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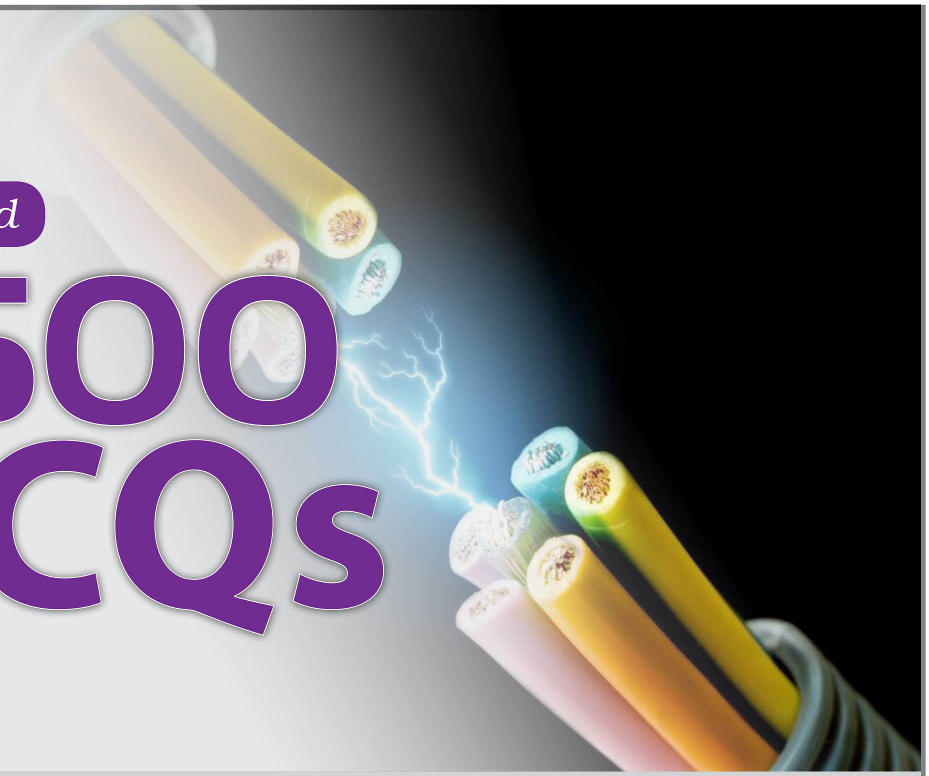
# 3500 MCQs



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# Electrical Engineering

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# PREFACE

**B. Singh** (Ex. IES)

It gives me great happiness to introduce the **Revised Edition** on Electrical Engineering containing nearly 3500 MCQs which focuses in-depth understanding of subjects at basic and advanced level which has been segregated topicwise to disseminate all kind of exposure to students in terms of quick learning and deep apt. The topicwise segregation has been done to align with contemporary competitive examination pattern. Attempt has been made to bring out all kind of probable competitive questions for the aspirants preparing for ESE, GATE & PSUs. The content of this book ensures threshold level of learning and wide range of practice questions which is very much essential to boost the exam time confidence level and ultimately to succeed in all prestigious engineer's examinations. It has been ensured from MADE EASY team to have broad coverage of subjects at chapter level.

While preparing this book utmost care has been taken to cover all the chapters and variety of concepts which may be asked in the exams. The solutions and answers provided are upto the closest possible accuracy. The full efforts have been made by MADE EASY Team to provide error free solutions and explanations.

I have true desire to serve student community by way of providing good sources of study and quality guidance. I hope, this book will be proved an important tool to succeed in competitive examinations. Any suggestions from the readers for the improvement of this book are most welcome.

**B. Singh** (Ex. IES)
Chairman and Managing Director
MADE EASY Group

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■■■■

# UNIT 1

# Electromagnetic Theory

## 1. Vector Analysis

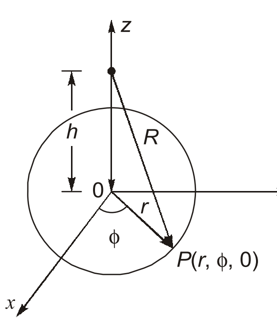
**Q.1** If $\vec{P} = x^2y^2\,\vec{i} + (x - y)\,\vec{k}$, $\vec{Q} = zx\vec{i}$ and $\phi = xy^2z^3$, then match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

| List-I | List-II |
|---|---|
| A. Div. $\vec{Q}$ | 1. $y^2z^3\,\vec{i} + 2yxz^3\,\vec{j} + 3z^2y^2x\vec{k}$ |
| B. Grad $\phi$ | 2. $-\vec{i} + \vec{k}x^2$ |
| C. Curl $\vec{P}$ | 3. $z$ |

**Codes:**

| | A | B | C |
|---|---|---|---|
| (a) | 1 | 2 | 3 |
| (b) | 2 | 1 | 3 |
| (c) | 3 | 1 | 2 |
| (d) | 3 | 2 | 1 |

**Q.2** The unit vector $\vec{a}_R$ which points from $z = h$ on the $z$-axis towards $(r, \phi, 0)$ in cylindrical co-ordinates as shown below is given by




(a) $\dfrac{h\vec{a}_r - r\vec{a}_z}{\sqrt{r^2 + h^2}}$ (b) $\dfrac{r\vec{a}_r - h\vec{a}_z}{\sqrt{r^2 + h^2}}$

(c) $\dfrac{h\vec{a}_\phi - r\vec{a}_z}{\sqrt{r^2 + h^2}}$ (d) $\dfrac{r\vec{a}_z - h\vec{a}_\phi}{\sqrt{r^2 + h^2}}$

**Q.3** If the vector $V$ given below is irrotational, then the values of $a$, $b$ and $c$ will be respectively

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

(a) $a = 4$, $b = 2$ and $c = -1$
(b) $a = 2$, $b = -1$and $c = 4$
(c) $a = 4$, $b = -1$ and $c = 2$
(d) $a = 2$, $b = 4$ and $c = -1$

**Q.4** Match **List-I (Vector Identities)** with **List-II (Equivalent expression)** and select the correct answer using the codes given below the lists:

**List-I**

A. $(\vec{A} \times \vec{B}) \cdot (\vec{C} \times \vec{D})$

B. $\vec{A} \times (\vec{B} \times \vec{C})$

C. $(\vec{A} \times \vec{B}) \times (\vec{C} \times \vec{D})$

**List-II**

1. $(\vec{A} \cdot \vec{C} \cdot \vec{D})\vec{B} - (\vec{B} \cdot \vec{C} \cdot \vec{D})\vec{A}$

2. $[(\vec{A} \cdot \vec{C})(\vec{B} \cdot \vec{D}) - (\vec{A} \cdot \vec{D})(\vec{B} \cdot \vec{C})]$

3. $(\vec{A} \cdot \vec{C})\vec{B} - (\vec{A} \cdot \vec{B})\vec{C}$

**Codes:**

| | A | B | C |
|---|---|---|---|
| (a) | 1 | 3 | 2 |
| (b) | 3 | 1 | 2 |
| (c) | 2 | 1 | 3 |
| (d) | 2 | 3 | 1 |

**Q.5** The vector differential operator, Del($\nabla$) in spherical co-ordinate system is given by

(a) $\nabla = \vec{a}_r \dfrac{\partial}{\partial r} + \vec{a}_\theta \dfrac{1}{r}\dfrac{\partial}{\partial \theta} + \vec{a}_\varphi \dfrac{1}{r\sin\theta}\dfrac{\partial}{\partial \varphi}$

(b) $\nabla = \vec{a}_r \dfrac{1}{r}\dfrac{\partial}{\partial r} + \vec{a}_\theta \dfrac{1}{r\sin\theta} + \vec{a}_\varphi \dfrac{\partial}{\partial \varphi}$

(c) $\nabla = \vec{a}_r \dfrac{\partial}{\partial r} + \vec{a}_\theta \dfrac{\partial}{\partial \theta} + \vec{a}_\varphi \dfrac{1}{r\cos\theta}\dfrac{\partial}{\partial \varphi}$

(d) $\nabla = \vec{a}_r \dfrac{1}{r}\dfrac{\partial}{\partial r} + \vec{a}_\theta \dfrac{1}{r}\dfrac{\partial}{\partial \theta} + \vec{a}_\varphi \dfrac{1}{r\cos\theta}\dfrac{\partial}{\partial \varphi}$

**Q.6** **Assertion (A):** Divergence of a vector function $\vec{A}$ at each point gives the rate per unit volume at which the physical entity is issuing from that point.

**Reason (R):** If some physical entity is generated or absorbed within a certain region of the field, then that region is known as source or sink respectively and if there are no sources or sinks in the field, the net outflow of the incompressible physical entity over any part of the region is zero. However, the net outflow is said to be positive, if the total strength of the sources are greater than the total strength of sink and vice-versa.

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

**Q.7** Which of the following identity is not true?

(a) $\vec{A}(\vec{B}\cdot\vec{C}) = (\vec{A}\cdot\vec{C})\vec{B} - (\vec{A}\cdot\vec{B})\vec{C}$
(b) $\nabla\cdot(\nabla\times\vec{A}) = 0$
(c) $\nabla\times\nabla\varphi \neq 0$
(d) None of the above

**Q.8** The vector $\vec{A}$ directed from (2, – 4, 1) to (0, –2, 0) in Cartesian coordinates is given by

(a) $-2\vec{a}_x + 2\vec{a}_y + \vec{a}_z$ (b) $-2\vec{a}_x + 2\vec{a}_y - \vec{a}_z$
(c) $-\vec{a}_x - 2\vec{a}_y + 2\vec{a}_z$ (d) $\vec{a}_x - 2\vec{a}_y - \vec{a}_z$

**Q.9** What is the value of $\int\int_s \vec{F}\cdot d\vec{s}$, where $\vec{F} = 4xz\vec{i}_1 - y^2\vec{i}_2 + yz\vec{i}_3$ ?
Here, $s$ is the surface bounded by $x = 0$, $x = 1$, $y = 0$, $y = 1$, $z = 0$, $z = 1$ and $\vec{i}_1, \vec{i}_2, \vec{i}_3$ are unit vectors along $x$, $y$ and $z$ axes respectively.

(a) 1/2 (b) 5/2
(c) 2 (d) 3/2

**Q.10** The vector field given by

$$\vec{A} = yz\vec{a}_x + xz\vec{a}_y + xy\vec{a}_z \text{ is}$$

(a) rotational and solenoidal
(b) rotational but not solenoidal
(c) irrotational and solenoidal
(d) irrotational but not solenoidal

**Q.11** If $\vec{A} = \dfrac{\vec{a}_x}{\sqrt{x^2+y^2}}$, then the value of $\nabla\cdot\vec{A}$ at (2, 2, 0) will be

(a) –0.0884 (b) 0.0264
(c) –0.0356 (d) 0.0542

**Q.12** If $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$, then the value of $\vec{i}\times(\vec{r}\times\vec{i}) + \vec{j}\times(\vec{r}\times\vec{j}) + \vec{k}\times(\vec{r}\times\vec{k})$ is

(a) $\vec{r}$ (b) $2\vec{r}$
(c) $3\vec{r}$ (d) $6\vec{r}$

**Q.13** What is the value of constant $b$ so that the vector

$$\vec{V} = (x+3y)\vec{i} + (y-2x)\vec{j} + (x+bz)\vec{k}$$

is solenoidal?

(a) 2 (b) –1
(c) 3 (d) –2

**Q.14** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

**List-I**

**A.** Gauss's divergence theorem
**B.** Stroke's theorem
**C.** The divergence
**D.** The curl

**List-II**

**1.** $\nabla\cdot\vec{A}$
**2.** $\oint_L \vec{A}\cdot d\vec{l} = \int\int_s (\nabla\times\vec{A})\cdot d\vec{s}$
**3.** $\int\int_s \vec{A}\cdot d\vec{s} = \int\int_s \vec{A}\cdot\vec{e}\,ds$ ($\vec{e}$ - An unit vector)
**4.** $\nabla\times\vec{A}$

**Codes:**

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

**Q.15** **Assertion (A):** Vector differential operator is a vector quantity and it signifies that certain operations of a differentiation are to be carried out on the scalar function following it.
**Reason (R):** Vector differential operator posses properties similar to ordinary vectors.

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

**Q.16** Consider the following statements:

1. Divergence of a vector function $\vec{A}$ at each point gives the rate per unit volume at which the physical entity is issuing from that point.
2. If a vector function $\phi$ represents temperature, then grad. $\phi$ or $\nabla\phi$ will represents rate of change of temperature with distance.
3. The curl of a vector function $A$ gives the measure of the angular velocity at every point of the vector field.

Which of the above statements is/are correct?

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

**Q.17** **Assertion (A):** The Gauss's divergence theorem permits us to express certain integrals by means of surface integrals.

**Reason (R):** Gauss's divergence theorem states that "the surface integral of the curl of a vector field taken over any surface $s$ is equal to the line integral of the vector field around the closed periphery (contour) of the surface.

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

**Q.18** Match **List-I (Physical quantities)** with **List-II (Dimensions)** and select the correct answer using the codes given below the lists:

| | List-I | | List-II |
|---|---|---|---|
| **A.** | Electric potential | **1.** | $MT^{-2}I^{-1}$ |
| **B.** | Magnetic flux | **2.** | $ML^2T^{-3}I^{-1}$ |
| **C.** | Magnetic field intensity | **3.** | $IL^{-1}$ |
| **D.** | Magnetic flux density | **4.** | $ML^2T^{-2}I^{-1}$ |

**Codes:**

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

**Q.19** Which of the following statements is not true regarding vector algebra?

(a) Dot product of like unit vector is unity.
(b) Dot product of unlike unit vector is zero.
(c) Cross product of two like unit vectors is a third unit vector having positive sign for normal rotation and negative for reverse rotation.
(d) All the above statements are true.

**Q.20** A rigid body is rotating with an angular velocity of $\omega$ where, $\vec{\omega} = \omega_x\vec{i} + \omega_y\vec{j} + \omega_z\vec{k}$ and $v$ is the line velocity. If $\vec{r}$ is the position vector given by $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$, then the value of curl $\vec{v}$ will be equal to

(a) $\frac{1}{2}\omega$ (b) $\omega$

(c) $\frac{1}{3}\omega$ (d) $2\omega$

**Q.21** If $\vec{r} = x\vec{I}_x + y\vec{I}_y + z\vec{I}_z$, then which of the following relation will hold true?

(a) $\nabla\vec{r} = 3$ (b) $\nabla\times\vec{r} = 0$
(c) Both (a) and (b) (d) Neither (a) nor (b)

**Q.22** If $\vec{E}$ is any vector field in cartesian co-ordinates system, then

(a) $\nabla.(\nabla\times\vec{E}) = \nabla\times\nabla\times\vec{E} - \nabla^2\vec{E}$

(b) Div. curl $\vec{E} = 0$

(c) $\nabla.(\nabla\times\vec{E}) = \nabla^2\vec{E} - \nabla\times\nabla\times\vec{E}$

(d) Div. curl $\vec{E} \neq 0$

**Q.23** If $\vec{c} = \vec{a}\times\vec{b}$ and $\vec{b} = \vec{a}\times\vec{c}$, then

(a) $\vec{b} = 0$ and $\vec{c} = 0$ (b) Only $\vec{b} = 0$
(c) Only $\vec{c} = 0$ (d) $\vec{b} \neq 0$ and $\vec{c} \neq 0$

**Q.24** If $S$ is any closed surface enclosing a volume $V$ and $\vec{A} = ax\vec{i} + by\vec{j} + cz\vec{k}$, then the value of $\iint_S \vec{A}\cdot\hat{n}d\vec{s}$ ($\hat{n}$ is a unit vector) will be equal to

(a) $\frac{1}{3}(a+b+c)V$ (b) $(a-b-c)V$

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

**Q.25** **Assertion (A):** The laplacian operator of a scalar function $\phi$ can be defined as "Gradient of the divergence of the scalar $\phi$".

**Reason (R):** Laplacian operator may be a "scalar laplacian" or a "vector laplacian" depending upon whether it is operated with a scalar function or a vector, respectively.

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

**Q.26** Match **List-I (Terms)** with **List-II (Type)** and select the correct answer using the codes given below the lists:

| List-I | List-II |
|---|---|
| A. Curl $(\vec{F}) = 0$ | 1. Laplace equation |
| B. Div $(\vec{F}) = 0$ | 2. Irrotational |
| C. Div grad $(\phi) = 0$ | 3. Solenoidal |
| D. Div div $(\phi) = 0$ | 4. Not defined |

**Codes:**

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

**Q.27** Which of the following relations are not correct?

(a) $[B \times C,\ C \times A,\ A \times B] = [ABC]^2$
(b) $A \times [B \times (C \times D)] = B \cdot D\,(A \times C) - B \cdot C\,(A \times D)$
(c) $(B \times C) \cdot (A \times D) + (C \times A) \cdot (B \times D) + (A \times B) \cdot (C \times D) = 0$
(d) $(A \times B)^2 = A^2B^2 - (A \cdot B)^2$

**Q.28** If $uF = \nabla v$, where $u$ and $v$ are scalar fields and $F$ is a vector field, then $F$. curl $F$ is equal to

(a) zero
(b) $\dfrac{\nabla^2 v}{u^2}$
(c) $\dfrac{(\nabla v \cdot \nabla)\, v}{u^2}$
(d) not defind

**Q.29** Which of the following option is not correct?

(a) A vector field $\vec{A}$ is solenoid, if $\nabla \cdot \vec{A} = 0$
(b) A vector field $\vec{A}$ is irrotational, if $\nabla \times \vec{A} = 0$
(c) A vector field $V$ is harmonics, if $\nabla^2 V \neq 0$
(d) All options are correct

**Q.30** Which of the following statements is not true of a phasor?

(a) It may be a scalar or a vector.
(b) It is a time dependent quantity.
(c) It is a complex quantity.
(d) All are true

**Q.31** A scalar function, $V$ is given by $V = xyz^2$. The gradient of $V$ is given by

(a) $xz^2\hat{a}_x + 2xyz\,\hat{a}_y + xz^2\,\hat{a}_z$
(b) $yz^2\hat{a}_x + xz^2\hat{a}_y + xyz\,\hat{a}_z$
(c) $2xyz\,\hat{a}_z + yz^2\hat{a}_y + xz^2\hat{a}_z$
(d) $yz^2\hat{a}_x + xz^2\hat{a}_y + 2xyz\,\hat{a}_z$

**Q.32** The scalar potential is given by

$$V = (x^2 - y^2 - z^2) \text{ Volts}$$

The laplacian of $V$ is

(a) 0
(b) –2
(c) 1
(d) –1

## 2. Electrostatics

**Q.33** What is the ratio of electrostatic repulsion and gravitational attraction between two electrons? Given:

$Q$ = Charge on an electron = $1.6 \times 10^{-19}$C
$G$ = Gravitation constant = $6.67 \times 10^{-11}$ Nm$^2$/kg$^2$
$m$ = Mass of an electron = $9.1 \times 10^{-31}$ kg

(a) $3.23 \times 10^{42}$
(b) $4.17 \times 10^{42}$
(c) $2.33 \times 10^{42}$
(d) $1.47 \times 10^{42}$

**Q.34** What is the electric field strength at a distance of 200 mm from a charge of $2 \times 10^{-6}$ Coulomb in vacuum?

(a) 450 kV/m
(b) 236 kV/m
(c) 525 kV/m
(d) 328 kV/m

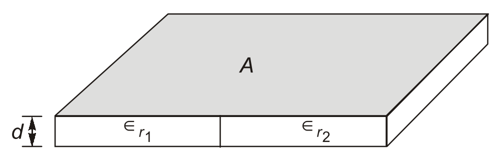
**Q.35** Two point charges of $3 \times 10^{-9}$ C and $-2 \times 10^{-9}$ C are spaced two meters apart. What is the electric field at a point which is one meter from each of the two point charges?

(a) 11 V/m
(b) 5 V/m
(c) 9 V/m
(d) 6 V/m

**Q.36** Five equal point charges of $Q = 20 \times 10^{-9}$ C, are placed at $x$ = 2,3,4,5 and 6 cm. The electric potential at origin will be

(a) 416 V
(b) 128 V
(c) 325 V
(d) 261 V

**Q.37** What is the equivalent capacitance of a parallel plate capacitor having two dielectrics, $\epsilon_{r1} = 1.5$ and $\epsilon_{r2} = 3.5$, each comprising one-half the volume as shown in figure below with $A = 2$ m$^2$ and $d = 1$ mm?




(a) 44.27 nF (b) 24.47 nF
(c) 27.44 nF (d) 42.47 nF

**Q.38** Four point charges 1, –2, –3 and 4 μC are located on the $x$-axis at $x$ = 1, 2, 3 and 4 metre respectively. The energy stored in the field is
(a) –2 Joule (b) 4 Joule
(c) 0 Joule (d) –1 Joule

**Q.39** The electric field strength at a point in front of an infinite sheet of charge is
(a) independent of the distance of the point from the sheet
(b) inversely proportional to the distance of the point from the sheet
(c) inversely proportional to the square of distance of the point from the sheet
(d) none of the above

**Q.40** **Assertion (A):** If all the points in space which have the same potential are jointed, then equipotential surfaces are obtained.
**Reason (R):** The field and the equipotential surfaces are orthogonal to each other.
(a) Both A and R are true and R is a correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**Q.41** Consider the following statements associated with various medias encountered in electostatics:
1. An isotropic media is one whose properties are independent of direction
2. A homogeneous media is one whose physical characteristics vary from point-to-point.
3. A non-homogenous media is one whose physical characteristics do not vary from point-to-point.
4. A linear media is a one in which the electric flux density is proportional to the electric field intensity.

Which of the above statements are correct?
(a) 2 and 3 (b) 3 and 4
(c) 1, 2 and 4 (d) 1 and 4

**Q.42** **Assertion (A):** Continuity of current equation is derived from law of conservation of charge.
**Reason (R):** Continuity of current equation states that there can be no accumulation of charge at any point.
(a) Both A and R are true and R is a correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**Q.43** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

| List-I | List-II |
|---|---|
| A. Joule's law | 1. $\vec{J} = \sigma\vec{E}$ |
| B. Ohm's law | 2. $\nabla \cdot \vec{J} = \frac{\partial \rho}{\partial t}$ |
| C. Solenoidal current | 3. $W = I^2Rt$ |
| D. Continuity equation | 4. $\int\int_s \vec{J}d\vec{s} = 0$ |

**Codes:**

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

**Q.44** **Assertion (A):** An electric field produces no migration of charge in a dielectric.
**Reason (R):** The permittivity of a dielectric is always less than the permittivity of vaccum.
(a) Both A and R are true and R is a correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**Q.45** Which one of the following pairs is NOT correctly matched?

(a) Gauss theorem: $\oint_s \vec{D} \cdot d\vec{s} = \oint_s \nabla \cdot \vec{D}\, dV$

(b) Gauss's law: $\oint \vec{D} \cdot d\vec{s} = \int \rho\, dV$

(c) Coulomb's law: $V = -\dfrac{d\phi_m}{dt}$

(d) Stoke's theorem: $\oint_L \vec{E} \cdot d\vec{l} = \int\int_s (\nabla \times \vec{E}) \cdot d\vec{s}$

**Q.46** Match **List-I (Law/Quantity)** with **List-II (Mathematical expression)** and select the correct answer using the codes given below the lists:

| List-I | List-II |
|---|---|
| A. Gauss's law | 1. $\nabla \cdot \vec{D} = \rho$ |
| B. Ampere's law | 2. $\nabla \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$ |
| C. Faraday's law | 3. $s = \vec{E} \times \vec{H}$ |
| D. Poynting vector | 4. $\vec{F} = q(\vec{E} \times \vec{v}\vec{B})$ |
| | 5. $\nabla \times \vec{H} = \vec{J}_c + \dfrac{\partial \vec{D}}{\partial t}$ |

**Codes:**

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 1 | 2 | 4 | 3 |
| (b) | 3 | 5 | 2 | 1 |
| (c) | 1 | 5 | 2 | 3 |
| (d) | 3 | 2 | 4 | 1 |

**Q.47** What is the value of total electric flux coming out of a closed surface?

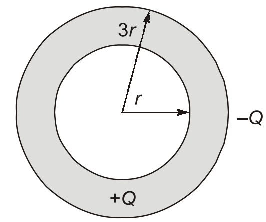
(a) Zero
(b) Equal to volume charge density
(c) Equal to the total charge enclosed by the surface
(d) Equal to the surface charge density

**Q.48** Which one of the following is the Poisson's equation for a linear and isotropic but in homogeneous medium?

(a) $\nabla^2 \nabla = -\rho/\in$ (b) $\vec{\nabla} \cdot (\in \vec{\nabla} V) = -\rho$

(c) $\vec{\nabla} \cdot \vec{\nabla}(\in V) = -\rho$ (d) $\nabla^2 V = -\rho/\in$

**Q.49** Two concentric spherical shells carry equal and opposite uniformly distributed charges over their surfaces as shown in figure below.




Electric field on the surface of inner shell will be

(a) zero (b) $\dfrac{Q}{4\pi\epsilon_0 r^2}$

(c) $\dfrac{Q}{8\pi\epsilon_0 r^2}$ (d) $\dfrac{Q}{16\pi\epsilon_0 R^2}$

**Q.50** Electric field intensity due to line charge of infinite length is

(a) $\dfrac{\rho_L}{2\pi\in r}$ (b) $\dfrac{\rho_L}{4\pi\in r}$

(c) $\dfrac{\rho_L}{\pi\in r}$ (d) $\dfrac{2\rho_L}{\pi\in r}$

**Q.51** Consider the following statements associated with equipotential surface:

1. Potential is same everywhere.
2. No current flows on this surface.
3. Work done in moving charge from one point to another is zero.
4. Potential is different everywhere.

Which of the above statements is/are not correct?

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

**Q.52** A finite sheet $0 \leq x \leq 1$, $0\ y \leq 1$ on the $z = 0$ plane has a charge density

$\rho_s = xy\,(x^2 + y^2 + 25)^{3/2}$ nC/m$^2$

The total charge on the sheet would be

(a) $\left(\dfrac{(25)^{7/2} - (27)^{7/2} - 2(26)^{7/2}}{25}\right)$ nC

(b) $\left(\dfrac{(26)^{7/2} - 2(25)^{7/2} + (27)^{7/2}}{35}\right)$ nC

(c) $\left(\dfrac{(26)^{7/2} - (27)^{7/2} + 2(25)^{7/2}}{25}\right)$ nC

(d) $\left(\dfrac{(27)^{7/2} + (25)^{7/2} - 2(26)^{7/2}}{35}\right)$ nC

**Q.53** **Assertion (A):** Gauss's law is an alternative statement of Coulomb's law.

**Reason (R):** Proper application of the divergence theorem to Coulomb's law results in Gauss's law.

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

**Q.54** If the potential $V = \frac{10}{r^2}\sin\theta\cos\phi$, then the work done in moving a 10 $\mu$C charge from point $A(1, 30°, 120°)$ to $B(4, 90°, 60°)$ would be equal to

(a) 16.65 $\mu$J (b) 28.125 $\mu$J
(c) 25.25 $\mu$J (d) 30.625 $\mu$J

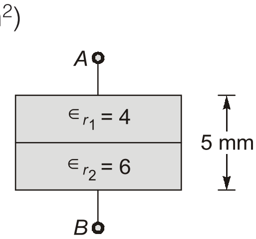
**Q.55** Three point charges –1 nC, 4 nC and 3 nC are located at (0, 0, 0) , (0,0,1) and (1,0,0,) respectively. To total energy contained in the system would be

(a) 22.25 nJ (b) 15.56 nJ
(c) 12.84 nJ (d) 13.37 nJ

**Q.56** A wire of diameter 1 mm and conductivity $5 \times 10^7$ S/m has $10^{29}$ free electrons /m$^3$ when an electric field of 10 mV/m is applied.
The current density and the drift velocity of the electrons will be respectively given by (take charge on an electrons $e = -1.6 \times 10^{-19}$ C)

(a) 500 kA/m$^2$ and $3.125 \times 10^{-5}$ m/s
(b) 300 kA/m$^2$ and $2.225 \times 10^{-5}$ m/s
(c) 500 kA/m$^2$ and $2.225 \times 10^{-5}$ m/s
(d) 300 kA/m$^2$ and $3.125 \times 10^{-5}$ m/s

**Q.57** The equivalent capacitance between the terminals *A* and *B* for the capacitor shown below would be (the area occupied by each dielectric is 30 cm$^2$)




(a) 26.53 pF (b) 28.68 pF
(c) 25.46 pF (d) 22.22 pF

**Q.58** The cylindrical coordinates equation

$$\frac{\partial^2\psi}{\partial\rho^2} + \frac{1}{\rho}\frac{\partial\psi}{\partial\rho} + \frac{\partial^2\psi}{\partial z^2} + 10 = 0 \text{ is called}$$

(a) Laplace's equation
(b) Poisson's equation
(c) Larentz's equation
(d) Maxwell's equation

**Q.59** Image theory is applicable to problems involving

(a) electrostatic field only
(b) magnetostatic fields only
(c) both electrostatic and magnetostatic fields
(d) neither electrostatic nor magnetostatic fields

**Q.60** The potential field at any point in space containing a dielectric material of relative permittivity 3 is given by
$V = (5x^2y + 3yz^2 + 6xz)$ Volts, where $x$, $y$, $z$ are in meters. The magnetude of volume charge density at point (1, 2, 3) will be given by

(a) $48\epsilon_0$ (b) $96\epsilon_0$
(c) $144\epsilon_0$ (d) $192\epsilon_0$

**Q.61** If $\vec{A}$ and $\vec{J}$ are the vector potential and current density vectors associated with a coil, then $\int_V \vec{A}\cdot\vec{J}\,dV$ has the unit of

(a) flux-linkage (b) power
(c) energy (d) inductance

**Q.62** In the infinite plane, $y$ = 6 m, there exists a uniform surface charge density of (1/600$\pi$) $\mu$C/m$^2$. The associated electric field strength is

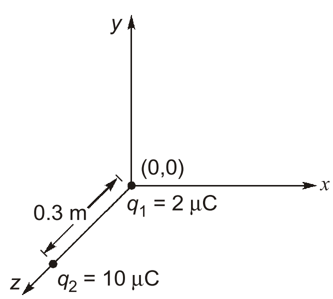
(a) $30\hat{i}$ V/m (b) $30\hat{j}$ V/m
(c) $30\hat{k}$ V/m (d) $60\hat{i}$ V/m

**Q.63** Consider the following statements:

1. Electric field intensity at any point is the negative of the potential gradient at that point.
2. Electric field due to a finite line of charge at a point is independent of the length of the line of charge.
3. The direction of the electric field is the direction in which the gradient is greatest.
4. Electric field due to an infinite line of charge at a point is inversely proportional to square of the distance of the point from the infinite line charge.

Which of the above statements is/are correct?
(a) 2, 3 and 4 only (b) 1, 2 and 4 only
(c) 3 only (d) 1 and 3 only

**Q.64** A positive charge of magnitude 2 μC is situated in air at the origin of a rectangular co-ordinate system and a second positive charge of magnitude 10 μC is situated on the positive *z*-axis at a separation of 0.30 meter from the origin as shown below.

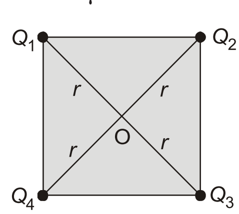



The force on the second charge is
(a) 2 N (b) 4 N
(c) 6 N (d) $\frac{1}{2}$ N

**Q.65** What is the flux crossing a 1 $m^2$ area that is normal to the $x$-axis at $x = 3$ m?

(Given, $\vec{D} = 10x\,\vec{a}_x$ C/$m^2$)
(a) 15 Coulombs (b) 20 Coulombs
(c) 25 Coulombs (d) 30 Coulombs

**Q.66** What is the value of electric potential at the centre of a square as shown below whose sides are equal to 1.0 meter and charges $Q_1$, $Q_2$, $Q_3$ and $Q_4$ are respectively + 0.01 μF, –0.02 μF, +0.03 μF and +0.02 μF?




(a) 426.8 V (b) 509.2 V
(c) 625.6 V (d) None of these

**Q.67** Conservative properties are applicable only to
(a) electrostatic field
(b) time varying electric field
(c) time varying magnetic field
(d) time varying electric and magnetic field

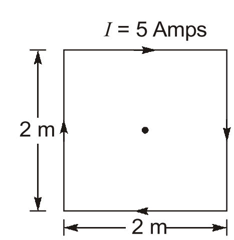
**Q.68** The resultant potential at a distance *r* from the electric dipole is
(a) inversely proportional to length of the dipole.
(b) directly proportional to dipole moment.
(c) inversely proportional to square of the distance *r*.
(d) both (b) and (c)

**Q.69** **Assertion (A)** Total electric flux out of a closed surface is equal to the net charge within that surface.
**Reason (R):** Gauss's law states that the total displacement or electric flux through any closed surfaces surrounding the charge is equal to the amount of charge enclosed.
(a) Both A and R are true and R is a correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

## 3. Magnetostatics

**Q.70** The magnitude of H at a radius of 1 meter from a long linear conductor is 1 A/m. The current in the wire is
(a) 2π Ampere (b) $\frac{\pi}{2}$ Ampere
(c) 4π Ampere (d) $\frac{\pi}{4}$ Ampere

**Q.71** What is the value of magnetic flux density at the centre of the square current loop shown in figure below?




(a) 1.25 mW/$m^2$ (b) 2.26 μWb/$m^2$
(c) 2.82 μWb/$m^2$ (d) 3.43 μWb/$m^2$

**Q.72** A solenoid of 20 cm long and 1 cm diameter has a uniform winding of 1000 turns. If the solenoid is placed in a uniform field of 2 Wb/$m^2$ flux density and a current of 10 amps. is passed through the solenoid winding, then the maximum torque on the solenoid will be

(a) 10 N-m (b) 20 N-m
(c) 30 N-m (d) 60 N-m

**Q.73** What is the value of magnetic flux density at the centre of a current carrying loop when the loop radius is 2 cm, loop current is 1 mA and the loop is placed in air?
(a) 1 μWb (b) 0.1 μWb
(c) 10 μWb (d) 0.01 μWb

**Q.74** A magnetic field known to be directed in a cartesian co-ordinate system so that $\vec{H}$ exists in the x-direction where $H_x$ = Constant. The value of curl $\vec{H}$ is
(a) 0 (b) –1
(c) +1 (d) none of these

**Q.75** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

**List-I**
**A.** Faraday's induction law
**B.** Maxwell equation in point form
**C.** Electric field strength general equation

**List-II**

1. $\nabla \times \vec{E}_e = -\dfrac{\partial \vec{B}}{\partial t}$
2. $\oint E_e . d\vec{l} = -\dfrac{d}{dt}\iint_s \vec{B} d\vec{s}$
3. $\vec{E} = -\nabla V - \dfrac{\partial \vec{A}}{\partial t}$
4. $\vec{E} = -\nabla V + \dfrac{\partial \vec{A}}{\partial t}$

**Codes:**

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

**Q.76** The force acting between two parallel wires carrying currents $I_1$ and $I_2$ and separated by a distance $r$ is given by
(a) $\dfrac{\mu}{2\pi}\dfrac{I_1 I_2}{r^2}$ (b) $\dfrac{\mu}{4\pi}\dfrac{I_1 I_2}{r}$
(c) $\dfrac{\mu}{2\pi}\dfrac{I_1 I_2}{r}$ (d) $\dfrac{\mu}{4\pi}\dfrac{I_1 I_2}{r^2}$

**Q.77** Flux lines are received at an iron-air boundary at an angle of 45° from the normal on the iron side of the boundary. If the iron has a relative permeability of 350, then the angle from the normal with which the flux emerges into the air would be
(a) 0 degree (b) $\tan^{-1}\left(\dfrac{1}{350}\right)$ degree
(c) 45 degree (d) $\tan^{-1}(350)$ degree

**Q.78** The unit of magnetic flux is given by
(a) $ML^2 T^{-2} I^{-1}$ (b) $ML^2 T^{-3} I^{-2}$
(c) $ML^2 T^{-1} I^{-1}$ (d) $ML^2 T^{-2} I^{-2}$

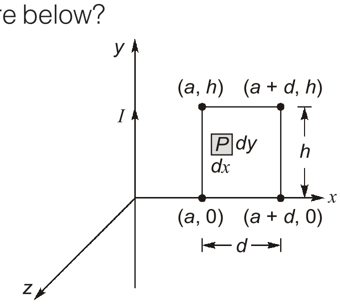
**Q.79** **Assertion (A):** The potential in case of magnetic field is a vector potential.
**Reason (R):** The potential in case of electric field is a scalar potential
(a) Both A and R are true and R is a correct explanation of A.
(b) Both A and R are true but R is not a correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

**Q.80** A circular conductor of 1 cm radius has an internal magnetic field

$$H = \frac{1}{r}\left(\frac{1}{a^2}\sin ar - \frac{r}{a}\cos ar\right)\vec{i}_\phi \text{ mA/m}$$

where $a = \dfrac{\pi}{2r_0}$, $r_0$ is the radius of the conductor and $\vec{a}_\phi$ is the unit vector. The total current in the conductor is given by
(a) 0.15 μA (b) 0.50 μA
(c) 0.25 μA (d) 0.75 μA

**Q.81** What is the value of mutual inductance between an infinitely long straight conductor along the $y$-axis and a rectangular single turn coil situated in $x$-$y$ plane with its corners located at point ($a$, 0), ($a$ + $d$, 0), ($a$, $h$) and ($a$ + $d$, $h$) as shown in figure below?



(a) $\frac{\mu h}{4\pi} ln\left(\frac{a+h}{a}\right)$ (b) $\frac{\mu h}{2\pi} ln\left(\frac{a}{a+h}\right)$

(c) $\frac{\mu h}{4\pi} ln\left(\frac{a}{a+h}\right)$ (d) $\frac{\mu h}{2\pi} ln\left(\frac{a+h}{a}\right)$

**Q.82** **Assertion (A):** The force acting between two parallel wires carrying currents is directly proportional to the individual currents and inversely proportional to the square of the distance between them.

**Reason (R):** The force is repulsive if the two currents $I_1$ and $I_2$ are in the same directions and attractive if in opposite directions.

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

**Q.83** The energy stored in a magnetic field is given by

(a) $\frac{H^2}{2\mu}$ (b) $\frac{\mu H^2}{2}$

(c) $\frac{\mu H}{2}$ (d) none of these

**Q.84** Lorentz force law is

(a) $\vec{F} = \vec{v} \times \vec{B}$ (b) $\vec{F} = Q(\vec{E} + \vec{v} \times \vec{B})$

(c) $\vec{F} = Q(\vec{v} \times \vec{B})$ (d) $\vec{F} = Q\vec{E}$

**Q.85** The equation $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ is the generalization of

(a) Faraday's law (b) Biot-Savart's law
(c) Gauss's law (d) Ampere's law

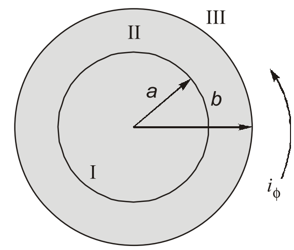
**Q.86** The unit of relative permeability is

(a) meter/Henry (b) Henry
(c) Henry/meter (d) it is dimensionless

**Q.87** Consider the volume current density distribution in cylindrical co-ordinates as

$$J(r, \phi, z) = 0,\ 0 < r < a$$
$$= J_0\left(\frac{r}{a}\right)\vec{i}_z,\ a < r < b$$
$$= 0,\ b < r < \infty$$

Where $a$ and $b$ are inner and outer radii of the cylinder as shown in figure below.




Now, consider the value of magnetic field intensity in various regions I, II and III respectively obtained as:

1. $\vec{H} = 0$ for region-I $(0 < r < a)$.
2. $\vec{H} = \frac{J_0}{3ar}(r^2 - a^3)\hat{i}_\phi$ for region-II $(a < r < b)$.
3. $\vec{H} = 0$ for region-III $(b < r < \infty)$.

Which of the above found values of $H$ are correct for the respective regions?

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

**Q.88** **Assertion (A):** It is not possible to have isolated magnetic charges.

**Reason (R):** The magnetic flux lines always close upon themselves.

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

**Q.89** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

**List-I**

**A.** Gauss's law for magnetostatic fields
**B.** Gauss's law for electrostatic fields
**C.** Conservativeness of electrostatic fields
**D.** Ampere's law

**List-II**

**1.** $\nabla \cdot V = \rho_v$
**2.** $\oint B \cdot ds = Q$
**3.** $\oint B \cdot ds = 0$
**4.** $\oint_L E \cdot dl = 0$
**5.** $\oint H \cdot dl = \int_s J \cdot ds$

Codes:

| | A | B | C | D |
|---|---|---|---|---|
| (a) | 5 | 4 | 1 | 2 |
| (b) | 3 | 1 | 4 | 5 |
| (c) | 3 | 4 | 1 | 5 |
| (d) | 5 | 1 | 4 | 2 |

**Q.90** The magnetic vector potential is given by

$$A = \frac{-\rho^2}{4} a_z \text{ Wb/m}$$

The total magnetic flux crossing the surface

$\phi = \frac{\pi}{2}, 1 \le \rho \le 2$ m, $0 \le z \le 5$ m is

(a) 3.75 Wb (b) 2.25 Wb
(c) 6.25 Wb (d) 1.75 Wb

**Q.91** Which of the following is not a source of magnetostatic fields?
(a) An electric field linearly changing with time
(b) An accelerated charge
(c) A permanent magnet
(d) Both (a) and (b)

**Q.92** Consider the following statements associated with the characteristics of static magnetic field:
1. It is solenoidal.
2. Magnetic flux lines are not closed in certain cases.
3. The total number of flux lines entering a given region is equal to the total number of flux lines leaving the region.
4. It is conservative.

Which of the above statements is/are not correct?
(a) 2 only (b) 1 and 4 only
(c) 2 and 4 only (d) 1, 2 and 3 only

**Q.93** What are the units for the product of two values whose respective units are Henrys and Amperes?
(a) $\Omega$/s (b) V-s
(c) $A^2$/s (d) $\Omega$-V

**Q.94** What are the possible dimensions for a rectangular coil that has a magnetic flux of 9.5 webers when in a magnetic field of strength 19 Tesla at an angle of 60° from the perpendicular to the plane of the coil?
(a) 360 cm × 30 cm (b) 1000 cm × 100 cm
(c) 80 cm × 70 cm (d) 250 cm × 40 cm

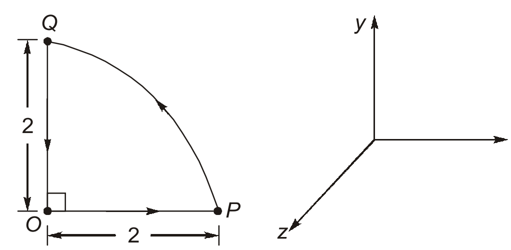
**Q.95** What is the change in magnetic flux in a coil of area 5 $m^2$ as its orientation relative to the perpendicular of a uniform 3.0 T magnetic field changes from 45° to 90°?
(a) –11 Wb (b) 7.5 Wb
(c) 0 Wb (d) 11 Wb

**Q.96** If a vector field $\vec{B}$ is solenoidal, which of these is true?

(a) $\oint_L \vec{B} \cdot d\vec{l} = 0$ (b) $\oint_s \vec{B} \cdot d\vec{s} = 0$

(c) $\nabla \times \vec{B} = 0$ (d) $\nabla \cdot \vec{B} = 0$

**Q.97** If $\vec{A} = \hat{a}_\rho + \hat{a}_\phi + \hat{a}_z$, the value of $\oint \vec{A} \cdot d\vec{l}$ around the closed circular quadrant shown in the given figure is

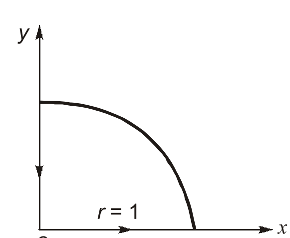



(a) $\pi$ (b) $\frac{\pi}{2} + 4$

(c) $\pi + 4$ (d) $\frac{\pi}{2} + 2$

**Q.98** The Maxwell's equation, $\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$ is based on
(a) Gauss's law (b) Ampere's law
(c) Faraday's law (d) Coulomb's law

**Q.99** Given a vector field $\vec{A} = 2r\cos\phi \hat{a}_r$ in cylindrical coordinates. For the contour as shown below, $\oint \vec{A} \cdot d\vec{l}$ is



(a) 1 (b) $1-\frac{\pi}{2}$

(c) $1+\frac{\pi}{2}$ (d) −1

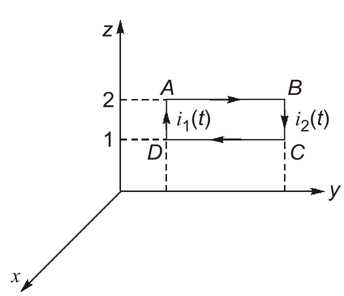
**Q.100** Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

| List-I | List-II |
|---|---|
| A. Continuity equation | 1. $\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$ |
| B. Ampere's law | 2. $\vec{J} = \frac{\partial \vec{D}}{\partial t}$ |
| C. Displacement current | 3. $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ |
| D. Faraday's law | 4. $\nabla \times \vec{J} = -\frac{\partial \rho_v}{\partial t}$ |

Codes:

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

**Q.101** In the given diagram, if $\phi$ = 90°, and $I_0$ = 2 A, then the total force acting on the coil will be ($i_1(t) = I_0 \cos\omega t$ and $i_2(t) = I_0 \sin(\omega t + \phi)$)




(a) $\frac{\mu_0}{\pi}\cos^2 \omega t$ (b) $\frac{\mu_0}{3\pi}\cos^2 \omega t$

(c) $\frac{4}{3\pi}\mu_0 \cos^2 \omega t$ (d) zero

**Q.102** What is the value of magnetomotive force generated by a multilayer coil of 100 turns of fine wire carrying a current of 100 mA?

(a) 10 AT (b) 20 AT
(c) 5 AT (d) none of these

**Q.103** The unit of $\nabla \times \vec{H}$ is

(a) Ampere (b) Ampere/meter
(c) Ampere/meter$^2$ (d) Ampere-meter

**Q.104** At any surface of discontinuity the following statements in respect of electric and magnetic fields may be stated:

1. The tangential component of $\vec{E}$ is continuous at the surface i.e. it is the same just inside the surface as just outside the surface.
2. The tangential component of $\vec{H}$ is continuous across a surface except at the surface of a perfect conductor.
3. The normal component of $\vec{B}$ is continuous at the surface of discontinuity.
4. The normal component of $\vec{D}$ is continuous if there is no surface charge density $\rho_s$, otherwise $\vec{D}$ is discontinuous by an amount equal to the surface charge density.

Which of the above statements are correct?

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

## 4. Time Varying EMT Fields

**Q.105** If the magnetic field vector $\vec{H}$ has only $\vec{a}_z$ component given by $H_z = 3x \cos\beta + 6y \sin\gamma$ and if the field is invariant with time, what is the expression for current density $\vec{J}$?

(a) $(3\cos\beta)\,\vec{a}_x + (6\sin\gamma)\,\vec{a}_y$
(b) $(6\sin\gamma)\,\vec{a}_x - (3\cos\beta)\,\vec{a}_y$
(c) $(6\cos\beta)\,\vec{a}_x + (3\sin\gamma)\,\vec{a}_y$
(d) $(3\sin\gamma)\,\vec{a}_x - (6\cos\beta)\,\vec{a}_y$

**Q.106** The conduction current in a straight copper wire of cross-sectional area A = 1.5 × $10^{-5}$ m$^2$ is $I$ = 2 A. If the constitutive parameters of copper are $\mu = \mu_0 = 4\pi \times 10^{-7}$ H/m, $\varepsilon = \varepsilon_0 = \frac{10^{-9}}{36\pi}$ F/m and $\sigma = 5.8 \times 10^7$ mho/m, then the displacement current $I_d$ in the wire at a frequency of $f$ = 1 GHz would be

(a) 1.9 nA (b) 1.0 nA
(c) 2.8 nA (d) 3.0 nA

**Q.107** A rectangular loop of length $a$ = 1 meter and width $b$ = 80 cm is placed in a uniform magnetic field. What is the maximum value of induced emf if the magnetic flux density $B$ = 0.1 Wb/m$^2$

is constant and the loop rotates about the $x$-axis with a frequency of 50 Hz?

(a) 32.65 volts (b) 18.54 volts
(c) 28 volts (d) 25.13 volts

**Q.108** A straight conducting wire of length 50 cm is moved in a direction at right angles to its length in a region in air permitted by a uniform flux density $B$ of magnitude $B$ = 1 Wb/m$^2$. If the magnetic flux density $\vec{B}$ is perpendicular to both the direction of the motion and the length of the wire and the magnitude of the velocity of motion $v$ = 10 m/s, the induced voltage in the conductor would be

(a) 2.5 V (b) 10 V
(c) 5 volt (d) 1.5 V

**Q.109** A Faraday disc of 10 cm radius rotates at 5000 rpm in a uniform magnetic field of 250 mWb/m$^2$, the field being normal to the plane of the disc. What is the emf between rpm and axis assuming the diameter of the axis very small?

(a) 0.35 volt (b) 0.65 volt
(c) 0.45 volt (d) 0.55 volt

**Q.110** What is the emf developed about the path $r$ = 0.5, $z$ = 0 and at $t$ = 0, if $\vec{B} = 0.1 \sin 377t\ \hat{a}_x$?

(a) 4.7 volt (b) 3.8 volt
(c) 2.2 volt (d) 1.6 volt

**Q.111** A square loop of wire 25 cm has a voltmeter (of infinite impedance) connected in series with one side. The plane of the loop is perpendicular to the magnetic field and the frequency is 10 MHz. If the maximum intensity is 1 Amp/m, then the voltage indicated by the meter when the loop is placed in the alternating field would be

(a) 3.6 volt (b) 2.8 volt
(c) 4.9 volt (d) none of these

**Q.112** **Assertion (A):** The total e.m.f. induced in a circuit is equal to the time rate of decrease of the total magnetic flux linking the circuit.

**Reason (R):** Changing magnetic field will induce on electric field.

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

**Q.113** **Assertion (A):** Motional induction or flux cutting law gives the e.m.f. induced in a moving conductor w.r.t. observer in a magnetic field.

**Reason (R):** The motional emf equation depends on the velocity of the conductor and its position.

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

**Q.114** In a material for which conductivity $\sigma$ = 5 Siemen/m and $\epsilon_r$ = 1, the electric field intensity is $E$ = 250 sin $10^{10}$ $t$ V/m. What is the frequency at which the displacement and conduction current densities will be equal?

(a) 60 GHz (b) 90 MHz
(c) 60 MHz (d) 90 GHz

**Q.115** Consider the following statements:

1. Electric charge at rest produces an electrostatic field.
2. Electric charge in motion produces a magnetic field.
3. Electric and magnetic fields are fundamentally fields of force which originate from electric charges.
4. Faraday's induction law is given by

$$V = \oint \vec{E}_e \cdot d\vec{l} = \frac{-d}{dt} \iint_s \vec{B} \cdot ds$$

Which of the above statements are correct?

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

**Q.116** A circular coil begins completely outside any magnetic field, and then during the next 10 sec. it moves completely into a uniform 15 $T$ magnetic field. Assuming that the plane of the loop and the direction of motion are both perpendicular to the magnetic field, the magnitude of induced emf in the coil with 25 loops and radius of 7 cm is

(a) 0 volt (b) 0.58 volt
(c) 1.2 volt (d) 0.23 volt

## Answers Electromagnetic Theory

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. (c) | 2. (b) | 3. (a) | 4. (d) | 5. (a) | 6. (a) | 7. (c) | 8. (b) |
| 9. (d) | 10. (c) | 11. (a) | 12. (b) | 13. (d) | 14. (c) | 15. (d) | 16. (b) |
| 17. (c) | 18. (a) | 19. (c) | 20. (d) | 21. (c) | 22. (b) | 23. (a) | 24. (d) |
| 25. (d) | 26. (a) | 27. (d) | 28. (a) | 29. (c) | 30. (a) | 31. (d) | 32. (b) |
| 33. (b) | 34. (a) | 35. (c) | 36. (d) | 37. (a) | 38. (c) | 39. (a) | 40. (b) |
| 41. (d) | 42. (a) | 43. (c) | 44. (c) | 45. (c) | 46. (c) | 47. (c) | 48. (b) |
| 49. (a) | 50. (a) | 51. (c) | 52. (d) | 53. (a) | 54. (b) | 55. (d) | 56. (a) |
| 57. (c) | 58. (b) | 59. (a) | 60. (b) | 61. (c) | 62. (b) | 63. (d) | 64. (a) |
| 65. (d) | 66. (b) | 67. (a) | 68. (d) | 69. (a) | 70. (a) | 71. (c) | 72. (b) |
| 73. (d) | 74. (a) | 75. (d) | 76. (d) | 77. (b) | 78. (a) | 79. (b) | 80. (c) |
| 81. (d) | 82. (c) | 83. (b) | 84. (b) | 85. (a) | 86. (d) | 87. (c) | 88. (a) |
| 89. (b) | 90. (a) | 91. (b) | 92. (c) | 93. (b) | 94. (d) | 95. (a) | 96. (b) |
| 97. (a) | 98. (b) | 99. (a) | 100. (b) | 101. (c) | 102. (a) | 103. (c) | 104. (b) |
| 105. (b) | 106. (a) | 107. (d) | 108. (c) | 109. (b) | 110. (a) | 111. (c) | 112. (b) |
| 113. (c) | 114. (d) | 115. (a) | 116. (b) | 117. (c) | 118. (d) | 119. (a) | 120. (a) |
| 121. (b) | 122. (a) | 123. (a) | 124. (c) | 125. (b) | 126. (d) | 127. (c) | 128. (d) |
| 129. (a) | 130. (c) | 131. (a) | 132. (c) | 133. (a) | 134. (b) | 135. (d) | 136. (b) |
| 137. (a) | 138. (c) | 139. (d) | 140. (a) | 141. (c) | 142. (b) | 143. (d) | 144. (a) |
| 145. (c) | 146. (b) | 147. (d) | 148. (c) | 149. (c) | 150. (b) | 151. (c) | 152. (d) |
| 153. (a) | 154. (d) | 155. (c) | 156. (c) | 157. (a) | 158. (b) | 159. (d) | 160. (c) |
| 161. (c) | 162. (b) | 163. (b) | 164. (a) | 165. (b) | 166. (b) | 167. (a) | 168. (c) |
| 169. (d) | 170. (b) | 171. (b) | 172. (a) | 173. (d) | 174. (d) | 175. (b) | 176. (b) |
| 177. (c) | 178. (a) | 179. (c) | 180. (c) | 181. (b) | 182. (d) | 183. (a) | 184. (b) |
| 185. (c) | 186. (a) | 187. (d) | 188. (a) | 189. (a) | 190. (b) | 191. (a) | 192. (c) |
| 193. (d) | 194. (c) | 195. (a) | 196. (b) | 197. (a) | 198. (d) | 199. (a) | 200. (a) |
| 201. (c) | 202. (b) | 203. (c) | 204. (c) | 205. (b) | 206. (b) | 207. (d) | |

## Explanations

**1. (c)**

Here, Div. $\vec{Q} = \nabla \cdot \vec{Q} = \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial y}\right) \cdot (\vec{i}\, zx)$

$$= (\vec{i} \cdot \vec{i})\left(\frac{\partial}{\partial x} \cdot zx\right) = 1 \cdot z = z$$

Also, Grad $\phi = \nabla\phi = \left(\frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j} + \frac{\partial}{\partial z}\vec{k}\right)(xy^2z^3) = (y^2z^3\,\vec{i} + 2yxz^3\,\vec{j} + 3z^2y^2x\vec{k})$

And, Curl $\vec{P} = \nabla \times \vec{P} = \begin{vmatrix} \vec{i} & 0 & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x^2y & 0 & (x-y) \end{vmatrix}$

$$= \vec{i}\left[\frac{\partial}{\partial y}(x-y) - 0\right] + \vec{k}\left[0 - \frac{\partial}{\partial y}(x^2y)\right]$$

$$= \vec{i}\,[-1] + \vec{k}\,[x^2] = -\vec{i} + x^2\,\vec{k}$$

**2. (b)**

Let the unit vector be given by $\vec{a}_R$.

Now, $\vec{R}$ = Difference of two vectors

$$= r\vec{a}_r - h\vec{a}_z$$

∴ Unit vector, $\vec{a}_R = \frac{\vec{R}}{|\vec{R}|} = \frac{r\,\vec{a}_r - h\vec{a}_z}{\sqrt{r^2 + h^2}}$

**3. (a)**

Since the given vector $V$ is irrotational, therefore curl $V = 0$ or , $\nabla \times V = 0$.

Now, $\nabla \times V = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ (x+2y+az) & (bx-3y-z) & (4x+cy+2z) \end{vmatrix}$

$$= \left\{\frac{\partial}{\partial y}(4x+cy+2z) - \frac{\partial}{\partial z}(bx-3y-z)\right\}\vec{i} + \left\{\frac{\partial}{\partial z}(x+2y+az) - \frac{\partial}{\partial x}(4x+cy+2z)\right\}\vec{j}$$

$$+\left\{\frac{\partial}{\partial x}(bx-3y-z) - \frac{\partial}{\partial y}(x+2y+az)\right\}\vec{k}$$

$$= (c+1)\vec{i} + (a-4)\vec{j} + (b-2)\vec{k}$$

Since, $\nabla \times V = 0$, therefore, $a = 4$, $b = 2$, and $c = -1$

**4. (d)**

- $(\vec{A} \times \vec{B}) \cdot (\vec{C} \times \vec{D})$ is called "product of four vectors".

- $\vec{A} \times (\vec{B} \times \vec{C})$ is called "vector triple product".
- $(\vec{A} \times \vec{B}) \cdot (\vec{C} \times \vec{D})$ is called "vector product of four vectors".

**6. (a)**

Both assertion and reason are true and reason is the correct explanation of assertion. Reason is the physical interpretation of divergence.

**7. (c)**

- $\vec{A} \times (\vec{B} \times \vec{C})$ is called "vector triple product" which is a correct expression.
- $$\nabla = \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right)$$

and let $\vec{A} = A_x\vec{i} + A_y\vec{j} + A_z\vec{k}$

Then, $$\nabla \times \vec{A} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ A_x & A_y & A_z \end{vmatrix}$$

$$\therefore \quad \nabla(\nabla \times \vec{A}) = \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right) \times \left[\vec{i}\left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right) + \vec{j}\left(\frac{\partial A_x}{\partial z} - \frac{\partial A_z}{\partial x}\right) + \vec{k}\left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right)\right]$$

$$= \frac{\partial}{\partial x}\left(\frac{\partial A_z}{\partial y} - \frac{\partial A_y}{\partial z}\right) + \frac{\partial}{\partial y}\left(\frac{\partial A_z}{\partial x} - \frac{\partial A_x}{\partial z}\right) + \frac{\partial}{\partial z}\left(\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}\right)$$

$$= \frac{\partial^2 A_z}{\partial x \partial y} - \frac{\partial^2 A_y}{\partial x \partial z} + \frac{\partial^2 A_z}{\partial y \partial x} - \frac{\partial^2 A_x}{\partial y \partial z} + \frac{\partial^2 A_y}{\partial z \partial x} - \frac{\partial^2 A_x}{\partial z \partial y} = 0$$

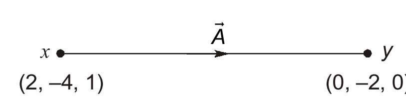
- $$\nabla \times \nabla\varphi = \left(\frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j} + \frac{\partial}{\partial z}\vec{k}\right) \times \left(\frac{\partial \varphi}{\partial x}\vec{i} + \frac{\partial \varphi}{\partial y}\vec{j} + \frac{\partial \varphi}{\partial z}\vec{k}\right)$$

$$= \left\{(\vec{i} \times \vec{j})\frac{\partial^2 \varphi}{\partial x \partial y} + (\vec{i} \times \vec{k})\frac{\partial^2 \varphi}{\partial x \partial z}\right\} + \left\{(\vec{j} \times \vec{i})\frac{\partial^2 \varphi}{\partial x \partial y} + (\vec{j} \times \vec{k})\frac{\partial^2 \varphi}{\partial y \partial z}\right\} + \left\{(\vec{k} \times \vec{i})\frac{\partial^2 \varphi}{\partial z \partial x} + (\vec{k} \times \vec{j})\frac{\partial^2 \varphi}{\partial y \partial z}\right\}$$

$$= \vec{k}\frac{\partial^2 \varphi}{\partial x \partial y} - \vec{j}\frac{\partial^2 \varphi}{\partial x \partial z} - \vec{k}\frac{\partial^2 \varphi}{\partial y \partial x} + \vec{i}\frac{\partial^2 \varphi}{\partial y \partial z} + \vec{j}\frac{\partial^2 \varphi}{\partial z \partial x} - \vec{i}\frac{\partial^2 \varphi}{\partial z \partial y} = 0$$

**8. (b)**

The vector $\vec{A}$ is given as




$$\vec{A} = (0-2)\vec{a}_x + [-2-(-4)]\vec{a}_y + (0-1)\vec{a}_z$$

$$= -2\vec{a}_x + 2\vec{a}_y - \vec{a}_z$$

**9. (d)**

By divergence theorem,

$$\iint_s \vec{F} \cdot d\vec{s} = \iiint_v \nabla \cdot \vec{F} dv$$

$$= \iiint_v \left[\vec{i}_1\frac{\partial}{\partial x} + \vec{i}_2\frac{\partial}{\partial y} + \vec{i}_3\frac{\partial}{\partial z}\right] \times (4xz\,\vec{i}_1 - y^2\,\vec{i}_2 + yz\,\vec{i}_3)dV$$

$$= \iiint_V \left[\frac{\partial}{\partial x}(4xz) - \frac{\partial}{\partial y}(y^2) + \frac{\partial}{\partial z}(yz)\right] dV$$

$$= \iiint_V [4z - 2y + y]\, dV = \iiint_V [4z - y]\, dV$$

Since, the surface $s$ is bounded by $x = 0, 1$; $y = 0, 1$ and $z = 0, 1$ so, putting the limits, we have:

$$\iint_s \vec{F} \cdot d\vec{s} = \int_0^1\int_0^1\int_0^1 (4z - y)\, dx\, dy\, dz = \int_0^1\int_0^1 \left(\frac{4z^2}{2} - yz\right)_0^1 dx\, dy$$

$$= \int_0^1\int_0^1 (2 - y)\, dx\, dy = \int_0^1 \left(2y - \frac{y^2}{2}\right)_0^1 dx = \int_0^1 \frac{3}{2} dx = \frac{3}{2}$$

**10. (c)**

The vector field $\vec{A}$ will be irrotational, if $\nabla \times \vec{A} = 0$.

Now, $$\nabla \times \vec{A} = \begin{vmatrix} \vec{a}_x & \vec{a}_y & \vec{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ yz & xz & xy \end{vmatrix}$$

$$= \left[\frac{\partial}{\partial y}(xy) - \frac{\partial}{\partial z}(xz)\right]\vec{a}_x + \left[\frac{\partial}{\partial x}(xy) - \frac{\partial}{\partial z}(yz)\right]\vec{a}_y + \left[\frac{\partial}{\partial x}(xz) - \frac{\partial}{\partial y}(yz)\right]\vec{a}_z$$

$$= [x - x]\,\vec{a}_x + [y - y]\,\vec{a}_y + [z - z]\,\vec{a}_z = 0$$

Hence, $\vec{A}$ is irrotational.

The vector field $\vec{A}$ will be solenoidal, if $\nabla \cdot \vec{A} = 0$

Here, $$\nabla \cdot \vec{A} = \left(\vec{a}_x \frac{\partial}{\partial x} + \vec{a}_y \frac{\partial}{\partial y} + \vec{a}_z \frac{\partial}{\partial z}\right) \cdot (yz\vec{a}_x + xz\vec{a}_y + xy\vec{a}_z)$$

$$= \vec{a}_x \cdot \vec{a}_x \frac{\partial}{\partial x}(yz) + \vec{a}_y \cdot \vec{a}_y \frac{\partial}{\partial y}(xz) + \vec{a}_z \cdot \vec{a}_z \frac{\partial}{\partial z}(xy) = 0 + 0 + 0 = 0$$

Hence, $\vec{A}$ is solenoidal.

**11. (a)**

Given, $$\vec{A} = \frac{1}{\sqrt{x^2 + y^2}}\vec{a}_x$$

$\therefore$ $$\nabla \cdot \vec{A} = \frac{\partial}{\partial x}(A_x) + \frac{\partial}{\partial y}(A_y) + \frac{\partial}{\partial z}(A_z)$$

$$= \frac{\partial}{\partial x}\left(\frac{1}{\sqrt{x^2 + y^2}}\right) + 0 + 0 = \frac{\partial}{\partial x}(x^2 + y^2)^{-1/2} = -\frac{1}{2}(x^2 + y^2)^{-3/2} \cdot 2x$$

$$= \nabla \cdot \vec{A} = -\frac{x}{\sqrt{(x^2 + y^2)(x^2 + y^2)}}$$

Now, $$(\nabla \cdot \vec{A})_{2,2,0} = -\frac{2}{\sqrt{(2^2 + 2^2)\cdot(2^2 + 2^2)}} = -\frac{2}{\sqrt{8.8}} = -0.0884$$

**12. (b)**

Given, $\vec{r} = x\vec{i} + y\vec{j} + z\vec{k}$

$\therefore$ $\vec{r} \times \vec{i} = (x\vec{i} + y\vec{j} + z\vec{k}) \times \vec{i} = -y\vec{k} + z\vec{j}$

Also, $\vec{i} \times (\vec{r} \times \vec{i}) = \vec{i} \times (-y\vec{k} + z\vec{j}) = \vec{j}y + z\vec{k}$

Similarly, $\vec{j} \times (\vec{r} \times \vec{j}) = \vec{i}x + \vec{k}z$

and $\vec{k} \times (\vec{r} \times \vec{k}) = \vec{i}x + \vec{j}y$

Thus, $\vec{i} \times (\vec{r} \times \vec{i}) + \vec{j} \times (\vec{r} \times \vec{j}) + \vec{k} \times (\vec{r} \times \vec{k}) = 2(x\vec{i} + y\vec{j} + z\vec{k}) = 2\vec{r}$

**13. (d)**

Since vector $\vec{V}$ is solenoidal, therefore

$$\nabla \cdot V = 0$$

$$\therefore \left[\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right] \cdot \begin{bmatrix} \vec{i}(x+3y) + \vec{j}(y-2x) \\ +\vec{k}(x+bz) \end{bmatrix} = 0$$

or, $[1 + 1 + b] = 0$ or $b = -2$

**15. (d)**

Vector differential operator ('$\nabla$') is not a vector quantity. Hence, assertion is a false statement.

**16. (b)**

All the given statements are correct.

**17. (c)**

Reason is a statement of stroke's theorem not that of Gauss's divergence theorem.

**18. (a)**

- Electric potential, $V = \dfrac{\text{Work done}}{\text{Test charge}} = \dfrac{\text{Force} \times \text{Displacement}}{\text{Current} \times \text{Time}}$

$\therefore$ $[V] = \dfrac{[MLT^{-2}][L]}{[I][T]} = [ML^2T^{-3}I^{-1}]$

- Emf induced, $V = \dfrac{d\phi}{dt}$

  or, $\phi = V.t = \text{Magnetic flux}$

  $\therefore$ $[\phi] = [ML^2T^{-3}I^{-1}]\,[T] = [ML^2T^{-2}I^{-1}]$

- Magnetic field intensity,

$$H = \frac{NI}{l}$$

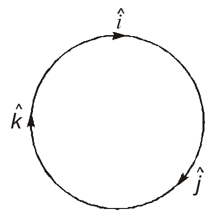
  $\therefore$ $[H] = \dfrac{[I]}{[L]} = [IL^{-1}]$

- Magnetic flux density $B = \dfrac{\phi}{A}$

$\therefore$ $[B] = \dfrac{[ML^2T^{-2}I^{-1}]}{[L^2]} = [MT^{-2}I^{-1}]$

**19. (c)**

Option (c) is not correct because cross product of two unlike vectors is a third unit vector having positive sign for normal rotation and negative for reverse rotation while cross product of two like unit vectors is zero.




**20. (d)**

Taking the curl, we have:

$$\nabla \times \vec{v} = \nabla \times \vec{\omega} \times \vec{r} \qquad (\text{Since } \vec{v} = \vec{\omega} \times \vec{r})$$

or,
$$\nabla \times \vec{v} = \left(\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right) \times \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \omega_x & \omega_y & \omega_z \\ x & y & z \end{vmatrix}$$

$$= \left[\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}\right] \times \left[\vec{i}(\omega_y z - \omega_z y) + \vec{j}(\omega_z x - \omega_x z) + \vec{k}(\omega_x y - \omega_y x)\right]$$

$$= (\vec{i} \times \vec{j})\frac{\partial}{\partial x}(\omega_z x - \omega_x z) + (\vec{i} \times \vec{k})\frac{\partial}{\partial x}(\omega_x y - \omega_y x) + (\vec{j} \times \vec{i})\frac{\partial}{\partial y}(\omega_y z - \omega_z y)$$

$$+ (\vec{j} \times \vec{k})\frac{\partial}{\partial y}(\omega_x y - \omega_y x) + (\vec{k} \times \vec{i})\frac{\partial}{\partial z}(\omega_y z - \omega_z y) + (\vec{k} \times \vec{j})\frac{\partial}{\partial z}(\omega_z x - \omega_x z)$$

$$= \vec{k}(\omega_z - 0) - \vec{j}(0 - \omega_y) - \vec{k}(0 - \omega_z) + \vec{i}(\omega_x - 0) + \vec{j}(\omega_y - 0) - \vec{i}(0 - \omega_x)$$

$$= \vec{i}(\omega_x + \omega_x) + \vec{j}(\omega_y + \omega_y) + \vec{k}(\omega_z + \omega_z)$$

$$= 2\omega_x\vec{i} + 2\omega_y\vec{j} + 2\omega_z\vec{k} = 2(\omega_x\vec{i} + \omega_y\vec{j} + \omega_z\vec{k}) = 2\omega$$

$\therefore \quad \nabla \times \vec{v} = \text{Curl } \vec{v} = 2\omega$

**21. (c)**

We have:
$$\nabla \vec{r} = \left(\vec{I}_x\frac{\partial}{\partial x} + \vec{I}_y\frac{\partial}{\partial y} + \vec{I}_z\frac{\partial}{\partial z}\right)(x\vec{I}_x + y\vec{I}_y + z\vec{I}_z)$$

$$= (\vec{I}_x \cdot \vec{I}_x)\frac{\partial x}{\partial x} + (\vec{I}_y \cdot \vec{I}_y)\frac{\partial y}{\partial y} + (\vec{I}_z \cdot \vec{I}_z)\frac{\partial z}{\partial z}$$

$$= 1.1 + 1.1 + 1.1 = 1 + 1 + 1 = 3$$

Also,
$$\nabla \times \vec{r} = \begin{vmatrix} \vec{I}_x & \vec{I}_y & \vec{I}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x & y & z \end{vmatrix} = \vec{I}_x\left[\frac{\partial z}{\partial y} - \frac{\partial y}{\partial z}\right] + \vec{I}_y\left[\frac{\partial x}{\partial z} - \frac{\partial z}{\partial x}\right] + \vec{I}_z\left[\frac{\partial y}{\partial x} - \frac{\partial x}{\partial y}\right]$$

$$= \vec{I}_x[0] + \vec{I}_y[0] + \vec{I}_z[0] = 0 + 0 + 0 = 0$$

Thus, $\nabla \times \vec{r} = 0$

Hence, both (a) and (b) will hold true.