



Attempt all questions before checking the answer key. Use $c = 3 \times 10^8$ m/s. Treat propagation as occurring in vacuum unless stated.

A. Very short answers - 1 mark each

1. What is displacement current?
2. Name the source of electromagnetic radiation in terms of charge motion.
3. Are electric and magnetic fields in an electromagnetic wave parallel or perpendicular?
4. Which electromagnetic radiation has the highest frequency in the usual spectrum classification?

B. Short answers / practice - 2 marks each

5. Why is a changing electric field associated with a magnetic field?
6. A wave has wavelength 600 nm. Find its frequency and identify the spectral region.
7. The electric-field amplitude is 90 V/m. Find the magnetic-field amplitude.
8. Give one use each of microwaves and infrared radiation and connect each use to a relevant property.
9. Do electromagnetic waves require a material medium?
10. Find wavelength for a 100 MHz radio wave.
11. Find frequency for wavelength 3 cm.
12. Calculate E_0 for $B_0 = 2 \mu\text{T}$.
13. Are electromagnetic waves transverse in vacuum?
14. Which radiation is used in thermal imaging? Explain its origin.
15. Why are X-rays suitable for imaging bones?
16. Compare ultraviolet and infrared radiation by frequency and photon energy.
17. Find the period of a wave of frequency 6×10^{14} Hz.
18. Does every electromagnetic wave have the same frequency?
19. Name the spectral region between visible light and X-rays.
20. Explain why a steady current does not create a changing electric field between fully charged capacitor plates.

21. Find displacement current when $d\Phi_E/dt = 10^{10}$ V m/s.

22. State how wave speed relates to vacuum permittivity and permeability.

C. Short answers - 3 marks each

23. Arrange radio waves, ultraviolet, visible light, gamma rays and infrared in increasing frequency. Explain why all have the same speed in vacuum.
24. A plane wave travels along +x with its electric field along +y at an instant. Find the magnetic-field direction and state how it changes if propagation reverses.
25. Explain the role of displacement current in resolving the apparent current discontinuity in a charging capacitor.
26. A capacitor's electric flux changes at 2×10^{12} V m/s. Find displacement current using $\epsilon_0 = 8.85 \times 10^{-12}$ F/m. Compare it with the conduction current in the connecting wire.

D. Long answers - 5 marks each

27. Describe the main characteristics of electromagnetic waves: origin, field directions, speed, energy transfer and need for a material medium.
28. A capacitor is charged at 0.02 A. Explain the conduction and displacement currents, calculate $d\Phi_E/dt$, and discuss their associated magnetic fields.
29. For radio, microwave, infrared, visible, ultraviolet, X-ray and gamma regions, give one typical source or production process and one application of each.
30. A vacuum plane wave has electric-field amplitude 120 V/m and frequency 5×10^{14} Hz. Find wavelength, magnetic amplitude and period; sketch the mutually perpendicular field and propagation directions.

ANSWER KEY - Numerical / short answers

- 3) Perpendicular to each other and to propagation. 6) 5×10^{14} Hz; visible. 7) 3×10^{-7} T. 9) No. 10) 3 m. 11) 10^{10} Hz. 12) 600 V/m. 13) Yes. 17) 1.67×10^{-15} s. 18) No; their vacuum speeds are the same. 19) Ultraviolet. 21) 0.0885 A. 22) $c = 1/\sqrt{(\mu_0\epsilon_0)}$. 24) +z; -z if propagation reverses while E remains +y. 26) 17.7 A; equal to the charging conduction current. 28) Both currents 0.020 A; $d\Phi_E/dt \approx 2.26 \times 10^9$ V m/s. 30) 600 nm; 4×10^{-7} T; 2×10^{-15} s.