

# CUET UG (Physics) - 20 May 2025 Shift 2

## Question1

For a short electric dipole, identify the incorrect statement(s).

- (A) The electric field intensity varies inversely with the cube of the distance from the center of the dipole.
- (B) The electric field is directed from negative to positive charge.
- (C) The electric potential at mid-point of the dipole is zero.
- (D) The electric field intensity at mid-point of the dipole is zero.

Choose the correct answer from the option given below:

- 1. (A) and (C) only
- 2. (B) and (D) only
- 3. (A) only
- 4. (B) only

Options:

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

Correct Answer: 2. (B) and (D) only

Let's analyze each option:

(A) **Correct** → For a short dipole, electric field  $\propto 1/r^3$  (true for both axial and equatorial positions).

(B) **Incorrect** → Electric field lines always go from positive to negative charge, not the other way.

(C) **Correct** → At the mid-point (center of dipole), potential is zero due to **symmetry**.

(D) **Correct** → At the mid-point, fields from both charges are in **same direction** which adds up instead of cancelling

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## Question2

Which of the following properties are desired in materials for permanent magnets ?

- (A) High retentivity
- (B) High coercivity
- (C) High permeability
- (D) low permeability

Choose the correct answer from the options given below:

1. (A) and (D) only
2. (B) and (C) only
3. (A), (B) and (C) only
4. (A) and (C) only

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: C

Solution:

Correct answer: (1) (A), (B) and (C) only

Key Points:

- **High retentivity:** Materials for permanent magnets must have high retentivity to **retain a strong magnetic field** after the external magnetizing force is removed.
- **High coercivity:** High coercivity is essential for permanent magnets as it makes them **resistant to demagnetization** from external magnetic fields, heat, or mechanical shock.
- **High permeability:** Materials with high magnetic permeability are used for permanent magnets because they can be **easily magnetized in the first place**, allowing them to support a strong magnetic field within the material.

Permanent magnets require **high retentivity**, **high coercivity**, and **High permeability**.

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## Question3

In the context of the Photoelectric effect, identify the statements which support quantum nature of light.

(A) The electric charge of photoelectrons is quantized

(B) The maximum kinetic energy of photoelectrons depends on the frequency of the incident light, but is independent of its intensity

(C) The photoelectric emission is an instantaneous process without any apparent time lag, even when the incident radiation is made exceedingly dim

(D) There is a minimum frequency of light below which no photoelectrons are emitted

Choose the correct answer from the options given below:

1. (A), (B) and (D) only
2. (A), (B), (C) and (D)
3. (B), (C) and (D) only
4. (B) and (D) only

Options:

- A.
- 1
- B.
- 2
- C.
- 3

D.

4

**Answer: C**

### Solution:

**Correct answer:** (3) (B), (C) and (D) only

**Key points:**

**Dependence on frequency:** Maximum kinetic energy of photoelectrons depends on the **frequency** of light, not its intensity, as per  $K(\text{max}) = hf - \Phi$ .

**Instantaneous emission:** Photoelectrons are emitted immediately, even at very low light intensity, because a **single photon** with sufficient energy can eject an electron.

**Threshold frequency:** No photoelectrons are emitted if light frequency is below the **threshold frequency**, since  $hf < \Phi$ .

Statement (A) is not specific to the photoelectric effect; it relates to the **quantization of electric charge**

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## Question4

**Light travels in the form of photons. Identify the correct statements**

**(A) Photons travel with the velocity of light in vacuum.**

**(B) The rest mass of photons is taken as zero.**

**(C) Photons have energy which depends on frequency.**

**(D) Photons have a momentum inversely dependent on frequency.**

**Choose the correct answer from the options given below.**

1. (A), (B), (C), and (D)
2. (A), (C), and (D) only
3. (A), (B) and (C) only
4. (B), (C) and (D) only

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

### Solution:

**Correct answer:** (3) (A), (B) and (C) only

**Key points:**

**Velocity:** Photons travel at the **speed of light** in vacuum.

**Rest mass:** Photons have **zero rest mass**.

**Energy:** Photon energy depends on **frequency**, given by  $E = hf$ .

**Momentum:** Photon momentum is **directly proportional to frequency** ( $p = h/\lambda$ ), not inversely.

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## Question5

**There are two electric charges, Q1 and Q2, placed in vacuum. Identify the correct statements from the following**

1. There will be an electrostatic force between them.

2. If these charges are placed in water, the force between them will increase.
3. The electrostatic force between them is a conservative force.
4. If both of the charges are doubled as  $2Q_1$  and  $2Q_2$ , then the force between them will become 4 times.

Choose the correct answer from the options given below:

1. (A) and (D) only
2. (A) , (C) and (D) only
3. (A) and (C) only
4. (A) , (B) and (C) only

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: B

Solution:

Answer: 2. (A), (C) and (D) only

Here's a quick breakdown of the statements for easy understanding:

(A) CORRECT → Any two charges in vacuum exert an electrostatic force on each other (Coulomb's law,  $F = KQ_1Q_2/r^2$ ).

(B) INCORRECT → In water, the force decreases due to the high dielectric constant which effects k value in coulomb's law

(C) CORRECT → Electrostatic force is conservative; work done is path-independent.

(D) CORRECT → Doubling both charges makes the force four times ( $F \propto Q_1Q_2$ ).

## Question6

In a series LCR circuit,  $C = 80 \mu\text{F}$ ,  $L = 5.0 \text{ H}$  and  $R = 40 \Omega$  are connected to a variable frequency source of 240 V.

The angular frequency of the source which drives the circuit at resonance will be:

1.  $5 \text{ rad s}^{-1}$
2.  $25 \text{ rad s}^{-1}$
3.  $0.05 \text{ rad s}^{-1}$
4.  $50 \text{ rad s}^{-1}$

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: D

Solution:

**Correct Answer:** 4. 50 rad/s

For a series LCR circuit, the angular frequency ( $\omega$ ) at resonance is given by the formula

$$\omega = 1/\sqrt{LC}$$

where L is **inductance** and C is **capacitance**

Substitution the given values  $L = 5 \text{ H}$  and  $C = 80 \times 10^{-6} \text{ F}$ . (Convert all in SI unit)

After further solving the value of  $\omega = 1/\sqrt{(5 \times 80 \times 10^{-6})}$

$$\omega = 50 \text{ rad/s}$$

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## Question7

A parallel plate air capacitor is charged, and then the battery is disconnected. Now on inserting a dielectric between the plates of the capacitor, which of the following change:

1. potential difference between the plates
2. charge on the plates
3. electric field between the plates
4. energy stored in the capacitor

Choose the correct answer from the options given below:

1. (A), (B) and (D) only
2. (A), (C) and (D) only
3. (B), (C) and (D) only
4. (A), (B), (C) and (D)

Options:

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

**Answer:** 2. (A), (C) and (D) only

Let's quickly see what happens when a dielectric is inserted in a disconnected capacitor:

(A) **CORRECT** → **Potential difference** decreases because battery is disconnected (charge remains constant) and **capacitance increases** and they are related by  $Q = CV$

(B) **INCORRECT** → **Charge** remains constant as the capacitor is isolated and no new charge can be added or removed.

(C) **CORRECT** → **Electric field** between the plates decreases due to dielectric as potential difference decreases and it is **related to electric field** by  $E = dv/dr$

(D) **CORRECT** → **Energy stored** decreases because  $U = \frac{1}{2} QV$  and **V decreases**.

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## Question8

In Snell's law of refraction, the refractive index of the second medium with respect to the first medium

1. a characteristic of the medium 1 only
2. a characteristic of the medium 2 only
3. independent of the angle of incidence.
4. not dependent on the wavelength of light

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct answer:** 3. independent of the angle of incidence

**Key points:**

**Refractive index (n<sub>21</sub>):** Ratio of the sine of the angle of incidence to the sine of the angle of refraction,  $n_{21} = \sin i / \sin r$ .

**Angle independence:** The refractive index depends on the **properties of the two media**, not on the **angle of incidence**.

**Wavelength dependence:** It **can vary with wavelength** (dispersion) as refractive index **depends on speed of light in media** and it is related to wavelength by  $v=f\lambda$ .

The refractive index is a **material property** that is independent of the angle at which light enters.

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## Question9

**Two coherent light sources have intensities in the ratio 25: 16. The ratio of the intensities of maxima to minima, in the interference pattern due to them would be**

- 1. 25 : 16
- 2. 9:1
- 3. 4:1
- 4. 81 :1

**Options:**

- A.
- 1
- B.
- 2
- C.
- 3
- D.
- 4

**Answer: D**

**Solution:**

**Correct Answer : 81 : 1**

The intensity of a wave ( $I$ ) is proportional to the square of its amplitude ( $a^2$ ).

Let  $I_1$  and  $I_2$  be the intensities, and  $a_1$  and  $a_2$  be the amplitudes of two sources.

Given that the ratio of intensities is  $I_1 : I_2 = 25 : 16$ ,

$$\frac{I_1}{I_2} = \frac{25}{16}$$

Therefore, the ratio of amplitudes is:  $\frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{25}{16}} = \frac{5}{4}$

The ratio of maximum to minimum intensity is given by:

$$\frac{I_{\max}}{I_{\min}} = \left( \frac{a_1 + a_2}{a_1 - a_2} \right)^2$$

$$= \left( \frac{\frac{a_1}{a_2} + 1}{\frac{a_1}{a_2} - 1} \right)^2$$

$$= \left( \frac{\frac{5}{4} + 1}{\frac{5}{4} - 1} \right)^2 = \left( \frac{\frac{9}{4}}{\frac{1}{4}} \right)^2 = (9)^2 = 81$$

Hence, the ratio of maximum to minimum intensity is  $\boxed{81 : 1}$ .

## Question10

A long straight conductor carries a current of 304 A. The magnitude of the magnetic field due to the current at a distance of 6 cm from the conductor is

1. 3.002 mT
2. 1003 mT
3. 1.013 mT
4. 2.012 T

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: C

Solution:

Solution: 1.013 mT

Formula for the magnetic field due to a long straight current-carrying conductor:

$$B = (\mu_0 I) / (2\pi r^2)$$

Given: I = 304 A r = 6 cm = 0.06 m  $\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$

Substitute:  $B = (4\pi \times 10^{-7} \times 304) / (2\pi \times 0.06)$

Simplify:  $\pi$  cancels  $\rightarrow B = (2 \times 10^{-7} \times 304) / 0.06 = (6.08 \times 10^{-5}) / 0.06 = 1.013 \times 10^{-3} \text{ T}$

Convert to millitesla (mT):  $1.013 \times 10^{-3} \text{ T} = 1.013 \text{ mT}$

## Question11

The half life of a radioactive substance is 20 s.

The time taken for its sample to decay  $\frac{7}{8}$  th of the initial value is:

1. 20 s
2. 40 s
3. 60 s
4. 80 s

Options:

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct Answer: 3. 60 s**

Correct Answer: 3. 60 s

1. Let the initial quantity be  $N_0$ .

After time  $t$ , remaining quantity =  $N$ .

Given that  $\frac{7}{8}$  of the sample has decayed  $\Rightarrow$  remaining =  $\frac{1}{8}$  of initial.

$$\frac{N}{N_0} = \frac{1}{8}$$

2. The decay law is:

$$N = N_0 \left( \frac{1}{2} \right)^{\frac{t}{T_{1/2}}}$$

3. Substitute values:

$$\frac{1}{8} = \left( \frac{1}{2} \right)^{\frac{t}{20}}$$

4. Note that  $\frac{1}{8} = \left( \frac{1}{2} \right)^3$ , hence:

$$\left( \frac{1}{2} \right)^3 = \left( \frac{1}{2} \right)^{\frac{t}{20}}$$

5. Equate exponents:

$$\frac{t}{20} = 3$$

$$\Rightarrow t = 60 \text{ s}$$

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## Question12

**Nichrome element is used in household appliances because of the following characteristics**

- 1. Its melting point is high**
- 2. Its resistivity is large**
- 3. It is tensile**
- 4. It does not oxidize easily by the oxygen of the air when heated**

**Choose the correct answer from the options given below:**

- 1. (A), (B) and (D) only**
- 2. (A), (B) and (C) only**
- 3. (A), (B), (C) and (D)**
- 4. (B), (C) and (D) only**

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct answer:** 1. (A), (B) and (D) only

**Key points:**

**High melting point:** Nichrome can withstand **high temperatures** without melting.

**High resistivity:** Its **large resistivity** allows it to produce heat efficiently.

**Non-oxidizing:** It **does not oxidize easily** when heated, ensuring durability.

Tensile property (C) is not a primary reason for its use in heating elements.

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## Question13

In Faraday's experiment on Electromagnetic Induction, in which of the following situations, more deflection will be shown by the galvanometer?

1. magnet is at rest inside the coil
2. magnet is accelerated towards the coil
3. magnet is in uniform motion towards the coil
4. magnet is decelerated away from the coil

Options:

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

**Answer:** 2. magnet is accelerated towards the coil

Let's analyze the situations in Faraday's experiment:

- (1) **INCORRECT** → Magnet at rest → **no change in flux**, no deflection.
  - (2) **CORRECT** → Magnet accelerated → **rapid change in flux**, maximum deflection.
  - (3) **INCORRECT** → Uniform motion → change in flux is less, smaller deflection.
  - (4) **INCORRECT** → Decelerated away → change in flux occurs but **less than acceleration**, smaller deflection.
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## Question14

The following statements are given related to Wheatstone Bridge:

1. when Wheatstone Bridge is balanced, no current flows through the galvanometer arm.
2. Wheatstone Bridge works on the principle of Kirchhoff's law.
3. Being a null method based experiment, the result is free from the effect of extra resistances (cell resistance) of the circuit
4. Wheatstone Bridge is most sensitive when all the four resistances are nearly of the same magnitude.

Choose the *correct* answer from the options given below:

1. (A), (B) and (D) only
2. (A), (B) and (C) only
3. (A), (B), (C) and (D)
4. (B), (C) and (D) only

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: C

### Solution:

Answer: 3. (A), (B), (C) and (D)

Here's a quick revision of Wheatstone Bridge statements:

(A) **CORRECT** → When **balanced**, **no current** flows through the galvanometer arm. ( **Balance Condition**  $R_1/R_2 = R_3/R_4$ )

(B) **CORRECT** → Works on **Kirchhoff's laws** which explains current distribution at junction and **net V zero** in closed loop.

(C) **CORRECT** → **Wheatstone bridge** measures **zero current at balance**. This makes the method **highly accurate**, because **voltage drops or contact resistances do not affect the measurement**.

(D) **CORRECT** → **Maximum sensitivity** occurs when all four **resistances are nearly equal** because in this condition, a **small change in one resistance** produces a **larger change in the bridge current or galvanometer deflection**, making it easier to detect **small resistance variations**.

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## Question15

The radii of curvature of the two surfaces of a concave lens are 20 cm each. The refractive index of the material of the lens is 1.5. The power of the lens would be-

1. -5 D
2. -1 D
3. 2.5 D
4. -0.5 D

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: A

### Solution:

Power  $P = 1/f$  (in diopters) = -5 D.

Correct Answer:  $-5D$

1. Use the lens-maker's formula for a thin lens in air:

$$\frac{1}{f} = (n - 1) \left( \frac{1}{R_1} - \frac{1}{R_2} \right)$$

where  $f$  is focal length (in m),  $n$  is refractive index,  $R_1, R_2$  are radii of curvature (signs by convention).

2. For a symmetric biconcave lens (both surfaces have magnitude  $R = 20 \text{ cm} = 0.20 \text{ m}$ ):

With the sign convention (centers of curvature: left of first surface  $\Rightarrow R_1 = -R$ ; right of second surface  $\Rightarrow R_2 = +R$ ),

$$\frac{1}{R_1} - \frac{1}{R_2} = \frac{1}{-R} - \frac{1}{+R} = -\frac{2}{R}$$

3. Substitute into lens-maker formula:

$$\frac{1}{f} = (n - 1) \left( -\frac{2}{R} \right)$$

Given  $n = 1.5 \Rightarrow (n - 1) = 0.5$ , and  $R = 0.20 \text{ m}$ , so

$$\frac{1}{f} = 0.5 \times \left( -\frac{2}{0.20} \right) = 0.5 \times (-10) = -5 \text{ (m}^{-1}\text{)}$$

4. Therefore  $f = -\frac{1}{5} \text{ m} = -0.20 \text{ m}$ .

Power  $P = \frac{1}{f}$  (in diopters) = -5 D.

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## Question16

A cell supplies a current of 0.6 A through a  $3\ \Omega$  resistor and a current of 0.2 A through a  $10\ \Omega$  resistor.

The internal resistance of the cell is:

1.  $0.5\ \Omega$
2.  $1.0\ \Omega$
3.  $0.05\ \Omega$
4.  $0.01\ \Omega$

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: A**

**Solution:**

**Correct Answer: 1.  $0.5\ \Omega$**

1. Let **E = emf of the cell** and **r = internal resistance**

Using *Ohm's law* for the circuit:

$$E = I(R + r)$$

2. For the first case:

$$E = 0.6(3 + r) \quad \dots(1)$$

For the second case:

$$E = 0.2(10 + r) \quad \dots(2)$$

3. Equate (1) and (2):

$$0.6(3 + r) = 0.2(10 + r)$$

4. Expand:

$$1.8 + 0.6r = 2 + 0.2r$$

$$\Rightarrow 0.6r - 0.2r = 2 - 1.8$$

$$\Rightarrow 0.4r = 0.2$$

$$\Rightarrow r = 0.5\ \Omega$$

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## Question 17

With the rise in temperature, the electrical resistance

1. increases for a conductor and a semiconductor
2. decreases for a conductor and a semiconductor
3. increases for a conductor and decreases for a semiconductor
4. decreases for a conductor and increases for a semiconductor

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct answer:** 3. increases for a conductor and decreases for a semiconductor

**Key points:**

**Conductor:** Resistance **increases** with temperature due to more frequent **collisions of electrons** with vibrating ions which decreases their speed and produces heat and hence also decreases the current speed.

**Semiconductor:** Resistance **decreases** with temperature as more **charge carriers** (electrons and holes) are generated which leads to increased current flow

Conductors and semiconductors thus show **opposite temperature dependence** of resistance.

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## Question18

Two long coaxial solenoids of the same length  $L$  have inner and outer coils with diameters  $D_1$  and  $D_2$  and number of turns  $N_1$  and  $N_2$ , respectively.

What will be the ratio of the self-inductance of the inner solenoid to the mutual inductance of both the solenoids?

1.  $N_1 N_2^{-1}$

2.  $N_2 N_1^{-1}$

3.  $\frac{N_2 D_2^2}{N_1 D_1^2}$

4.  $\frac{N_2 D_2}{N_1 D_1}$

**Options:**

A.

1

B.

2

C.

3

D.

4

**Answer: A**

**Solution:**

**Correct Answer:  $N_1 / N_2$**

1. For a long solenoid of length  $L$  and cross-sectional area  $A$ , the self-inductance is

$$L = \mu_0 N^2 A / L$$

For the inner solenoid:  $L_1 = \mu_0 N_1^2 A_1 / L$ , where  $A_1 = \pi (D_1/2)^2$ .

2. The mutual inductance between two coaxial solenoids (with the inner entirely inside the outer) is

$$M = \mu_0 N_1 N_2 A_1 / L$$

because the flux linking both coils equals the flux through the inner coil's area  $A_1$ .

3. Form the ratio:

$$L_1 / M = [\mu_0 N_1^2 A_1 / L] / [\mu_0 N_1 N_2 A_1 / L] = N_1 / N_2$$

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## Question19

In n-type semiconductors, A are the majority charge carriers and B are the minority charge carriers. He

1. A- electrons ; B- protons

2. A- protons ; B- electrons

3. A- electrons ; B- holes

4. A- holes ; B- electrons

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct Answer: 3. A- electrons ; B- holes**

In n-type semiconductors, **pentavalent impurities** are added to a pure semiconductor. This process **introduces extra electrons that are free** that are not part of the covalent bonds, making them the majority charge carriers. The minority charge carriers are **holes which forms when their is absence of electron in covalent bond** formation and hence assumed **as + charge**, which are present in a smaller number due to **thermal energy**.

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## Question20

A 600 pF capacitor is charged by a 150 V battery. The charge on the capacitor is:

- 1. 9  $\mu\text{C}$
- 2. 4 pC
- 3. 90 nC
- 4. 9 nC

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct Answer: 90 nC**

1. We know  **$Q = C \times V$**   
where **Q = charge**, **C = capacitance**, and **V = voltage**
  2. Given:  
 $C = 600 \text{ pF} = 600 \times 10^{-12} \text{ F}$   
 $V = 150 \text{ V}$
  3. Substitute:  
 $Q = (600 \times 10^{-12}) \times 150$   
 $= 9.0 \times 10^{-8} \text{ C}$
  4. Convert to nanocoulombs:  
 $9.0 \times 10^{-8} \text{ C} = 90 \times 10^{-9} \text{ C} = 90 \text{ nC}$
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## Question21

The magnetic flux through a coil placed in a magnetic field is given by

$$\phi = 5t^3 + 4t^2 + 2t - 5 \text{ Wb}$$

The resistance of the coil is  $10 \Omega$ .

The induced current through the coil at  $t = 2 \text{ s}$  is:

- 1. 7.8 A

2. 15.6 A

3. 0.78 A

4. 3.9 A

**Options:**

A. 1

B. 2

C. 3

D. 4

**Answer: A**

**Solution:**

Correct Answer: 7.8 A

1. Induced emf ( $\varepsilon$ ) is given by Faraday's law:

$$\varepsilon = -\frac{d\Phi}{dt}$$

(We take only the magnitude.)

2. Differentiate  $\Phi$  with respect to  $t$  :

$$\frac{d\Phi}{dt} = \frac{d}{dt}(5t^3 + 4t^2 + 2t - 5)$$

$$\frac{d\Phi}{dt} = 15t^2 + 8t + 2$$

3. At  $t = 2$  s:

$$\frac{d\Phi}{dt} = 15(2)^2 + 8(2) + 2$$

$$= 15 \times 4 + 16 + 2$$

$$= 60 + 16 + 2 = 78 \text{ V}$$

4. Induced current:

$$I = \frac{\varepsilon}{R} = \frac{78}{10} = 7.8 \text{ A}$$

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## Question22

A proton enters a uniform magnetic field of 0.2 T with speed  $v$ . It describes a semicircular path of radius 5 cm and comes out of the field. The final speed of the proton will be

1. 0.5  $v$

2.  $v$

3. 4  $v$

4. 0.02  $v$

**Options:**

A.

1

B.

2

C.

3

D.

4

**Answer: B**

### Solution:

**Correct answer: 2. v**

1. When a charged particle (like a proton) moves in a uniform magnetic field,

the magnetic force acts **perpendicular** to its velocity at all times.  $\mathbf{F} = q(\mathbf{V} \times \mathbf{B})$

Hence, it **changes only the direction** of velocity, not the **magnitude**. and constant direction changes to **formation of semi circular path** through which the charges particle travels without changing magnitude until it moves out of field

2. Therefore, as the proton travels along a semicircular path, its speed **remains constant** —

the field does no work on the proton (since force  $\perp$  displacement).

(Radius of semicircular path is given by  $r = mv/qb$   $m$ =mass,  $v$ =velocity (perpendicular),  $q$ =charge,  $b$ = magnetic field)

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## Question23

**The main causes of energy loss in transformers are**

1. Hysteresis loss
2. Flux leakage
3. Eddy current
4. Damping

**Choose the correct answer from the options given below:**

1. (A), (B) and (D) only
2. (A), (B) and (C) only
3. (A), (B), (C) and (D)
4. (B), (C) and (D) only

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

### Solution:

**Correct Answer: 2. (A), (B) and (C) only**

The main causes of energy loss in a transformer are:

**Hysteresis loss:** This is the energy loss due to the **repeated magnetization** and demagnetization of the transformer's core.

**Eddy current loss:** This occurs when **circulating currents** are induced in the core material by the changing magnetic flux. These currents produce heat, which is a form of energy loss.

**Copper loss (or I<sup>2</sup>R loss):** This is the energy loss in the windings of the transformer due to the **resistance of the copper wire**.

**Flux leakage:** This is the loss of magnetic flux that does not link the primary and secondary windings, which **reduces the efficiency** of the transformer.

---

## Question24

A ferromagnetic core of susceptibility 799 is subjected to a magnetizing field. The permeability of the material is  
(Take  $\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$ )

1.  $3.2\pi \times 10^{-4} \text{ T m A}^{-1}$
2.  $3.2 \times 10^{-4} \text{ T m A}^{-1}$
3.  $3.2\pi \times 10^{-5} \text{ T m A}^{-1}$
4.  $3.2\pi \times 10^{-7} \text{ T m A}^{-1}$

**Options:**

A.

1

B.

2

C.

3

D.

4

**Answer: A**

**Solution:**

**Correct Answer:**  $3.2\pi \times 10^{-4} \text{ T}\cdot\text{m}\cdot\text{A}^{-1}$

The relation between magnetic permeability and magnetic susceptibility is:

$$\mu = \mu_0(1 + \chi)$$

Substitute the given values:

$$\mu = 4\pi \times 10^{-7} \times (1 + 799)$$

$$\mu = 4\pi \times 10^{-7} \times 800$$

$$\mu = 3200\pi \times 10^{-7} = 3.2\pi \times 10^{-4} \text{ T}\cdot\text{m}\cdot\text{A}^{-1}$$

**Where:**

$\mu$  =magnetic permeability of the material ( $\text{T}\cdot\text{m}\cdot\text{A}^{-1}$ )

$\mu_0$  =permeability of free space ( $4\pi \times 10^{-7} \text{ T}\cdot\text{m}\cdot\text{A}^{-1}$ )

$\chi$  =magnetic susceptibility of the material (dimensionless)

-----

## Question25

A regular hexagon of side 12 cm has a charge of 6  $\mu\text{C}$  at each of its vertices.

What will be the potential at the centre of the hexagon?

1.  $2.7 \times 10^4 \text{ V}$
2.  $4.5 \times 10^6 \text{ V}$
3.  $2.65 \times 10^{-16} \text{ V}$
4.  $2.7 \times 10^6 \text{ V}$

**Options:**

A.

1

B.

2

C.

3

D.

4

**Answer: D**

**Solution:**

Correct Answer:  $2.7 \times 10^6 \text{ V}$

1. Potential at the centre due to a point charge:

$$V = k \frac{Q}{r}$$

where  $k = \frac{1}{4\pi\epsilon_0} \approx 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$ ,  $Q$  =charge,  $r$  =distance from charge to point.

2. For a regular hexagon of side  $a$ , distance from centre to each vertex:

$r = a$  (for a regular hexagon, radius of circumscribed circle = side length)

$r = 0.12 \text{ m}$

3. Total potential at the centre (superposition principle, scalar sum):

$$V_{\text{total}} = 6 \times V_{\text{single}} = 6 \times \frac{kQ}{r}$$

4. Substitute values:

$$Q = 6 \mu\text{C} = 6 \times 10^{-6} \text{ C}$$

$r = 0.12 \text{ m}$

$$k = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$$

$$V_{\text{total}} = 6 \times \left( \frac{9 \times 10^9 \times 6 \times 10^{-6}}{0.12} \right)$$

$$= 6 \times \left( \frac{54 \times 10^3}{0.12} \right)$$

$$= 6 \times 450 \times 10^3$$

---

## Question26

**An eye specialist prescribes spectacles having a combination of a converging lens of focal length 25 cm and a diverging lens of focal length of 20 cm. The power of the combination of two lenses (in dioptre) is**

**1. + 1.0**

**2. - 1.0**

**3. + 1.1**

**4. +2.0**

**Options:**

A.

1

B.

2

C.

3

D.

4

**Answer: B**

## Solution:

**Correct Answer: -1D**

1. Power of a lens:  $P = 100 / f$  (f in cm)

2. Power of converging lens:

$$P_1 = 100 / 25 = +4 \text{ D}$$

3. Power of diverging lens:

$$P_2 = 100 / (-20) = -5 \text{ D}$$

4. Total power of combination (lenses in contact):

$$P_{\text{total}} = P_1 + P_2 = 4 + (-5) = -1 \text{ D}$$

-----

## Question27

**Match List-I with List-II for the band gap energy for different materials**

| List-I        | List-II         |
|---------------|-----------------|
| Substances    | Band gap Energy |
| (A) Germanium | (I) 1.1 eV      |
| (B) Silicon   | (II) 0.7 eV     |
| (C) Insulator | (III) Zero      |
| (D) metal     | (IV) 5 eV       |

**Choose the correct answer from the options given below:**

1. (A) - (II), (B) - (I), (C) - (IV), (D) - (III)
2. (A) - (I), (B) - (I), (C) - (III), (D) - (IV)
3. (A) - (I), (B) - (I), (C) - (IV), (D) - (III)
4. (A) - (II), (B) - (IV), (C) - (I), (D) - (III)

**Options:**

A.

1

B.

2

C.

3

D.

4

**Answer: A**

## Solution:

**Correct Answer: 1. (A)-(II), (B)-(I), (C)-(IV), (D)-(III)**

Band gap energy is the **minimum energy** required for an electron to jump from the **valence band** (where it is bound to an atom) to the **conduction band** (where it can move freely and conduct electricity).

**Germanium** (A) is a semiconductor with a band gap energy of approximately **0.7 eV** (II).

**Silicon** (B) is also a semiconductor with a band gap energy of approximately **1.1 eV** (I).

**insulator** (C) has a **large band gap** energy, typically greater than 4 eV. The value **5eV** (IV) is a representative example.

**metal** (D) has **no band gap**; the conduction and valence bands overlap, so the band gap energy is **zero** (III).

---

## Question28

A circular coil with 5 turns, each of radius 7 cm, carries a current of 1.4 A.

The magnetic field at the center of the coil is:

1.  $10^{-5} \text{ T}$
2.  $2 \times 10^{-5} \text{ T}$
3.  $\pi \times 10^{-5} \text{ T}$
4.  $2\pi \times 10^{-5} \text{ T}$

**Options:**

- A. 1  
B. 2  
C. 3  
D. 4

**Answer: D**

**Solution:**

**Correct Answer: 4.  $2\pi \times 10^{-5} \text{ T}$**

1. Magnetic field at the center of a circular coil of N turns and radius R carrying current I:

$$B = (\mu_0 N I) / (2 R)$$

2. Given:

$$N = 5, R = 7 \text{ cm} = 0.07 \text{ m}, I = 1.4 \text{ A}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}$$

3. Substitute values:

$$B = (4\pi \times 10^{-7} \times 5 \times 1.4) / (2 \times 0.07)$$

$$= (28\pi \times 10^{-7}) / 0.14$$

$$= 200\pi \times 10^{-7}$$

$$= 2\pi \times 10^{-5} \text{ T}$$

---

## Question29

The speed of electromagnetic waves in a material medium is given by (symbols have their usual meanings):

1.  $v = (\mu\epsilon)^{0.5}$
2.  $v = (\mu_0\epsilon_0)^{-0.5}$
3.  $v = (\mu\epsilon)^{-0.5}$
4.  $v = (\mu_0\epsilon_0)^{0.5}$

**Options:**

- A. 1  
B. 2

C. 3

D. 4

**Answer: C**

**Solution:**

The speed of electromagnetic waves in a medium with **permeability**  $\mu$  and **permittivity**  $\epsilon$  is given by:

$$v = 1 / \sqrt{(\mu \epsilon)}$$

---

## Question30

The current in a resistive series circuit is 7.0 A.

On adding a resistance of  $1.6 \Omega$  in the same circuit in series, the current drops to 5.0 A.

The original resistance of the circuit is:

1.  $1.0 \Omega$

2.  $4.0 \Omega$

3.  $2.0 \Omega$

4.  $8.0 \Omega$

**Options:**

A. 1

B. 2

C. 3

D. 4

**Answer: A**

**Solution:**

**Correct Answer:** 2.  $4 \Omega$

**1. Let the original resistance be**  $R$  and the voltage of the source be  $V$ .

$$\text{Original circuit: } I_1 = \frac{V}{R} \Rightarrow 7 = \frac{V}{R} \Rightarrow V = 7R \quad \dots(1)$$

**2. After adding**  $1.6 \Omega$  :

$$I_2 = \frac{V}{R + 1.6} \Rightarrow 5 = \frac{V}{R + 1.6} \Rightarrow V = 5(R + 1.6) \quad \dots(2)$$

**3. Equating (1) and (2):**

$$7R = 5(R + 1.6)$$

$$7R = 5R + 8$$

$$7R - 5R = 8 \Rightarrow 2R = 8 \Rightarrow R = 4 \Omega$$

---

## Question31

In a large building, there are 20 bulbs of 40 W each, 5 bulbs of 100 W each, 5 fans of 80 W each, and 1 heater of 1 kW.

The voltage supply is 220 V. The minimum capacity of the main fuse of the building should be

12.27 A

10.42 A

8.31 A

4. 6 A

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: A**

**Solution:**

**Correct Answer: 1. 12.27 A**

1. Total power of all appliances:

$$\begin{aligned} P_{\text{total}} &= (20 \times 40) + (5 \times 100) + (5 \times 80) + 1000 \\ &= 800 + 500 + 400 + 1000 \\ &= 2700 \text{ W} \end{aligned}$$

2. Current drawn from the supply:

$$I = P_{\text{total}} / V = 2700 / 220 \approx 12.27 \text{ A}$$

## Question32

In a Young's double-slit experiment, the slits are separated by 0.28 mm and the wavelength of light used is 6000 Å.

The fringes are observed on a screen placed 1.4 m away from the slits. The distance between the central bright fringe and the fourth bright fringe will be

- 1. 0.3 cm
- 2. 0.6 cm
- 3. 1.2 cm
- 4. 2.4 cm

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: C**

**Solution:**

**Correct Answer: 3. 1.2 cm**

**1. Fringe width in a double-slit experiment:**

$$\beta = \frac{\lambda L}{d}$$

where  $\lambda$  is wavelength of light,  $L$  is the distance between slits and screen, and  $d$  is the distance between the slits.

**2. Convert units:**

$$\lambda = 6000 \text{ Å} = 6000 \times 10^{-10} \text{ m} = 6 \times 10^{-7} \text{ m}$$

$$d = 0.28 \text{ mm} = 0.28 \times 10^{-3} \text{ m} = 2.8 \times 10^{-4} \text{ m}$$

$$L = 1.4 \text{ m}$$

**3. Calculate fringe width:**

$$\beta = \frac{6 \times 10^{-7} \times 1.4}{2.8 \times 10^{-4}}$$

$$= \frac{8.4 \times 10^{-7}}{2.8 \times 10^{-4}} = 3 \times 10^{-3} \text{ m} = 0.3 \text{ cm}$$

4. Distance between central fringe and fourth bright fringe:

$$x = 4\beta = 4 \times 0.3 = 1.2 \text{ cm}$$

## Question33

Two concentric coils of radius  $2\pi$  cm each are placed with their planes at right angles to each other and carry currents of 3 A and 4 A, respectively. The net magnetic field in  $\text{Wb/m}^2$  at the center of the coils will be

1.  $10^{-5}$
2. zero
3.  $7 \times 10^{-5}$
4.  $5 \times 10^{-5}$

Options:

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: D**

**Solution:**

Correct Answer:  $4.5 \times 10^{-5} \text{ Wb/m}^2$

1. Magnetic field at the center of a single circular coil:

$$B = \frac{\mu_0 I}{2R}$$

where  $I$  is current,  $R$  is radius, and  $\mu_0$  is the permeability constant.

2. Convert radius to meters:

$$R = 2\pi \text{ cm} = 0.02\pi \text{ m} \approx 0.0628 \text{ m}$$

3. Magnetic field due to each coil:

$$B_1 = \frac{\mu_0 I_1}{2R} = \frac{4\pi \times 10^{-7} \times 3}{2 \times 0.0628}$$

$$\approx \frac{12\pi \times 10^{-7}}{0.1256} \approx 3 \times 10^{-5} \text{ T}$$

$$B_2 = \frac{\mu_0 I_2}{2R} = \frac{4\pi \times 10^{-7} \times 4}{2 \times 0.0628}$$

$$\approx 4 \times 10^{-5} \text{ T}$$

4. Since the coils are perpendicular, the net magnetic field is:

$$B_{\text{net}} = \sqrt{B_1^2 + B_2^2} \approx \sqrt{(3 \times 10^{-5})^2 + (4 \times 10^{-5})^2}$$

$$= \sqrt{9 + 16} \times 10^{-10}$$

$$= \sqrt{25} \times 10^{-10} = 5 \times 10^{-5} \text{ Wb/m}^2$$

## Question34

In a coil, the current is changed from 12 A to 24 A in 1 s. The self-induced emf of the coil is 24 V. The change in energy in the coil is

1. 432J
2. 360 J
3. 216 J
4. 108 J

Options:

- A. 1  
B. 2  
C. 3  
D. 4

Answer: A

Solution:

Correct Answer: 1. 432 J

1. Self-induced emf of a coil:

$$E = L \frac{\Delta I}{\Delta t} \Rightarrow L = \frac{E \Delta t}{\Delta I}$$

2. Substitute values:

$$\Delta I = I_2 - I_1 = 24 - 12 = 12 \text{ A}$$

$$L = \frac{24 \times 1}{12} = 2 \text{ H}$$

3. Energy stored in an inductor:

$$U = \frac{1}{2} L I^2$$

4. Change in energy:

$$\begin{aligned} \Delta U &= \frac{1}{2} L (I_2^2 - I_1^2) \\ &= 0.5 \times 2 \times (24^2 - 12^2) \\ &= 1 \times (576 - 144) \\ &= 432 \text{ J} \end{aligned}$$

---

## Question35

The energy required to excite an electron in hydrogen atom to its first excited state is

1. 13.6 eV
2. 3.4 eV
3. 10.2 eV
4. - 13.6 eV

Options:

- A. 1  
B. 2  
C. 3  
D. 4

Answer: C

### Solution:

Correct Answer: 3. 10.2 eV

1. Energy levels of hydrogen atom:

$$E_n = -\frac{13.6}{n^2} \text{ eV, where } n \text{ is the principal quantum number.}$$

$$2. \text{ Ground state } (n = 1): E_1 = -\frac{13.6}{1^2} = -13.6 \text{ eV}$$

$$\text{First excited state } (n = 2): E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4 \text{ eV}$$

3. Energy required to excite the electron:

$$\Delta E = E_2 - E_1 = (-3.4) - (-13.6) = 10.2 \text{ eV}$$

---

## Question36

A printed page is kept pressed by a glass cube-shaped paper-weight of edge 3.0 cm.

The refractive index of the glass is  $\mu = 1.5$ .

By what amount will the printed letters appear to be shifted when viewed from the top?

1. 1.0 cm
2. 0.5 cm
3. 2.0 cm
4. 2.5 cm

### Options:

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: A**

### Solution:

**Correct Answer: 1. 1.0 cm**

1. Apparent depth formula:

$$\text{Apparent depth} = \text{Real depth} / \mu$$

$$\text{Shift} = \text{Real depth} - \text{Apparent depth}$$

2. Given:

$$\text{Real depth, } d = 3.0 \text{ cm}$$

$$\mu = 1.5$$

3. Apparent depth:

$$d' = d / \mu = 3.0 / 1.5 = 2.0 \text{ cm}$$

4. Shift:

$$\Delta = d - d' = 3.0 - 2.0 = 1.0 \text{ cm}$$

---

## Question37

The ratio of the radius of the third orbit to that of the second orbit in a hydrogen atom is

1. 3:2
2. 9:4
3.  $\sqrt{2} : \sqrt{3}$
4. 4:9

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: B

Solution:

Correct Answer: 2. 9:4

1. Radius of nth orbit in hydrogen atom:

$r_n = n^2 a_0$ , where  $a_0$  = Bohr radius

2. Radius of 2nd orbit:  $r_2 = 2^2 a_0 = 4 a_0$

Radius of 3rd orbit:  $r_3 = 3^2 a_0 = 9 a_0$

3. Ratio:  $r_3 : r_2 = 9 a_0 : 4 a_0 = 9:4$

---

## Question38

A point charge of  $17.7 \mu\text{C}$  is placed at a perpendicular distance of 5 cm from the centre of a square.

The amount of electric flux going through the square will be:

(Given  $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$ )

1.  $3.33 \times 10^5 \text{ N}\cdot\text{m}^2/\text{C}$
2.  $2.00 \times 10^6 \text{ N}\cdot\text{m}^2/\text{C}$
3.  $4.08 \times 10^6 \text{ N}\cdot\text{m}^2/\text{C}$
4.  $6.4 \times 10^7 \text{ N}\cdot\text{m}^2/\text{C}$

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: A

Solution:

Correct Answer: 1.  $3.33 \times 10^5 \text{ N}\cdot\text{m}^2/\text{C}$

1. Approximate method: consider the square as one face of an imaginary cube surrounding the charge. A cube has 6 faces, so flux through one face:

$$\Phi = q / (6 \epsilon_0)$$

2. Substitute values:

$$q = 17.7 \mu\text{C} = 17.7 \times 10^{-6} \text{ C}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$$

$$\Phi = 17.7 \times 10^{-6} / (6 \times 8.85 \times 10^{-12})$$

$$= 17.7 \times 10^{-6} / 5.31 \times 10^{-11}$$

$$\approx 3.33 \times 10^5 \text{ N}\cdot\text{m}^2/\text{C}$$

---

## Question39

If the radii of curvature of the faces of a double convex lens are 10 cm and 15 cm, respectively and its refractive index is 1.5, the focal length of the lens in air is

1. 6 cm
2. 12 cm
3. 30 cm
4. 28 cm

Options:

A.

1

B.

2

C.

3

D.

4

**Answer: B**

**Solution:**

Correct Answer: 2. 12 cm

1. Lensmaker's formula for a lens in air:

$$\frac{1}{f} = (\mu - 1) \left[ \frac{1}{R_1} - \frac{1}{R_2} \right]$$

where  $R_1$  and  $R_2$  are radii of curvature of the two surfaces of the lens.

(Convex surfaces: take  $R_1 > 0$ ,  $R_2 < 0$ )

2. Substitute values:

$$\mu - 1 = 1.5 - 1 = 0.5$$

$$\frac{1}{R_1} - \frac{1}{R_2} = \frac{1}{10} - \frac{1}{-15} = \frac{1}{10} + \frac{1}{15} = \frac{3+2}{30} = \frac{5}{30} = \frac{1}{6} \text{ cm}^{-1}$$

3. Focal length:

$$\frac{1}{f} = 0.5 \times \frac{1}{6} = \frac{1}{12} \implies f = 12 \text{ cm}$$

---

## Question40

A current through a wire varies with time, as  $I = \alpha t + \beta t^2$  where  $\alpha = 10 \text{ A s}^{-1}$  and  $\beta = 4 \text{ A s}^{-2}$ . How much charge will cross through a section of the wire in 12 s?

1. 106 C
2. 696 C
3. 912 C
4. 3024 C

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: D**

**Solution:**

Correct Answer: 4. 3024 C

1. Charge  $Q$  is the integral of current over time:

$$Q = \int_0^{12} I(t) dt = \int_0^{12} (At + Bt^2) dt$$

2. Integrate:

$$\int (At + Bt^2) dt = \frac{A}{2} t^2 + \frac{B}{3} t^3$$

3. Substitute values at  $t = 12$  s:

$$\frac{A}{2} t^2 = \frac{10}{2} \times 12^2 = 5 \times 144 = 720 \text{ C}$$

$$\frac{B}{3} t^3 = \frac{4}{3} \times 12^3 = \frac{4}{3} \times 1728 = 2304 \text{ C}$$

4. Total charge:

$$Q = 720 + 2304 = 3024 \text{ C}$$

---

## Question41

According to Bohr's theory, the angular momentum of an electron revolving in the second orbit of the hydrogen atom will be:

1.  $\pi h$
2.  $2\pi h$
3.  $\frac{\pi}{h}$
4.  $\frac{h}{\pi}$

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: D**

**Solution:**

**Correct Answer: 4.  $h/\pi$**

According to Bohr's theory, the angular momentum of an electron in a stationary orbit is **quantized** and is given by the formula:  $L = nh/2\pi$

For the second orbit of the hydrogen atom, the principal quantum number is  $n=2$  substituting  $n=2$  into the formula:  $L = 2h/2\pi = h/\pi$

---

## Question42

A magnetic field energy of  $34 \times 10^{-6} \text{ J}$  is stored in an inductor of inductance 1.7 mH in an LC circuit.

The current flowing in the inductor is:

1. 0.141 A
2. 0.2 A
3. 1.41 A
4. 0.004 A

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

Correct Answer: 2. 0.2 A

1. Energy stored in an inductor:

$$U = \frac{1}{2} LI^2$$

2. Solve for current:

$$I = \sqrt{\frac{2U}{L}}$$

3. Substitute values:

$$L = 1.7 \text{ mH} = 1.7 \times 10^{-3} \text{ H}$$

$$U = 34 \times 10^{-6} \text{ J}$$

$$I = \sqrt{\frac{2 \times 34 \times 10^{-6}}{1.7 \times 10^{-3}}}$$

$$= \sqrt{\frac{68 \times 10^{-6}}{1.7 \times 10^{-3}}}$$

$$= \sqrt{0.04}$$

$$\approx 0.2 \text{ A}$$

---

## Question43

At an instant of time, a magnetic field is applied along the velocity of the particle. The acceleration produced in the particle will be

1. along the velocity.
2. Opposite to the direction of velocity.
3. Perpendicular to the direction of velocity.
4. Zero.

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: D**

**Solution:**

**Correct Answer:** 4. zero

**1. The magnetic force on a charged particle:**

$$F = q(\vec{v} \times \vec{B})$$

**2. If  $\vec{B}$  is along  $\vec{v}$ , then  $\vec{v} \times \vec{B} = vB \sin \theta = 0$ , since  $\theta = 0^\circ$ .**

**3. Hence, the magnetic force  $F = 0 \Rightarrow a = \frac{F}{m} = 0$**

---

## Question44

Which of the following statements is NOT true about X-rays?

- 1. Wavelength Range:  $100 \text{ \AA} - 0.1 \text{ \AA}$
- 2. Frequency Range:  $10^{11} \text{ Hz} - 10^{14} \text{ Hz}$
- 3. Source: Sudden deceleration of fast-moving electrons by a metal target
- 4. More energetic than UV rays

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

Final Answer: Statement (2) is NOT true.

1. Typical X-ray wavelength range:  $0.01 \text{ nm} - 10 \text{ nm}$  ( $0.1 \text{ \AA} - 100 \text{ \AA}$ )  $\rightarrow$  True.

2. Corresponding frequency:  $f = \frac{c}{\lambda} \approx \frac{3 \times 10^8}{10^{-10} \text{ to } 10^{-8} \text{ m}}$

$\Rightarrow f \approx 3 \times 10^{16} \text{ Hz} - 3 \times 10^{19} \text{ Hz} \Rightarrow$  NOT  $10^{11} - 10^{14} \text{ Hz}$  (False).

3. Natural sources include cosmic rays from outer space and radioactive elements on Earth, while artificial sources are primarily X-ray tubes in medical devices and scanners, particle accelerators, and nuclear power plants.  $\Rightarrow$  True.

4. X-rays are more energetic than UV rays since they have higher frequency, and energy of an EM wave is given by  $E = hf$ .

---

## Question45

Identify the important features of the semiconductor devices from the following

1. Semiconductor devices require cathode heating for the production of charge carriers.
2. They have long life and high reliability.
3. They are small in size and consume low power.
4. They operate at high voltage.

Choose the correct answer from the options given below:

1. (A) and (D) only
2. (B) and (C) only
3. (A) and (B) only
4. (B), (C) and (D) only

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: A

Solution:

Correct Answer: 2. (B) and (C) only

Semiconductor devices are known for their **small size and low power consumption**, making them highly suitable for modern electronics. They also have a long **operational life** and are very reliable. In contrast to vacuum tubes, which require cathode heating to emit electrons, semiconductor devices do not need this process for charge carrier production. They typically operate at **lower voltages**.

-----

## Question46

Which of the following statements is correct for a compound microscope?

1. Both the objective and the eye piece should have large aperture
2. Both the objective and the eye piece should have large focal lengths.
3. The eyepiece essentially functions like a simple microscope or a magnifier.
4. The final image is erect with respect to the original object.

Options:

- A. 1
- B. 2
- C. 3
- D. 4

Answer: C

Solution:

A compound microscope uses two lenses: **an objective lens and an eyepiece** (or ocular lens). The objective lens creates a **real, inverted, and magnified** image of the object. The eyepiece then acts like a **simple magnifier**, taking this intermediate image and producing a **final, virtual, and further magnified image** that is inverted with respect to the original object.

Statement 1 is incorrect. To achieve high magnification and resolving power, the objective lens should have a large numerical aperture, which is related to a large aperture, but the **eyepiece's aperture is not the primary factor**.

Statement 2 is incorrect. To achieve high magnification, **both** the objective and eyepiece lenses should have **short focal lengths**.

Statement 4 is incorrect. The final image produced by a compound microscope is **inverted** with respect to the original object, not erect.

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## Question47

Assume an electric field  $E = 30x \hat{i}$  exists in space.

If  $V_0$  is the potential at the origin and  $V_A$  is the potential at  $x = 2$  m, then the potential difference  $V_A - V_0$  is:

1.  $-40$  V
2.  $-60$  V
3.  $0$  V
4.  $60$  V

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

Correct Answer: 2.  $-60$  V

1. Relation between electric field and potential:

$$E = -\frac{dV}{dx} \Rightarrow dV = -E dx$$

2. Integrate to find potential difference:

$$V_A - V_0 = -\int_0^2 E dx = -\int_0^2 30x dx$$

$$= -[15x^2]_0^2$$

$$= -(15 \times 4 - 0)$$

$$= -60 \text{ V}$$

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## Question48

The work functions of Cesium and Platinum are  $1.9$  eV and  $5.7$  eV, respectively. The ratio of their threshold wavelengths, respectively is

1.  $1:3$
2.  $3:1$
3.  $1:9$
4.  $9:1$

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

### Solution:

**Correct Answer: 2. 3:1**

1. Threshold wavelength:  $\lambda = hc / \phi$  h= planck constant, c= speed of light,  $\phi$ =work function of metal

2. Ratio of threshold wavelengths:

$$\lambda_1 / \lambda_2 = \phi_2 / \phi_1$$

$$= 5.7 / 1.9 = 3$$

3. Therefore,  $\lambda_1 : \lambda_2 = 3 : 1$

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## Question49

A series combination of two capacitors  $C_1 = 3 \mu\text{F}$  and  $C_2 = 6 \mu\text{F}$  is connected in parallel with a third capacitor  $C_3 = 4 \mu\text{F}$ .

This system is connected to a 10 V battery. The total energy stored in the system is:

1.  $4 \times 10^{-4} \text{ J}$

2.  $3 \times 10^{-4} \text{ J}$

3.  $6 \times 10^{-4} \text{ J}$

4.  $9 \times 10^{-4} \text{ J}$

**Options:**

A. 1

B. 2

C. 3

D. 4

**Answer: B**

### Solution:

Correct Answer:  $2. 3 \times 10^{-4} \text{ J}$

1. Equivalent capacitance of  $C_1$  and  $C_2$  in series:

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{3} + \frac{1}{6} = \frac{1}{2} \Rightarrow C_s = 2 \mu\text{F}$$

(For series, reciprocals of capacitances are added)

2. Now,  $C_s$  in parallel with  $C_3$  :

$$C = C_s + C_3 = 2 + 4 = 6 \mu\text{F}$$

(For parallel, capacitances are directly added)

3. Energy stored in the system:

$$U = \frac{1}{2} CV^2$$

$$= \frac{1}{2} \times 6 \times 10^{-6} \times (10)^2$$

$$= 0.5 \times 6 \times 10^{-6} \times 100 = 3 \times 10^{-4} \text{ J}$$

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## Question50

The peak value of the electric field associated with an electromagnetic wave traveling through vacuum is  $8.1 \text{ N}\cdot\text{C}^{-1}$ .

The peak value of the associated magnetic field will be:

1.  $24.3 \times 10^8 \text{ T}$
2.  $2.7 \times 10^{-8} \text{ T}$
3.  $2.7 \times 10^8 \text{ T}$
4.  $24.3 \times 10^{-8} \text{ T}$

**Options:**

- A. 1
- B. 2
- C. 3
- D. 4

**Answer: B**

**Solution:**

**Correct Answer: 2.  $2.7 \times 10^{-8} \text{ T}$**

1. Relation between electric and magnetic fields in an EM wave in vacuum:

$$\mathbf{B}_0 = \mathbf{E}_0 / c$$

where  $c$  = speed of light  $\approx 3 \times 10^8 \text{ m/s}$ ,  $\mathbf{B}_0$  is max magnetic field value,  $\mathbf{E}_0$  is max electric field value in that medium

2. Substitute values:

$$\begin{aligned} B_0 &= 8.1 / (3 \times 10^8) \\ &\approx 2.7 \times 10^{-8} \text{ T} \end{aligned}$$

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