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Electromagnetic Waves — CBSE Class 12 Physics Chapter Test

FREE CHAPTER TEST · CLASS XII · PHYSICS (042) · PATTERN OF THE CBSE SAMPLE QUESTION PAPER 2026-27

TIME ALLOWED	MAXIMUM MARKS	QUESTIONS	NAME / ROLL NO.
1½ hours	37	17 (A 8 · B 3 · C 3 · D 1 · E 2)	

GENERAL INSTRUCTIONS

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 17 questions. All questions are compulsory.
2. This question paper is divided into five sections: A, B, C, D and E.
3. Section A (Q1–8) contains 6 multiple choice questions and 2 assertion-reason based questions of 1 mark each.
4. Section B (Q9–11) contains short answer questions of 2 marks each.
5. Section C (Q12–14) contains short answer questions of 3 marks each.
6. Section D (Q15) contains case study based questions of 4 marks each, with four sub-parts of 1 mark.
7. Section E (Q16–17) contains long answer questions of 5 marks each.
8. There is no overall choice. However, an internal choice has been provided in 1 question in Section B, 1 question in Section C, 2 questions in Section E. Attempt only one of the alternatives in such questions.
9. Use of calculators is not allowed. You may use: $c = 3 \times 10^{8}$ m s^{-1}, $\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}, $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}.
10. This chapter test follows the section structure, question types and marks per question of the CBSE Class XII Physics (042) Sample Question Paper 2026-27, at about half the length of the 70-mark board paper: 37 marks in 1½ hours.
11. The answer key and the marking scheme are at the end of this booklet. Attempt the paper in 1½ hours before you look at them.

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Chapter: Electromagnetic Waves · **Topics:** Displacement current and the Ampère-Maxwell law · Sources and nature of electromagnetic waves · Energy density and intensity · Electromagnetic spectrum and uses

SECTION A

This section comprises 8 questions of 1 mark each: 6 multiple choice questions (MCQs) and 2 assertion-reason based questions.

1. A 2.0 μF capacitor is being charged so that the potential difference across it rises at 5.0×10^5 V s^{-1}. The displacement current between its plates is 1

(A) 0.10 A (B) 1.0 A

(C) 10 A (D) 2.5 A

2. In a plane electromagnetic wave in vacuum, the amplitude of the electric field is 30 V m^{-1}. The amplitude of the magnetic field is 1

(A) 9.0×10^9 T (B) 3.0×10^{-7} T

(C) 30 T (D) 1.0×10^{-7} T

3. Which of the following has the shortest wavelength? 1

(A) Gamma rays (B) X-rays

(C) Ultraviolet rays (D) Microwaves

4. The frequency of light of wavelength 600 nm in vacuum is 1

(A) 5.0×10^{12} Hz (B) 2.0×10^{14} Hz

(C) 5.0×10^{14} Hz (D) 1.8×10^{17} Hz

5. The electromagnetic waves used in radar systems for aircraft navigation are 1

(A) infrared rays (B) gamma rays

(C) X-rays (D) microwaves

6. In a plane electromagnetic wave, the electric and magnetic fields are 1

(A) parallel to each other (B) perpendicular to each other and to the direction of propagation

(C) both along the direction of propagation (D) out of phase by π/2

7. **Assertion (A) :** Electromagnetic waves can travel through a vacuum. 1

Reason (R) : An electromagnetic wave consists of oscillating electric and magnetic fields that sustain each other, so it needs no material medium.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

8. **Assertion (A) :** Infrared radiation is often called heat waves. 1

Reason (R) : Infrared radiation has a shorter wavelength than ultraviolet radiation.

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

SECTION B

This section comprises 3 short answer questions of 2 marks each.

9. A parallel plate capacitor with plates of area 0.020 m^2 is being charged by a current of 0.15 A. Find the displacement current between the plates and the rate at which the electric field between them is changing. 2

10. (a) Why did Maxwell have to add the displacement current to Ampère's circuital law? Write the Ampère-Maxwell law. 2

OR

(b) Show that in a plane electromagnetic wave in vacuum, the energy density of the electric field equals the energy density of the magnetic field.

11. The magnetic field of a plane electromagnetic wave in vacuum is $B_y = 3.0 \times 10^{-8} \sin(2.0 \times 10^2 x + 6.0 \times 10^{10} t)$ T (x in metres, t in seconds). Find its wavelength and frequency, and the amplitude of its electric field. 2

SECTION C

This section comprises 3 short answer questions of 3 marks each.

12. (a) Name the part of the electromagnetic spectrum (i) used to kill germs in water purifiers, (ii) used to treat some cancers and (iii) used in TV remote controls. Arrange the three in order of increasing wavelength. 3

OR

(b) (i) What produces electromagnetic waves?
(ii) Why does a charge moving with constant velocity not produce them?
(iii) A charge oscillates with frequency ν. What is the frequency of the electromagnetic wave it produces?

13. A charge oscillating at a frequency of 1.5×10^9 Hz produces electromagnetic waves. (i) Find their wavelength and name the part of the spectrum. (ii) Find the period. (iii) What is the speed of these waves in a medium of relative permittivity 4.0 and relative permeability 1.0? 3

14. The amplitude of the electric field in a laser beam is 600 V m^{-1}. Find (i) the amplitude of its magnetic field, (ii) its average energy density and (iii) its intensity. 3

SECTION D

This section comprises 1 case study based question of 4 marks, with four sub-parts of 1 mark each.

15. A microwave oven heats food with microwaves of frequency 2.45 GHz. The waves are absorbed by the water molecules in the food, which then vibrate faster, and the food gets hot. The metal walls of the oven reflect the microwaves and keep them inside.

(I) The wavelength of these microwaves is about

(A) 1.22 cm (B) 12.2 cm (C) 122 cm (D) 0.122 cm [1]

(II) Food is heated in a microwave oven mainly because the microwaves

(A) ionise the food (B) are reflected by the food (C) travel faster inside the food (D) are absorbed strongly by water molecules [1]

(III) In the electromagnetic spectrum, microwaves lie between

(A) infrared and radio waves (B) ultraviolet and visible light (C) X-rays and gamma rays (D) visible light and ultraviolet [1]

(IV) Compared with visible light, the speed of microwaves in vacuum is

(A) greater (B) smaller (C) the same (D) dependent on their intensity [1]

SECTION E

This section comprises 2 long answer questions of 5 marks each.

16. (a) (i) Explain, with the example of a capacitor being charged, why the idea of displacement current is needed. Show that the displacement current between the plates equals the conduction current in the connecting wires. 5

(ii) A capacitor with circular plates of radius 10 cm is being charged by a steady current of 0.20 A. Find the magnetic field between the plates at a distance of 5.0 cm from the axis, and at 20 cm from the axis.

OR

(b) (i) Write any four properties of electromagnetic waves.

(ii) An electromagnetic wave of frequency 50 MHz travels in vacuum along the +x direction. At a certain point and instant its electric field is $9.0\,\hat{\jmath}$ V m^{-1}. Find the magnitude and direction of the magnetic field there, and the wavelength.

17. (a) (i) Arrange gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves and radio waves in order of increasing wavelength. State how X-rays and microwaves are produced. 5

(ii) Visible light has wavelengths from about 400 nm to 700 nm. Find the corresponding range of frequencies.

OR

(b) (i) Show that the average intensity of a plane electromagnetic wave of electric-field amplitude E_0 in vacuum is $\tfrac{1}{2}c\varepsilon_0 E_0^2$.

(ii) Sunlight reaching the ground has an intensity of about 1.0 kW m^{-2}. Treating it as a plane wave, find the amplitudes of its electric and magnetic fields.

END OF THE QUESTION PAPER

ANSWER KEY — SECTION A

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
(B)	(D)	(A)	(C)	(D)	(B)	(A)	(C)

MARKING SCHEME AND WORKED SOLUTIONS

Marks for each step are shown in brackets, as in the CBSE marking scheme. Any correct alternative method earns full marks.

Q1. Answer (B). $i_d = \varepsilon_0 \, d\Phi_E/dt = C \, dV/dt = 2.0 \times 10^{-6} \times 5.0 \times 10^5 = 1.0$ A.

Q2. Answer (D). $B_0 = E_0/c = 30/(3 \times 10^8) = 1.0 \times 10^{-7}$ T.

Q3. Answer (A). Gamma rays have the highest frequency and the shortest wavelength (below about 10^{-10} m).

Q4. Answer (C). $\nu = c/\lambda = 3 \times 10^8/(600 \times 10^{-9}) = 5.0 \times 10^{14}$ Hz.

Q5. Answer (D). Radar uses microwaves: short enough to be beamed and reflected from aircraft.

Q6. Answer (B). The wave is transverse: E ⊥ B, both ⊥ the direction of propagation (along E × B), and they oscillate in phase.

Q7. Answer (A). A changing E produces B and a changing B produces E: the wave carries itself without a medium. R explains A. Answer (A).

Q8. Answer (C). A is true (infrared is readily absorbed by water molecules and raises the temperature). R is false: infrared has a longer wavelength than ultraviolet. Answer (C).

Q9. (2 marks) Answer: 0.15 A; ≈ 8.5×10^{11} V m^{-1} s^{-1}.
The displacement current equals the conduction current in the leads: $i_d = 0.15$ A. [1]
$i_d = \varepsilon_0 A \, dE/dt$, so $dE/dt = 0.15/(8.854 \times 10^{-12} \times 0.020) \approx 8.5 \times 10^{11}$ V m^{-1} s^{-1}. [1]

Q10. (2 marks) Answer: (a) $\oint B \cdot dl = \mu_0(i_c + \varepsilon_0 \, d\Phi_E/dt)$; (b) $u_B = u_E$.
(a) For a loop round the wire leading to a charging capacitor, $\oint B \cdot dl = \mu_0 i$ for a surface cut by the wire but zero for a surface passing between the plates (no conduction current there): the law gave two answers. The changing electric field between the plates acts as a current, $i_d = \varepsilon_0 \, d\Phi_E/dt$, which removes the contradiction. [1]
$\oint B \cdot dl = \mu_0(i_c + \varepsilon_0 \, d\Phi_E/dt)$. [1]
OR (b) $u_E = \tfrac{1}{2}\varepsilon_0 E^2$ and $u_B = B^2/2\mu_0$. [1] With $B = E/c$ and $c^2 = 1/\mu_0\varepsilon_0$: $u_B = E^2/(2\mu_0 c^2) = \tfrac{1}{2}\varepsilon_0 E^2 = u_E$. [1]

Q11. (2 marks) Answer: ≈ 3.14 cm; ≈ 9.5×10^9 Hz; 9.0 V m^{-1}.
$\lambda = 2\pi/k = 2\pi/200 \approx 3.14 \times 10^{-2}$ m; $\nu = \omega/2\pi = 6.0 \times 10^{10}/2\pi \approx 9.5 \times 10^9$ Hz ($\omega/k = 3 \times 10^8$ m s^{-1}, as it must be). [1]
$E_0 = cB_0 = 3 \times 10^8 \times 3.0 \times 10^{-8} = 9.0$ V m^{-1} (along the z-axis, the wave moving along −x). [1]

Q12. (3 marks) Answer: (a) UV; gamma; infrared; γ < UV < IR.
(a) (i) Ultraviolet rays. [½] (ii) Gamma rays. [½] (iii) Infrared rays. [½]
Increasing wavelength: gamma rays < ultraviolet < infrared. [1½]
OR (b) (i) An accelerated charge: its electric field changes, which sets up a changing magnetic field, and so on: a wave. [1]
(ii) A charge moving with constant velocity has fields that move along with it without radiating; a wave needs acceleration. [1]
(iii) Its frequency equals the frequency of oscillation of the charge. [1]

Q13. (3 marks) Answer: (i) 0.20 m, microwaves; (ii) ≈ 6.7×10^{-10} s; (iii) 1.5×10^8 m s^{-1}.
(i) $\lambda = c/\nu = 3 \times 10^8/1.5 \times 10^9 = 0.20$ m: microwaves. [1]
(ii) $T = 1/\nu \approx 6.7 \times 10^{-10}$ s. [1]
(iii) $v = 1/\sqrt{(\mu_0\mu_r\varepsilon_0\varepsilon_r)} = c/\sqrt{(\varepsilon_r\mu_r)} = 3 \times 10^8/2 = 1.5 \times 10^8$ m s^{-1}. [1]

Q14. (3 marks) Answer: (i) 2.0×10^{-6} T; (ii) $\approx 1.6 \times 10^{-6}$ J m^{-3}; (iii) $\approx 4.8 \times 10^{2}$ W m^{-2}.

(i) $B_0 = E_0/c = 600/3 \times 10^8 = 2.0 \times 10^{-6}$ T. [1]

(ii) The time-average of $\varepsilon_0 E^2$ is $\tfrac{1}{2}\varepsilon_0 E_0^2$, and the magnetic part is equal: $u = \tfrac{1}{2}\varepsilon_0 E_0^2 = \tfrac{1}{2} \times 8.854 \times 10^{-12} \times 600^2 \approx 1.6 \times 10^{-6}$ J m^{-3}. [1]

(iii) $I = uc \approx 1.6 \times 10^{-6} \times 3 \times 10^8 \approx 4.8 \times 10^{2}$ W m^{-2}. [1]

Q15. (4 marks) Answer: (I) B; (II) D; (III) A; (IV) C.

(I) (B) $\lambda = c/\nu = 3 \times 10^8/2.45 \times 10^9 \approx 0.122$ m = 12.2 cm. [1]

(II) (D) The energy is absorbed by the water molecules, raising their kinetic energy. [1]

(III) (A) The order is … infrared, microwaves, radio waves. [1]

(IV) (C) All electromagnetic waves travel at $c = 1/\sqrt{(\mu_0\varepsilon_0)}$ in vacuum. [1]

Q16. (5 marks) Answer: (a) $i_d = i$; 2.0×10^{-7} T at both points; (b) 3.0×10^{-8} T along $\hat{k}$; 6.0 m.

(a) (i) Ampère's law applied to a loop round the wire gives $\mu_0 i$ for a flat surface cut by the wire, but zero for a pot-shaped surface passing between the plates, where no charge flows. [1] Between the plates $E = q/\varepsilon_0 A$, so $\Phi_E = EA = q/\varepsilon_0$ and $\varepsilon_0 \, d\Phi_E/dt = dq/dt = i$: the displacement current equals the conduction current, and both surfaces now give $\mu_0 i$. [2]

(ii) Inside (r = 5 cm) the loop encloses $i_d \, r^2/R^2$: $B = \mu_0 i \, r/(2\pi R^2) = 2 \times 10^{-7} \times 0.20 \times 0.05/0.01 = 2.0 \times 10^{-7}$ T. [1] Outside (r = 20 cm) it encloses all of it: $B = \mu_0 i/(2\pi r) = 2 \times 10^{-7} \times 0.20/0.20 = 2.0 \times 10^{-7}$ T. [1]

OR (b) (i) Any four, e.g. [3]: transverse — E and B perpendicular to each other and to the direction of travel (along E × B); E and B in phase, with $E_0/B_0 = c$; speed in vacuum $c = 1/\sqrt{(\mu_0\varepsilon_0)} \approx 3 \times 10^8$ m s^{-1} for all wavelengths; need no medium; carry energy (and momentum), shared equally by E and B.

(ii) $B_0 = E/c = 9.0/3 \times 10^8 = 3.0 \times 10^{-8}$ T. [1] E × B must point along x: $\hat{\jmath} \times \hat{k} = \hat{\imath}$, so B is along +z ($\hat{k}$). $\lambda = c/\nu = 3 \times 10^8/50 \times 10^6 = 6.0$ m. [1]

Q17. (5 marks) Answer: (a) γ < X < UV < visible < IR < micro < radio; $\approx 4.3 \times 10^{14}$ Hz to 7.5×10^{14} Hz; (b) $I = \tfrac{1}{2}c\varepsilon_0 E_0^2$; $\approx 8.7 \times 10^{2}$ V m^{-1}; $\approx 2.9 \times 10^{-6}$ T.

(a) (i) Gamma rays < X-rays < ultraviolet < visible < infrared < microwaves < radio waves. [1] X-rays: by bombarding a metal target with high-energy electrons (X-ray tube). [1] Microwaves: in special vacuum tubes such as klystrons, magnetrons and Gunn diodes. [1]

(ii) $\nu = c/\lambda$: $3 \times 10^8/700 \times 10^{-9} \approx 4.3 \times 10^{14}$ Hz to $3 \times 10^8/400 \times 10^{-9} = 7.5 \times 10^{14}$ Hz. [2]

OR (b) (i) Average energy density: $u_E + u_B = \tfrac{1}{2}\varepsilon_0 E^2 + B^2/2\mu_0 = \varepsilon_0 E^2$ (the two equal, as $B = E/c$). The time-average of $E^2 = E_0^2 \sin^2\omega t$ is $\tfrac{1}{2}E_0^2$, so $u = \tfrac{1}{2}\varepsilon_0 E_0^2$. [2] This energy moves at c, so the energy crossing unit area per second is $I = uc = \tfrac{1}{2}c\varepsilon_0 E_0^2$. [1]

(ii) $E_0 = \sqrt{(2I/c\varepsilon_0)} = \sqrt{(2 \times 1000/(3 \times 10^8 \times 8.854 \times 10^{-12}))} \approx 8.7 \times 10^{2}$ V m^{-1}. [1] $B_0 = E_0/c \approx 2.9 \times 10^{-6}$ T. [1]

All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: speeds and wavelengths from the constants, the wave equation by finite differences, intensities by averaging the field energy over a cycle.