UP Board Class 12 Physics Question Paper with Solutions(Memory Based)

Time Allowed :2 Hour	Maximum Marks :30	Total Questions :16

General Instructions

Read the following instructions very carefully and strictly follow them:

- Answers to this Paper must be written on the paper provided separately.
- You will not be allowed to write during the first 15 minutes
- This time is to be spent in reading the question paper.
- The time given at the head of this Paper is the time allowed for writing the answers,
- The paper has four Sections.
- Section A is compulsory - All questions in Section A must be answered.
- You must attempt one question from each of the Sections B, C and D and one other question from any Section of your choice.

1. How a galvanometer be converted into an ammeter and a voltmeter? Express by the correct circuit.

Correct Answer: By connecting a low resistance shunt in parallel for an ammeter and a high resistance in series for a voltmeter.

Solution:

Step 1: Understanding the Concept:
A galvanometer is an instrument designed to detect very small electric currents.
Because it is highly sensitive and has relatively high resistance, it cannot directly measure large currents or voltages unless it is modified.

Step 2: Key Formula or Approach:
1. **Conversion to Ammeter:** Attach a low resistance S (called a shunt) in parallel with the galvanometer.
Formula: $S = \left(\frac{I_g}{I-I_g}\right) G$, where I is the total current and I_g is the full-scale deflection current.
2. **Conversion to Voltmeter:** Attach a high resistance R in series with the galvanometer.
Formula: $R = \frac{V}{I_g} - G$, where V is the desired voltage range.

Step 3: Detailed Explanation:
(a) Conversion into Ammeter:

For current measurement, the instrument should have very low resistance so that it does not noticeably affect the circuit current.
A small resistance called a shunt (S) is connected in parallel with the galvanometer (G).
Most of the current flows through the shunt, thereby safeguarding the delicate galvanometer coil.
Circuit Layout: The total current I divides at a junction; I_g passes through G and $(I - I_g)$ flows through S.

(b) Conversion into Voltmeter:
For voltage measurement, the instrument must have very high resistance so that it draws minimal current.
A large resistance (R) is connected in series with the galvanometer (G).
This ensures that the current through the galvanometer remains limited to I_g.
Circuit Layout: Terminal A, resistor R, galvanometer G, and terminal B are arranged in a single series path.

Step 4: Final Answer:
To convert into an ammeter, use a **low resistance shunt connected in parallel**.
To convert into a voltmeter, use a **high resistance connected in series**.

Quick Tip

Use the memory aids: **PAL** (Parallel-Ammeter-Low) and **SHV** (Series-High-Voltmeter) to easily recall the conversion rules.

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2. Explain the construction and working theory of a transformer.

Correct Answer: It works on the principle of mutual induction using a primary coil, secondary coil, and a soft iron core.

Solution:

Step 1: Understanding the Concept:
A transformer is a stationary electrical device that transfers electrical energy from one circuit to another using electromagnetic induction.
It is commonly used to either raise (step-up) or lower (step-down) AC voltage levels.

Step 2: Key Formula or Approach:
The basic relation for an ideal transformer is based on the turns ratio:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = K$$

Here, V_s and V_p represent the secondary and primary voltages, while N_s and N_p denote the number of turns in the respective coils.

Step 3: Detailed Explanation:
Construction:
1. **Core:** Constructed from laminated soft iron sheets to reduce losses such as eddy currents.
2. **Primary Coil:** Connected to the input AC supply.
3. **Secondary Coil:** Connected to the load where the transformed voltage is delivered.
Both coils are electrically insulated and wound on a shared iron core.

Working Theory:
1. When an alternating voltage is supplied to the primary coil, an alternating current flows through it.
2. This current produces a time-varying magnetic flux in the iron core.
3. The secondary coil, being wound on the same core, is linked with this changing magnetic flux.
4. By Faraday's Law of Electromagnetic Induction, an alternating EMF is induced in the secondary coil.
5. This phenomenon is called **mutual induction**.

Step 4: Final Answer:
A transformer is made up of a **laminated iron core** with **primary and secondary windings**, and it works on the principle of **mutual induction**.

> Quick Tip
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> Transformers operate only on Alternating Current (AC) because Direct Current (DC) does not produce the changing magnetic flux required for electromagnetic induction.

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3. What are electromagnetic waves? By drawing its propagation diagram, show the electric field and magnetic field component in it.

Correct Answer: Waves consisting of oscillating electric and magnetic fields perpendicular to each other and the direction of propagation.

Solution:

Step 1: Understanding the Concept:
Electromagnetic (EM) waves are coupled oscillations of electric and magnetic fields that travel through space.
Unlike mechanical waves, they can propagate even in the absence of a material medium.

Step 3: Detailed Explanation:
Definition:
EM waves are transverse waves generated by accelerating charges.
The electric field vector ($\vec{E}$) and magnetic field vector ($\vec{B}$) oscillate in mutually perpendicular planes.
Both fields are also perpendicular to the direction in which the wave travels.

Propagation Diagram (Descriptive Representation):
Consider a 3D coordinate system (x, y, z):
1. Assume the wave propagates along the **x-axis**.
2. The electric field component E_y oscillates along the **y-axis** (vertical direction).
3. The magnetic field component B_z oscillates along the **z-axis** (perpendicular to both).
If a sine wave representing E is drawn in the vertical plane (xy), the corresponding B wave would appear as a sine curve in the horizontal plane (xz).

Step 4: Final Answer:
Electromagnetic waves are **transverse in nature**, with $\vec{E}$, $\vec{B}$, and the direction of propagation all **mutually perpendicular**.

Quick Tip

All electromagnetic waves travel at the same speed in vacuum, $c \approx 3 \times 10^8$ m/s, independent of their frequency or wavelength.

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4. How is p-n junction diode used as a half-wave rectifier? Explain its working by circuit diagram. Also show input and output waveforms.

Correct Answer: By using its unidirectional current property to block the negative half-cycles of an AC input.

Solution:

Step 1: Understanding the Concept:
Rectification is the process of converting Alternating Current (AC) into Direct Current (DC).
A p-n junction diode functions like a one-way valve, allowing current to pass only in the forward bias condition.

Step 2: Key Principle or Formula:
The operation of a half-wave rectifier is based on the unidirectional conduction property of a diode.
When forward biased, the diode conducts current; when reverse biased, it blocks current.

The average (DC) output voltage for a half-wave rectifier is given by:

$$V_{\text{dc}} = \frac{V_m}{\pi}$$

where V_m is the peak value of the input AC voltage.

Step 3: Detailed Explanation:
Circuit Construction:
A step-down transformer is connected to an AC supply. The secondary winding is connected in series with a diode and a load resistor (R_L).

Working:
1. **Positive Half-Cycle:** The terminal connected to the p-region becomes positive and the n-region becomes negative. The diode is in **forward bias**, so it conducts. Current flows through the load resistor, producing a voltage across it.
2. **Negative Half-Cycle:** The polarity reverses. The p-region becomes negative and the n-region becomes positive. The diode is in **reverse bias**, so it blocks current. No current flows through the load, and the output voltage is zero during this interval.

Waveforms:
- **Input:** A sinusoidal AC wave with alternating positive and negative half-cycles.
- **Output:** Only positive half-cycles appear across the load, while the negative halves are suppressed.

Step 4: Final Answer:
A half-wave rectifier uses **a single diode** to allow only the **positive half-cycles** of an AC input to reach the load, producing a pulsating DC output.

Quick Tip

The maximum efficiency of a half-wave rectifier is approximately 40.6%. For higher efficiency, full-wave rectifiers are preferred.

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5. What is wavefront? Explain refraction of waves by the principle of Huygens secondary wavelets.

Correct Answer: A wavefront is the locus of all points in a medium vibrating in the same phase. Refraction is explained by the change in wavelet speed across a boundary.

Solution:

Step 1: Understanding the Concept:
Huygens' Principle gives a geometrical way to locate the position of a wavefront at any later time.

Step 2: Key Principle or Statement:
According to Huygens' Principle:
1. Every point on a wavefront acts as a source of secondary spherical wavelets.
2. The new wavefront at a later time is the common tangent (envelope) to all these secondary wavelets.

Step 3: Detailed Explanation:
Wavefront:
A wavefront is the surface joining all points of a wave that vibrate in the same phase at a given instant. For a point source, it is spherical; for a distant source, it becomes planar.

Refraction using Huygens' Principle:
1. Consider a plane wavefront AB incident on the boundary separating medium 1 (speed v_1) and medium 2 (speed v_2).
2. Suppose the wave takes time t to travel from point B to C in the first medium, covering distance $v_1 t$.
3. By Huygens' Principle, point A acts as a secondary source. In the same time t, the wavelet from A enters the second medium and travels a distance $v_2 t$.
4. If the second medium is optically denser ($v_2 < v_1$), the wavelet from A advances a shorter distance.
5. The new refracted wavefront is obtained by drawing a tangent to these secondary wavelets.
6. From the geometry of this construction, Snell's Law follows: $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \mu$.

Step 4: Final Answer:
A **wavefront** is a surface of constant phase. Refraction occurs because **secondary wavelets** travel with **different speeds** in different media, causing the wavefront to bend.

> **Quick Tip**
>
> Imagine Huygens' wavelets as tiny ripples emerging from every point on a wave. The visible wavefront is simply the outer boundary of all those overlapping ripples.

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6. Establish an expression of relation between resistance of arms of Wheatstone bridge in its equilibrium position with the help of Kirchhoff's law.

Correct Answer: $\frac{P}{Q} = \frac{R}{S}$ (where P, Q, R, and S are the resistances of the four arms)

Solution:

Step 1: Understanding the Concept:
A Wheatstone bridge is an electrical circuit made of four resistors arranged in a diamond configuration, mainly used to determine an unknown resistance.
The bridge is said to be in equilibrium or balanced when there is no potential difference across the galvanometer.
In this condition, no current flows through the galvanometer ($I_g = 0$).

Step 2: Key Formula or Approach:
The balanced condition is derived using **Kirchhoff's Laws**:
1. **Kirchhoff's Current Law (KCL):** The total current entering a junction equals the total current leaving it ($\sum I = 0$).
2. **Kirchhoff's Voltage Law (KVL):** The algebraic sum of potential differences in a closed loop is zero ($\sum V = 0$).

Step 3: Detailed Explanation:
Consider a bridge with resistors P, Q, R, and S forming quadrilateral $ABCD$.
- A galvanometer of resistance G is connected between points B and D.
- A battery of EMF E is connected across points A and C.

Let total current I reach junction A. It divides into I_1 through arm AB (resistance P) and I_2 through arm AD (resistance R).
At junction B, current I_1 splits into I_g through the galvanometer and I_3 through arm BC (resistance Q). By KCL: $I_1 = I_g + I_3$.
At junction D, currents I_2 and I_g combine to form I_4 through arm DC (resistance S). By KCL: $I_2 + I_g = I_4$.

Balanced Condition:
When the bridge is balanced, $I_g = 0$.
Hence:

$$I_1 = I_3 \quad \text{and} \quad I_2 = I_4$$

Apply KVL to two loops:

Loop $ABDA$:

$$-I_1 P - I_g G + I_2 R = 0$$

Since $I_g = 0$:

$$-I_1 P + I_2 R = 0 \Rightarrow I_1 P = I_2 R \quad \ldots (1)$$

Loop $BCDB$:

$$-I_3 Q + I_4 S + I_g G = 0$$

Using $I_g = 0$, $I_3 = I_1$, and $I_4 = I_2$:

$$-I_1Q + I_2S = 0 \Rightarrow I_1Q = I_2S \quad \ldots(2)$$

Dividing equation (1) by equation (2):

$$\frac{I_1P}{I_1Q} = \frac{I_2R}{I_2S}$$

Cancelling the current terms gives the balanced bridge condition:

$$\frac{P}{Q} = \frac{R}{S}$$

Step 4: Final Answer:

The equilibrium condition of a Wheatstone bridge is:

$$\frac{P}{Q} = \frac{R}{S}$$

Quick Tip

When the bridge is balanced, no current flows through the galvanometer. You can ignore the central branch and treat the circuit as two parallel series arms, making calculations much simpler.
