

Electromagnetic Waves — CBSE Pattern Test 1

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 12 Physics · Electromagnetic Waves · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.

(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.

(3) For MCQ questions choose the single correct option; for VSA answers write a single line.

(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- Displacement current arises due to a changing
 - electric field
 - magnetic field
 - current
 - charge
- The displacement current is given by
 - $\epsilon_0 d\Phi_E/dt$
 - $\mu_0 d\Phi_E/dt$
 - $\epsilon_0 \Phi_E$
 - $\mu_0 d\Phi_B/dt$
- Electromagnetic waves are
 - transverse
 - longitudinal
 - stationary
 - mechanical
- The speed of an EM wave in vacuum is
 - $1/\sqrt{(\mu_0 \epsilon_0)}$
 - $\sqrt{(\mu_0 \epsilon_0)}$
 - $1/(\mu_0 \epsilon_0)$
 - $\mu_0 \epsilon_0$
- The intensity of an electromagnetic wave is proportional to
 - E_0^2
 - E_0
 - $1/E_0$
 - E_0^3
- Which electromagnetic wave has the longest wavelength?
 - radio waves
 - gamma rays
 - X-rays
 - ultraviolet
- Which electromagnetic wave has the highest frequency?
 - gamma rays

(B) radio waves

(C) microwaves

(D) infrared

8. Infrared waves are used in

(A) remote controls and night vision

(B) radiography

(C) cancer therapy

(D) water sterilisation

9. Define displacement current.

10. What is the relation between E_0 and B_0 in an EM wave in vacuum?

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. An EM wave has an electric field amplitude of 60 V/m. Find the magnetic field amplitude.

12. A radio wave has a frequency of 3×10^9 Hz. Find its wavelength.

13. An EM wave has an intensity of 30 W/m². Find the radiation pressure on complete absorption.

14. Arrange gamma rays, X-rays, visible light and radio waves in increasing order of wavelength.

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Define displacement current and show that it equals the conduction current in a charging capacitor.

16. State the properties of electromagnetic waves and derive the expression for their speed in vacuum.

17. Derive the expression for the average energy density of an EM wave and show it is shared equally between the electric and magnetic fields.

18. What is the electromagnetic spectrum? Describe its regions in order of increasing wavelength with one use of each.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Explain the concept of displacement current and why Maxwell introduced it. Show that in a charging parallel-plate capacitor the displacement current equals the conduction current in the connecting wires.

20. Derive the expressions for the average energy density, intensity and radiation pressure of an electromagnetic wave, distinguishing between the absorbed and reflected cases.

Answer Key (Marking Scheme)

Q1 — (A) electric field. Q2 — (A) $\epsilon_0 d\Phi_E/dt$. Q3 — (A) transverse. Q4 — (A) $1/\sqrt{(\mu_0\epsilon_0)}$.

Q5 — (A) E_0^2 . Q6 — (A) radio waves. Q7 — (A) gamma rays. Q8 — (A) remote controls and night vision.

Q9 — The current due to a changing electric field: $I_d = \epsilon_0 d\Phi_E/dt$.

Q10 — $E_0 = cB_0$.

Q11 — $B_0 = E_0/c = 2 \times 10^{-7}$ T.

Q12 — $\lambda = c/f = 3 \times 10^8 / 3 \times 10^9 = 0.1$ m.

Q13 — $P = I/c = 30 / 3 \times 10^8 = 1 \times 10^{-7}$ Pa.

Q14 — gamma < X-rays < visible < radio waves (increasing wavelength).

Q15 — Between the plates $\Phi_E = EA$ with $E = \sigma/\epsilon_0$; $\epsilon_0 d\Phi_E/dt = dq/dt = I$, the conduction current.

Q16 — Transverse, $E \perp B$, no medium needed; from Maxwell's equations $c = 1/\sqrt{(\mu_0\epsilon_0)}$.

Q17 — $u_E = \frac{1}{2}\epsilon_0 E^2$, $u_B = \frac{B^2}{2\mu_0}$ with $E = cB$, giving $u_E = u_B$; total $u = \epsilon_0 E^2_{\text{rms}}$ etc.

Q18 — The ordered array of EM waves by wavelength/frequency: radio, microwave, IR, visible, UV, X-ray, gamma; with uses as in the notes.

Q19 — A charging capacitor has a changing E between the plates, giving a displacement current that maintains current continuity; $I_d = \epsilon_0 d\Phi_E/dt = dq/dt = I$.

Q20 — $u = \frac{1}{2}\epsilon_0 E_0^2$, $I = u c$, radiation pressure $P = I/c$ (absorbed) and $P = 2I/c$ (reflected).