EM Field Theory Important Questions PDF

Electromagnetic Field Theory usually covers vector analysis and coordinate systems, electrostatics, magnetostatics, Maxwell's equations with plane waves, and transmission lines with waveguides. The most repeated questions are Gauss law and boundary conditions, Biot-Savart and Ampere's law, displacement current, wave equation and skin depth, Poynting theorem, reflection coefficient, VSWR and waveguide cut-off.

Key takeaways

- Vector analysis: Cartesian, cylindrical and spherical coordinates, gradient, divergence, curl and integral theorems.
- Electrostatics and magnetostatics: Gauss law, potential, capacitance, boundary conditions, Biot-Savart and Ampere's law.
- Time-varying fields: Maxwell's equations, plane waves, intrinsic impedance, skin depth and Poynting vector.
- Transmission lines and waveguides: Z0, reflection coefficient, VSWR, quarter-wave transformer, Smith chart, TE10 cut-off.
- These are practice questions based on common syllabus topics, not verified past papers.

About these important questions

These are **practice questions** built from topics that appear in most Indian B.Tech syllabi for Electromagnetic Field Theory, including AKTU and universities that follow the AICTE model curriculum. They are **not verified past papers**, and we do not claim that any question will appear in your exam. Unit numbers and topic order differ between universities, so first match each unit below with your own university syllabus. For real previous papers, use your university's official archive. AKTU students can download them from the AKTU old question paper page.

Each unit lists key definitions, derivations or theory questions, numericals with short answer outlines, and long-answer questions. Use the outlines to check your method, then write full solutions yourself.

Unit 1: Vector Analysis and Coordinate Systems

Key definitions: scalar and vector fields, dot and cross products, Cartesian, cylindrical and spherical coordinates, differential length, area and volume elements, gradient, divergence, curl, Laplacian.

Important questions:

- Transform a vector from Cartesian to cylindrical or spherical coordinates at a given point.
- Find the divergence and curl of a given field and state whether it is solenoidal or irrotational.
- Verify the divergence theorem for a given field over a cube or cylinder.
- Verify Stokes' theorem for a given field over a quarter circle or rectangle.

Unit 2: Electrostatics

Key definitions: Coulomb's law, electric field intensity, electric flux density, Gauss law, electric potential, $E = -\nabla V$, dipole, energy density, conductors and dielectrics, polarisation, boundary conditions, capacitance, Poisson's and Laplace's equations, method of images.

Derivations:

- Use Gauss law to find E due to an infinite line charge ($E = \rho L/(2\pi\varepsilon 0\ r)$) and an infinite sheet of charge ($E = \rho S/(2\varepsilon 0)$).
- Derive the boundary conditions at a dielectric-dielectric interface: tangential E is continuous, and normal D is continuous when there is no surface charge.
- Derive the capacitance of a parallel plate capacitor ($C = \varepsilon A/d$) and of a coaxial cable.
- Derive the energy density in an electrostatic field: $w = (1/2)\varepsilon E^2$.

Numericals (answer outline):

- Find E at a point due to two point charges using vector addition of Coulomb fields.
- Solve Laplace's equation for the potential between two parallel plates and find the field.

Unit 3: Magnetostatics

Key definitions: Biot-Savart law, Ampere's circuital law, magnetic flux density, magnetic vector potential, magnetic force on a charge and a current, magnetic boundary conditions, inductance, magnetic energy.

Derivations:

- Use Biot-Savart law to find H on the axis of a circular loop and due to a finite straight conductor.
- Use Ampere's law to find H due to an infinite line current ($H = I/(2\pi r)$) and inside a coaxial cable.
- Derive the inductance of a solenoid and of a coaxial cable.
- Derive the magnetic boundary conditions.

Unit 4: Maxwell's Equations and Plane Waves

Key definitions: Faraday's law, displacement current, Maxwell's equations in point and integral form, wave equation, uniform plane wave, intrinsic impedance, propagation constant, loss tangent, skin depth, Poynting vector, polarisation, reflection at normal incidence.

Results to remember: intrinsic impedance of free space $\eta 0 = 120\pi \approx 377\ \Omega$; skin depth $\delta = 1/\sqrt{(\pi f \mu \sigma)}$; reflection coefficient at normal incidence $\Gamma = (\eta 2 - \eta 1)/(\eta 2 + \eta 1)$.

Derivations and numericals (answer outline):

- Explain why Maxwell added the displacement current term to Ampere's law, using the continuity equation.
- Derive the wave equation for a lossy medium and find α and β.
- State and prove the Poynting theorem and explain each term.
- Find the skin depth of copper at a given frequency, using $\sigma \approx 5.8 \times 10^7$ S/m and $\mu = \mu_0$.
- A wave in air hits a lossless dielectric with $\varepsilon_r = 4$ at normal incidence. Find Γ. Outline: $\eta_2 = \eta_0/2$, so $\Gamma = (\eta_0/2 - \eta_0)/(\eta_0/2 + \eta_0) = -1/3$.

Unit 5: Transmission Lines and Waveguides

Key definitions: distributed parameters (R, L, G, C), characteristic impedance, propagation constant, lossless line, input impedance, reflection coefficient, VSWR, quarter-wave and half-wave lines, stub matching, Smith chart, TE and TM modes, cut-off frequency.

Numericals (answer outline):

- A 50 Ω line is terminated in 100 Ω. Find Γ and VSWR. Answer: $\Gamma = (100 - 50)/(100 + 50) = 1/3$, VSWR $= (1 + 1/3)/(1 - 1/3) = 2$.
- Match a 100 Ω load to a 50 Ω line with a quarter-wave transformer. Answer: $Z = \sqrt{(50 \times 100)} \approx 70.7$ Ω.
- Find the cut-off frequency of the TE10 mode in a rectangular waveguide with $a = 2.286$ cm. Answer: $f_c = c/(2a) \approx 6.56$ GHz.
- Use the Smith chart to find the input impedance of a line of given length and load, and to design a single-stub match.

Long-answer questions: Derive the input impedance of a lossless transmission line: $Z_{in} = Z_0(Z_L + jZ_0 \tan \beta l)/(Z_0 + jZ_L \tan \beta l)$. Explain why TEM waves cannot travel in a hollow rectangular waveguide.

How to score well in Electromagnetic Field Theory

- Always write which coordinate system you are using and the correct differential elements.
- Draw the Gaussian surface or Amperian loop in every symmetry-based question.
- Learn the four Maxwell equations in both forms with their physical meaning. They are asked in almost every paper.
- Practise the Smith chart with a ruler and compass before the exam.

Short-answer (2-mark) questions for Electromagnetic Field Theory

Short questions test definitions and one-line results. Practise answering each in two to four lines:

1. Define divergence and give its physical meaning.
2. State Gauss law.
3. Write the relation between E and V.
4. What are the boundary conditions at a conductor surface?
5. State Ampere's circuital law.

6. What is magnetic vector potential?
7. What is displacement current density? (Answer: ∂D/∂t.)
8. What is the intrinsic impedance of free space? (Answer: about 377 Ω.)
9. Define skin depth.
10. What does the Poynting vector represent?
11. Define VSWR and give its range. (Answer: 1 to infinity.)
12. Why can a waveguide not carry TEM waves?

A 7-day revision plan for Electromagnetic Field Theory

Use this plan in the last week before the exam. Adjust it to the units and weightage in your own syllabus.

- **Day 1 (Unit 1, Vector Analysis and Coordinate Systems):** revise the definitions, then solve the numericals and one long answer from this unit without notes.
- **Day 2 (Unit 2, Electrostatics):** revise the definitions, then solve the numericals and one long answer from this unit without notes.
- **Day 3 (Unit 3, Magnetostatics):** revise the definitions, then solve the numericals and one long answer from this unit without notes.
- **Day 4 (Unit 4, Maxwell's Equations and Plane Waves):** revise the definitions, then solve the numericals and one long answer from this unit without notes.
- **Day 5 (Unit 5, Transmission Lines and Waveguides):** revise the definitions, then solve the numericals and one long answer from this unit without notes.
- **Day 6:** attempt one full three-hour practice paper made from these questions, or an official previous paper from your university archive.
- **Day 7:** go through your formula sheet, the short-answer list and every question you got wrong in the practice paper.

Frequently asked questions

Why is Electromagnetic Field Theory considered difficult?

It needs vector calculus, three coordinate systems and physical reasoning together. Revising vector analysis first and drawing each problem makes the later units much easier.

Which derivations are most important in EMFT?

Gauss law applications, boundary conditions, Biot-Savart and Ampere's law applications, the wave equation, the Poynting theorem and the input impedance of a transmission line are asked most often.

Do I need the Smith chart for the exam?

Most syllabi include it. Practise finding input impedance, VSWR and single-stub matching on a printed Smith chart, and check whether your university provides charts in the exam.

Are these questions from real past papers?

No. These are practice questions based on topics that are common in B.Tech syllabi. They are not verified past papers, and no question is promised to appear in your exam. Check your own university syllabus and official previous papers; AKTU students can use the AKTU old question paper archive.

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