V}{20} + \frac{V-100}{30} = 0$

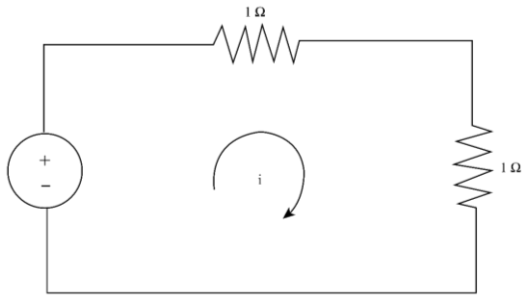
$\frac{11}{60}$ V = 8.33

V = 45.45 V

$i_1 = \frac{50-45.45}{10} = 0.4545$ A

$i_2 = \frac{45.45-100}{30} = -1.818$ A

38. Explanation: (b)



$i = \frac{E}{2}$

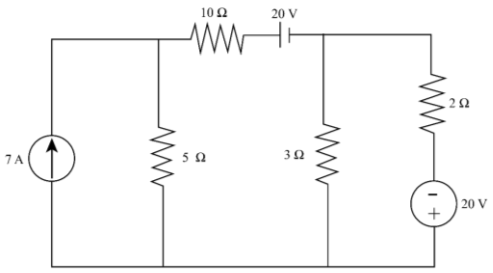
Power dissipated,

$P = \left(\frac{E}{2}\right)^2 \times 2 = 8$

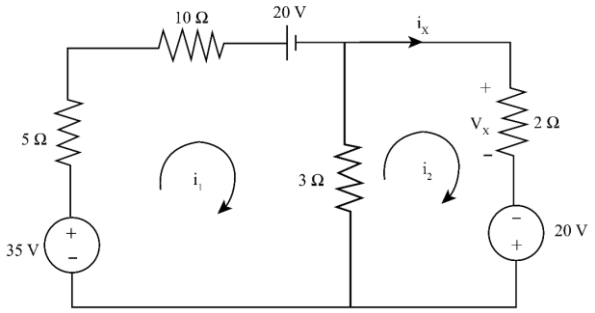
$E^2 = 16$

E= 4 V

39. Explanation: (a)



By applying source transformation in above circuit ,



$35 - 20 = 18i_1 - 3i_2$

$15 = 18i_1 - 3i_2$ … (i)

$20 = 5i_2 - 3i_1$ … (ii)

Equation (i) and (ii),

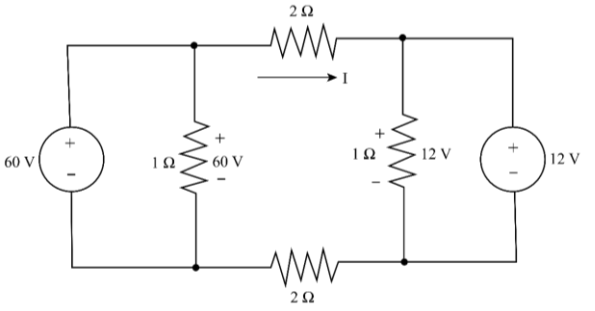
$i_1 = 1.66$ A

$i_2 = 5$ A

So, $i_x = 5$ A

$V_x = 10$ V

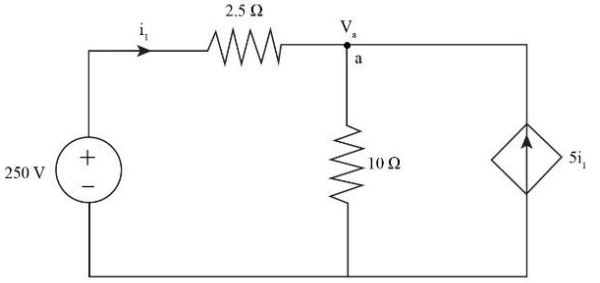
40. Explanation: (d)



$-60 + 2I + 12 + 2I = 0$

$48 = 4I \Longrightarrow I = 12$ A

41. Explanation: (a)



Applying KCL at node a.

$$-i_1 - 5i_1 + \frac{V_a}{10} = 0$$

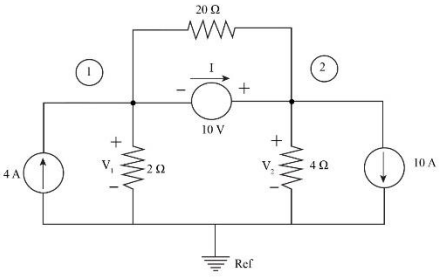
$\Rightarrow \quad V_a = 60\, i_1$

$$i_1 = \frac{250 - V_a}{2.5} = \frac{250 - 60i_1}{2.56}$$

$\Rightarrow \quad i_1 = \frac{250}{62.5} = 4$ A

Hence, option (a) is correct.

42. Explanation: (a)



Let current through 10 V source is I .

Applying KCL at node 1,

$$-4 + \frac{V_1}{2} + \frac{V_1 - V_2}{20} + I = 0 \qquad \text{…(i)}$$

Applying KCL at node 2,

$$-I + \frac{V_2}{4} + \frac{V_2 - V_1}{20} + 10 = 0 \qquad \text{…(ii)}$$

Adding equation (i) and (ii) we get,

$$-6 = \frac{V_1}{2} + \frac{V_2}{4}$$

Hence, option (a) is correct.

43. Explanation: (d)

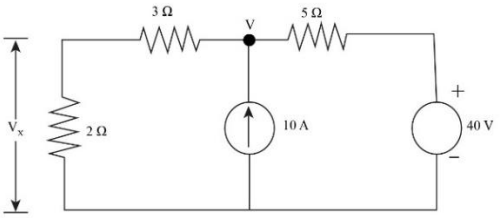
Applying KCL,

$$\frac{V-30}{10} - 9 + = \frac{V-36}{20} = 0$$

$V = 92$ V

Hence, option (d) is correct.

44. Explanation: (c)



Applying KCL,

$$\frac{V}{5} + \frac{V-40}{5} - 10 = 0$$

$V = 45$ V

$$V_x = \frac{V}{5} \times 2 = \frac{45}{5} \times 2 = 18 \text{ V}$$

45. Explanation: (c)

$$I_1 = \frac{E}{2R}\ ;\ I_2 = \frac{E}{4R}\ ;\ I_3 = \frac{E}{6R}$$

$$I_1 : I_2 : I_3 = \frac{E}{2R} : \frac{E}{4R} : \frac{E}{6R} = 6 : 3 : 2$$

46. Explanation: (c)

The resistance between A and B with C open:

12 Ω

$R_A + R_B = 12\ \Omega$ … (i)

The resistance between B and C with A open:

22 Ω

$R_B + R_C = 22\ \Omega$ … (ii)

The resistance between C and A with B open:
18 Ω

$$R_A + R_C = 18\ \Omega \quad \text{... (iii)}$$

On solving equation (i), (ii) and (iii) we get,
$R_A = 4\ \Omega, R_B = 8\ \Omega$ and $R_C = 14\ \Omega$
Hence, option (c) is correct

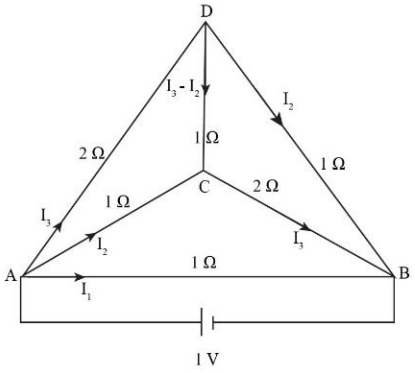
47. Explanation: (b)

List-I and List=II are dual of each other

48. Explanation: (b)

In any linear, planar network, the number of independent Kirchhoff's Voltage Law (KVL) equations is equal to the number of links, while the number of Kirchhoff's Current Law (KCL) equations is (n-1), where "n" represents the number of nodes in the network.

49. Explanation: (c)



$$1 = 2I_3 + I_2 \quad \text{... (i)}$$

$$2I_3 + I_3 - I_2 - I_2 = 0 \quad \text{... (ii)}$$

$$\Rightarrow \quad I_3 = \frac{2}{3} I_2$$

From equation (i),

$$1 = 2 \times \frac{2}{3} I_2 + I_2$$

$$1 = \frac{7}{3} I_2 \Rightarrow I_2 = \frac{3}{7} A$$

50. Explanation: (d)

Since the circuit is a combination of series and parallel components, we know that in a series circuit, the current remains the same, and in a parallel circuit, the voltage remains the same. Therefore, X cannot represent current, voltage, or resistance. According to Tellegen's theorem, the total instantaneous power supplied by the sources is always equal to the total power consumed by the passive elements in the network's branches at any given time.
Therefore option (d) is correct.

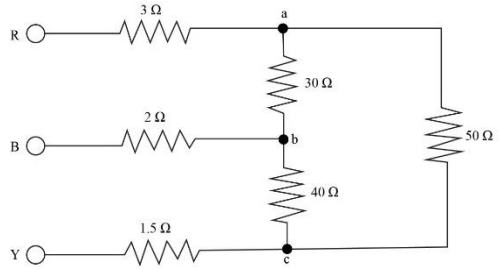
51. Explanation: (b)

An element connected in parallel with a voltage source is redundant because the voltage across the voltage source remains constant. Similarly, an element connected in series with a current source is unnecessary, as the current source supplies a constant current to the network.

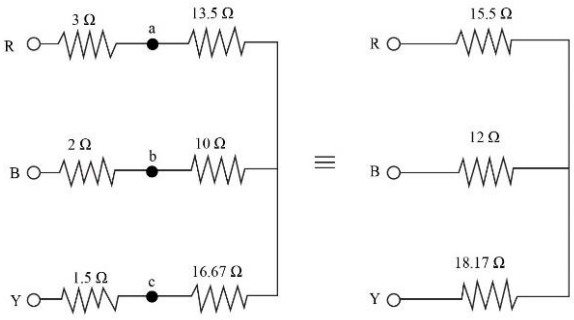
52. Explanation: (d)

Let current flowing through the circuit = I
So that, $V_A = 7I$
∴ Using KVL,
$36 - 15I - 2V_A - V_A = 0$
$36 - 15I - 3 \times (7I) = 0$
$\Rightarrow \quad I = 1\ A$
And $V_A = 7\ V$
∴ Power dissipated in the controlled source
$= 2 V_A I = 14\ W$

53. Explanation: (b)



Using suitable star delta conversion
We have,

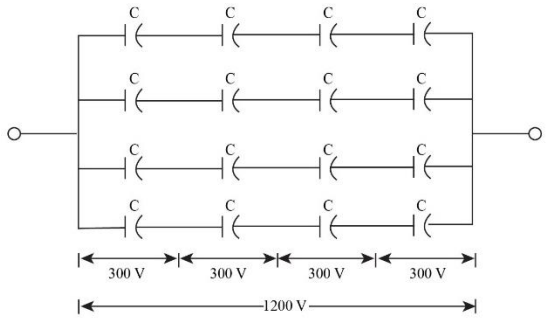


Now taking 2 phases at a time and grounding the third phase,
We have,
$Z_{RB} = 27.5\ \Omega$
$Z_{BY} = 30.17\ \Omega$
$Z_{RY} = 33.67\ \Omega$

54. Explanation: (a)

Hint: Determinant of any network is independent of voltage and current sources.

55. Explanation: (a)



C = 2 μF

$C_{overall} = \frac{C}{4} + \frac{C}{4} + \frac{C}{4} + \frac{C}{4} = 2\ \mu F$

Number of capacitor = 16

56. Explanation: (b)

$r = \frac{(r+2)\times 3}{r+2+3} + 2$

On solving, r = 4 Ω

57. Explanation: (a)

When an ideal voltage source and an ideal current source are connected in series, they behave like an ideal current source. Conversely, when they are connected in parallel, they function as an ideal voltage source.

58. Explanation: (*)

$P = I^2 R = I^2 \times P\frac{l}{A}$

$P \propto I^2 \times \frac{l}{d^2}$

$\frac{W}{x} = \frac{P_1}{P_2} = \frac{I^2 \times \frac{l}{d^2}}{(3I)^2 \times \frac{l/2}{(2d)^2}}$

$= \frac{I^2 \times \frac{l}{d^2}}{9I^2 \times \frac{l}{2} \times \frac{1}{4d^2}}$

$x = \frac{9}{8} W$

59. Explanation: (d)

An element in **series with an ideal current source** is redundant because the current is fixed by the source.

An element in **parallel with an ideal voltage source** is redundant because the voltage is fixed by the source.

Elements in parallel with an ideal current source or in series with an ideal voltage source are not redundant

Hence, the correct answer is **(d) 1 and 4**.

60. Explanation: (a)

Voltage sources of different values cannot be connected in parallel, because voltage across A parallel paths will be equal.

The current sources of different values cannot be connected in series, because current Through a series circuit path is same.

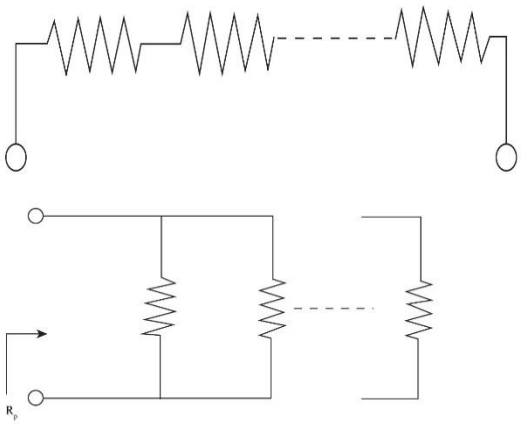
61. Explanation: (c)

$V = L\frac{di}{dt} = \frac{Ld(t)}{dt}$

V = L = constant = 2 V

So, L = 2 H

62. Explanation: (d)



$R_S = nR$

$R_P = \frac{R}{n}$

$\Rightarrow$ n . R = 50

$2 = \frac{R}{n}$

$R = \frac{50}{n}$ … (1)

$\Rightarrow$ R = 2n … (2)

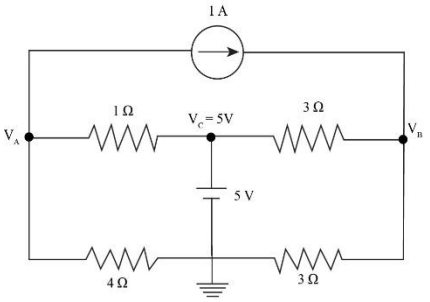
Multiplying equation (1) and (2),

$R^2 = \frac{50}{n} \times 2n = 100$

$\Rightarrow$ $R = \sqrt{100}$

= 10 Ω

63. Explanation: (b)



$V_c - 0 = 5 \Longrightarrow V_c = 5$ V

At node A :

$1 + \frac{V_A - 5}{1} + \frac{V_A}{4} = 0$

$5\,V_A = 16$

$\Rightarrow \quad V_A = \frac{16}{5}$ V

At node B :

$-1 + \frac{V_B - 5}{3} + \frac{V_B}{3} = 0 \Rightarrow 2\,V_B = 8$

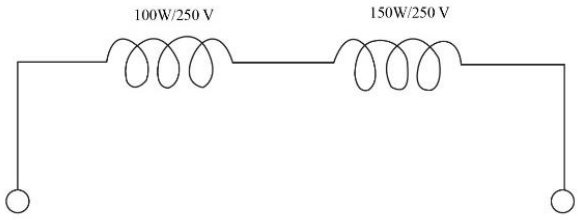
$\therefore \quad V_B = 4$ V

$\therefore \quad V_{AB} = V_A - V_B$

$= \frac{16}{5} - 4$

$= -0.8$ V

64. Explanation: (b)



$R_1 = \frac{V^2}{P_1} = \frac{250 \times 250}{100} = 625\ \Omega$

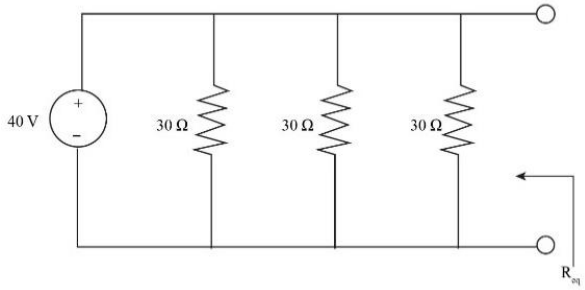
$R_2 = \frac{V^2}{P_2}$

$= \frac{250 \times 250}{150} = 416.67\ \Omega$

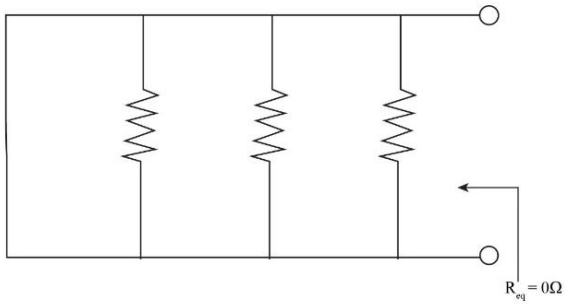
$R_{eq} = R_1 + R_2 = 1041.67\ \Omega$

$P = \frac{V^2}{R_{eq}} = \frac{250 \times 250}{1041.66} \simeq 60$ W

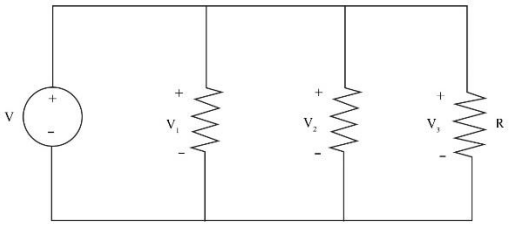
65. Explanation: (a)



Replacing voltage source by a short circuit



66. Explanation: (d)

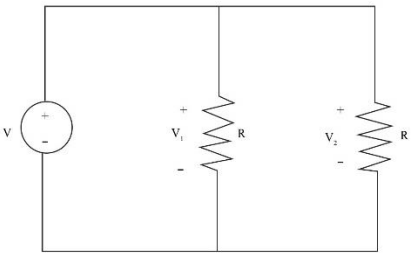


$R_{eq} = \frac{R}{3}$

$P = \frac{V^2}{R_{eq}} = \frac{V^2}{R/3} = \frac{3\,V^2}{R}$

$V_1 = V_2 = V_3 = V$

$R_{eq} = \frac{R}{2}$



$P = \frac{V^2}{R/2} = \frac{2\,V^2}{R}$

$V_1 = V_2 = V$

As observed from the circuits above:

- The total resistance increases.
- The total power decreases.
- Both the total voltage and the branch voltage remain unchanged.

  Even when unequal resistances are used, the analysis remains the same.

67. Explanation: (b) The reference node is typically chosen as the one connected to the most parts of the network.

68. Explanation: (b) Mesh analysis is applicable only to planar networks, where Kirchhoff's Voltage Law (KVL) is applied for its analysis.

69. Explanation: (d) A short circuit in any type of network results in a decrease in the total resistance, leading to an increase in the current.

70. Explanation: (b)

$I(t = 2) = \frac{1}{L}\int_0^2 v\,dt = \text{area under the curve}$

$= \frac{\frac{1}{2} \times 2 \times 20}{L} = 8$

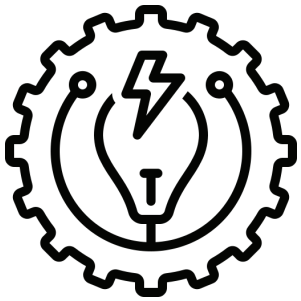
$L = \frac{20}{8} = 2.5\text{H}$

COMPUTER FUNDAMENTALS

SECTION 5

SYLLABUS

NUMBER SYSTEMS, BOOLEAN ALGEBRA, ARITHMETIC FUNCTIONS, BASIC ARCHITECTURE, CENTRAL PROCESSING UNIT, I/O AND MEMORY ORGANISATION; PERIPHERAL DEVICES, DATA REPRESENATION AND PROGRAMMING, BASICS OF OPERATING SYSTEM AND NETWORKING, VIRTUAL MEMORY, FILE SYSTEMS; ELEMENTS OF PROGRAMMING LANGUAGES, TYPICAL EXAMPLES.



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ESE ELECTRICAL ENGINEERING: NUMBER OF QUESTIONS ASKED IN PREVIOUS EXAMS (2017-2025)										
COMPUTER FUNDAMENTALS		2017	2018	2019	2020	2021	2022	2023	2024	2025
5.1	Data Representation	2	1	3	3	-	-	1	-	1
5.2	Computer Architecture	-	1	-	1	1	5	3	7	2
5.3	Memory organization	1	3	7	1	2	3	1	1	1
5.4	Networking Fundamentals	1	1	2	1	-	2	-	2	1
5.5	C-Programming	2	4	1	-	-	-	2	-	1
5.6	Basics of Operating System	-	2	-	1	1	2	4	1	2

CHAPTER-5 COMPUTER FUNDAMENTALS

Unit 5.1 Data Representation

Previous Year Exam Questions

[ESE-2017]

1. What is the octal equivalent of $(5621 \cdot 125)_{10}$?
(a) $11774 \cdot 010$ (b) $12765 \cdot 100$
(c) $16572 \cdot 100$ (d) $17652 \cdot 010$

[ESE-2017]

2. What is the hexadecimal representation of $(657)_8$?
(a) 1 AF (b) D 78
(c) D 71 (d) 32 F

[ESE-2018]

3. The decimal value $0 - 5$ in IEEE single precision floating point representation has fraction bits of
(a) $000 \ldots 000$ and exponent value of 0
(b) $000 \ldots 000$ and exponent value of -1
(c) $100 \ldots 1000$ and exponent value of 0
(d) $100 \ldots 000$ and exponent value of -1

[ESE-2019]

4. The decimal equivalent of binary number 1001.101 is
(a) 9.750 (b) 9.625
(c) 10.750 (d) 10.625

[ESE-2019]

5. Convert decimal 41.6875 into equivalent binary:
(a) 100101.1011 (b) 100101.1101
(c) 101001.1011 (d) 101001.1101

[ESE-2019]

6. The decimal value of signed binary number 11101000 expressed in 1's complement is
(a) -223 (b) -108
(c) -104 (d) -23

7. Statement (I): Sign magnitude representation is generally used in implementing the integer portion of the ALU.
Statement (II): In sign magnitude representation there are two representations of 0.

[ESE-2020]

8. The hexadecimal of the binary number $(11010011)_2$ is
(a) $D3_{16}$ (b) $D4_{16}$
(c) $C3_{16}$ (d) $C4_{16}$

[ESE-2020]

9. Which of the following factors are to be considered while selecting number representations to be used in a computer?
1. Number types to be represented
2. Range of values to be encountered
3. Cost of the hardware to store and process the numbers
4. Positional notation with fixed weight.
(a) 1, 2 and 4 only (b) 1, 3 and 4 only
(c) 2, 3 and 4 only (d) 1, 2 and 3 only

[ESE-2020]

10. If a negative binary number is to be represented by n-bits, then the standard format will be
(a) Sign bit 10' on left and magnitude on right
(b) Sign bit 'T' on left and magnitude on right
(c) Sign bit '' on right and magnitude on left
(d) Sign bit '1' on right and magnitude on left

[ESE-2023]

11. What is the exponent length in bits for IEEE double-precision floating point format?
(a) 32 bits (b) 8 bits
(c) 16 bits (d) 11 bits

[ESE-2025]

12. Which one of the following file operations is used with random access files to first position read/write pointer to a specific place in file so that the data can be read from, or written to that position?
(a) Read (b) Write
(c) Seek (d) Set attribute

Answer Key									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(b)	(a)	(a)	(b)	(c)	(d)	(d)	(a)	(a)	(b)
11	**12**								
(d)	(c)								

EXPLANATIONS

1. Explanation (b):
To convert the decimal number 5621.125_{10} to octal:
Convert the integer part (5621):

Divide 5621 by 8 and record the remainders:
$5621 \div 8 = 702$ remainder 5
$702 \div 8 = 87$ remainder 6
$87 \div 8 = 10$ remainder 7
$10 \div 8 = 1$ remainder 2
$1 \div 8 = 0$ remainder 1
Reading the remainders from bottom to top, the integer part in octal is **12765**.
Convert the fractional part (0.125):
Multiply 0.125 by 8:
$0.125 \times 8 = 1.0$
The integer part of the result is 1, so the fractional part in octal is **0.1**.
Combining the integer and fractional parts, the octal equivalent of 5621.125_{10} is $(\mathbf{12765.100})_{\mathbf{8}}$.
Thus, the correct answer is **(b) 12765.100**.

2. **Explanation (a):**
$(658)_8 = 1$ AF H as 657 oct $= 11010111$ in binary
So take group to 4 bits then it would be 1 AF in hex.

3. **Explanation (a):** For the decimal value **0.5** in IEEE single precision, the **fraction bits** are **000...000** (since the number is normalized), and the **exponent** value is **-1**. In IEEE format, the exponent is stored with a bias of 127, resulting in an exponent value of **126** (binary 11111110).

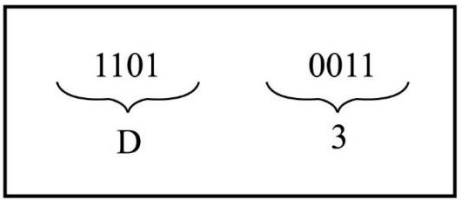
4. **Explanation (b):** The decimal equivalent of the binarary number 1001.101 is,
$= 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3}$
$= 9.625$

5. **Explanation (c):**
$(41)_{10} = (101001)_2$
Now, to convert the decimal number (0.6875) into a binary number, we have to do the repeated multiplication of 2 till we get zero.
0.6875 × 2 = 1.375
0.375 × 2 = 0.75
0.75 × 2 = 1.5
0.5 × 2 = 1.0
$(0.6875)_{10} = (1011)_2$
Therefore, the binary equivalent of $(41.6875)_{10}$ is $(101001.1011)_2$

6. **Explanation (d):** 1's complement representation of signed binary number 11101000
Here sign bit is 1 and 1's complement of the required number is 1101000.
As the sign bit is 1, the given number is negative.
The required original number = 1's complement of 1101000 = 0010111 = (23)10.
Now, the required decimal number = -23.

7. **Explanation (d):**
Statement (I) is false because **sign magnitude representation** is not commonly used in ALUs for integer arithmetic, while **Statement (II)** is true, as **sign magnitude representation** has two representations of zero. Thus, the correct answer is **(d)**.

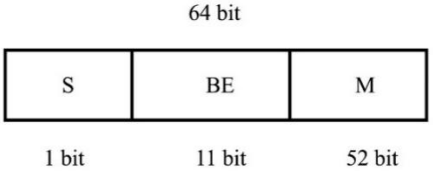
8. **Explanation (a):** To convert a binary number into hexadecimal, we start from the LSB binary digit and from groups of 4 binary digits. Next, we write the hexadecimal equivalent of each group of 4 bits.



9. **Explanation (a):**
When selecting number representations for a computer, important factors to consider are the types of numbers to be represented, the range of values, and the use of positional notation with fixed weight for encoding the numbers.

10. **Explanation (b):**
In signed binary number representation, the MSB represents the sign of the number and remaining bits represent the magnitude of the number.
Moreover, if the number is positive the sign bit = 0; and if the number is negative, the sign bit = 1

11. **Explanation (d):**



12. **Explanation (c):** The **seek** operation is used with random access files to move the read/write pointer to a specific position in the file.

Unit 5.2 Computer Architecture

Previous Year Exam Questions

[ESE-2018]

1. Consider the following statements regarding Computer Architecture:

1. The advantage with dedicated bus is decrease in size and cost

2. In synchronous timing, the occurrence of events on the bus is determined by the clock

3. Data bus width decides the number of bits transferred at one time

Which of the above statements are correct?

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

(c) 2 and 3 only (d) 1, 2 and 3

[ESE 2020]

2. Which of the following design levels of a computer are widely used in computer design?

1. Gate level **2. Processor level**

3. Register level **4. user level**

(a) 1 and 3 only (b) 2 and 4 only

(c) 3 and 4 only (d) 1, 2 and 3 only

[ESE-2021]

3. Consider the following statements for a simple assembler:

1. It scans the entire assembly program twice, where each scan is called a pass.

2. It generates a table that includes all symbols and their binary values.

3. It will use the symbol table and other tables to generate the object program and output some information that will be needed by the linker.

Which of the above statements are correct?

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

(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2022]

4. Which one of the following controllers is to check the status of each device and inform the central processing unit of the status of each?

(a) Programmable I/o interrupt controller

(b) DMA controller

(c) Disk controller

(d) Pipeline controller

[2022]

5. Which one of the following bus architectures is used to maximize throughput of video graphics memory?

(a) EISA bus (b) VESA bus

(c) PCI bus (d) MCA bus

[ESE-2022]

6. Which one of the following bus architectures is having maximum data rate (MB/s)?

(a) VESA bus (b) PCI-64 bus

(c) MCA bus (d) EISA bus

[ESE-2022]

7. Which one of the following layers in PCI express protocol architecture is used for compatibility with PCI, initialization and enumeration of the devices connected to the PCI express?

(a) PCI express physical layer (b) Software layer

(c) Data link layer (d) Hardware layer

[ESE-2022]

8. Which of the following statements are correct regarding multiprocessing architecture?

1. It can cause a system to change its memory access model from uniform memory access to non-uniform memory access.

2. There are two types of systems such as asymmetric multiprocessing and symmetric multiprocessing.

3. It adds CPUS to decrease computing power.

Select the correct answer using the code given below.

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

(c) 2 and 3 only (d) 1, 2 and 3

[ESE-2023]

9. A benchmark program is run on a 200 MHz processor. The executed program consists of 1 million instruction executions, with the following instruction mix and clock cycle count:

Instruction Type	Instruction Count (Millions)	Cycles per Instruction
Arithmetic and logic	8	1
Load and store	4	3
Branch	2	4
Others	4	3

What is the effective MIPS rate for the given program?

(a) 90 (b) 70

(c) 110 (d) 80

[ESE-2023]

10. Which one of the following statements is correct for machine parallelism?

(a) It is a measure of the ability of the processor to take disadvantage of instruction-level parallelism.

(b) It is determined by the frequency of true data dependencies and procedural dependencies in the code.

(c) It is determined by the number of instructions that can be fetched and executed at the same time and by the speed and sophistication of the mechanisms that the processor uses to find independent instructions.

(d) It is determined by the time until the result of an instruction is available for use as an operand in a subsequent instruction.

[ESE-2023]

11. Which one the following methods is used when the processor issues an I/O command, continues to execute other instructions, and is interrupted by the I/O module when the latter has completed its work?

(a) Interrupt-driven I/O
(b) I/O device controller
(c) I/O channel processor controller
(d) Programmed I/O

[ESE-2024]

12. Consider the following characteristics of Complex Instruction Set Computer (CISC) processor:

1. It is having a small number of instructions.
2. It is having less addressing modes.
3. Most instructions can manipulate operands in the memory.
4. Control unit is microprogrammed.

Which of the above characteristics is/are not correct?

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

[ESE-2024]

13. In which of the following processors, the designer can add easily new instruction without changing the architecture of the processor?

(a) CISC processor only
(b) RISC processor only
(c) Both CISC and RISC processors
(d) Neither CISC processor nor RISC processor

[ESE-2024]

14. Which one of the following is used to increase the performance of CPU, that means executing more instructions in less time?

(a) Sequencing (b) Pipelining
(c) Scheduling (d) Spooling

[ESE-2024]

15. In Double Data Rate SDRAM, if 100 MHz clock rate and 64 bits data bus transfers data, then what is the approximate transfer rate for DDR3?

(a) 1600 MB/s (b) 6400 MB/s
(c) 3200 MB/s (d) 800 MB/s

[ESE-2024]

16. What is the approximate rotational delay if the disk drive has 8 surfaces, each surface has 1024 tracks, each track has 64 sectors, each sector can hold 512 bytes and rotation speed of 6000 r.p.m.? (It is assumed that the sector is away from head half of the track)

(a) 0.005 s (b) 0.050 s
(c) 0.500 s (d) 0.505 s

[ESE-2024]

17. Consider the following set of processes that arrive at time 0 with the length of the CPU burst given in milliseconds:

Process	Burst time
P_1	24
P_2	3
P_3	3

What is the average waiting time under the Round-Robin Scheduling, if we use a time quantum of 4 milliseconds?

(a) $5 \cdot 66$ milliseconds (b) $3 \cdot 50$ milliseconds
(c) $7 \cdot 00$ milliseconds (d) $6 \cdot 55$ milliseconds

[ESE-2024]

18. Consider the following set of processes, assumed to have arrived at time 0 in the order $P_1, P_2, \ldots P_5$, with the length of the CPU burst given in milliseconds:

Process	Burst time	Priority
P_1	10	3
P_2	1	1
P_3	2	4
P_4	1	5
P_5	5	2

Assuming that low numbers represent high priority, what is the average waiting time under the priority scheduling?

(a) $5 \cdot 66$ milliseconds (b) $4 \cdot 50$ milliseconds
(c) $8 \cdot 20$ milliseconds. (d) $6 \cdot 55$ milliseconds

[ESE-2025]

19. Statement (I): A computer's control unit does not perform any actual processing of jobs, but acts as the central nervous system for other components of the computer systems.

Statement (II): It obtains instructions from a program stored in main memory, interprets the instructions and issues signals causing other units of the system to execute them.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE-2025]

20. The necessary steps that the processor has to carry out for fetching an instruction from the memory and executing it, constitute

(a) an interrupt (b) an addressing
(c) an instruction cycle (d) a control signal

Answer Key									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
(c)	(b)	(d)	(a)	(c)	(b)	(a)	(b)	(a)	(c)
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
(a)	(b)	(a)	(b)	(b)	(a)	(a)	(c)	(a)	(c)

EXPLANATIONS

1. Explanation: (c)

Statement 1 is incorrect because dedicated buses generally increase size and cost, not decrease them.
Statement 2 is correct as, in synchronous systems, events on the bus are synchronized with the clock.
Statement 3 is correct, as the data bus width determines how many bits are transferred at once.

2. Explanation: (b)

The widely used design levels in computer design are:
Gate level (logic gates & digital circuits)
Processor level (CPU microarchitecture)
Register level (RTL for data flow between registers)
User level (software applications) is not a hardware design level.

3. Explanation: (d)

All three statements correctly describe the functions of a simple two-pass assembler:

1. **Statement 1:** True. A two-pass assembler scans the assembly program twice. The first pass processes labels and addresses; the second pass resolves symbols and generates machine code.
2. **Statement 2:** True. It creates a symbol table containing all symbols (labels, addresses) and their corresponding binary values (addresses or constants).
3. **Statement 3:** True. The assembler utilizes symbol tables to generate the object program, along with other necessary linking information.

4. Explanation: (a)

A programmable I/O interrupt controller is designed to monitor multiple peripheral devices, check their status, and inform the CPU when an interrupt or status update occurs. It helps manage communication between peripherals and the CPU efficiently.

5. Explanation: (c)

The VESA (Video Electronics Standards Association) bus was specifically designed to maximize throughput for video graphics memory, allowing faster data transfer rates and better graphics performance compared to other bus architectures like EISA, PCI, or MCA at that time.

6. Explanation: (b)

Among the given options, the **PCI-64 bus** provides the highest data transfer rate (measured in MB/s). PCI (Peripheral Component Interconnect) with a 64-bit width offers higher bandwidth compared to older architectures like VESA, ISA, or EISA, making it suitable for applications requiring fast data transfers.

7. Explanation: (a)

The PCI Express physical layer is responsible for the electrical signaling, link initialization, and device enumeration. It ensures compatibility with PCI and handles the physical connection and communication between devices.

8. Explanation: (b)

Multiprocessing can change the memory access model from uniform to non-uniform memory access (NUMA).There are two types of multiprocessing systems: asymmetric (AMP) and symmetric (SMP).
The third statement, **"It adds CPUs to decrease computing power,"** is incorrect because adding CPUs aims to increase, not decrease, computing power. Thus, only statements 1 and 2 are correct.