

Recitation Questions for

Chapter 12 – Plane Wave Reflection and Dispersion

in W. H. Hayt, Jr. and J. A. Buck, *Engineering Electromagnetics*, McGraw-Hill, 2019, pp. 409-455.

The purpose of these recitation questions is to assist the reader in assessing their mastery of the key concepts introduced in this chapter. The answers can be found in the textbook. ELEC 311 students should be prepared to provide answers to these questions in class or on an exam.

Introduction

1. What are the two major themes of this chapter?

12.1 Reflection of Uniform Plane Waves at Normal Incidence

1. What is the goal of this section?

12.1.1 Reflected and Transmitted Waves at a Boundary

1. Sketch the problem geometry for reflected and transmitted waves at a boundary.
2. Give expressions for the incident, reflected and transmitted fields at the boundary.

12.1.2 Reflection and Transmission Coefficients

1. What conditions must be satisfied by the incident, reflected and transmitted fields in the case of a single interface and normal incidence
2. Derive an expression for the voltage reflection coefficient at a boundary in terms of the intrinsic impedances of each region.

12.1.3 Total Reflection: Standing Wave Ratio

1. What is a standing wave?
2. Describe the standing wave pattern that arises when a forward travelling wave is totally reflected.
3. Give expressions for the distance between, and the location of, the nulls in the standing wave pattern.
4. What is the average power as determined through the Poynting in the forward and backward directions?

12.1.4 *Partial Reflection and Power Reflectivity*

1. Given the voltage reflection coefficient at a boundary, find the power reflection coefficient.
2. Given the voltage transmission coefficient at a boundary, find the power transmission coefficient.
3. What is the general relation between the reflected and incident power?

12.2 *Standing Wave Ratio*

1. Given an expression for the locations of the minima and maxima in a standing wave in terms of Γ .
2. What are two ways we can express the total field in a standing wave?
3. How is the voltage standing wave ratio defined in terms of Γ ?
4. How is the voltage standing wave ratio defined in terms of V_{\max} and V_{\min} ?

12.3 *Wave Reflection from Multiple Interfaces*

1. Why is wave reflection from multiple interfaces of interest?

12.3.1 *The Two-Interface Problem*

1. Sketch the problem geometry for reflected and transmitted waves in the two-interface problem.
2. List the five reflected and transmitted waves in the two-interface problem.

12.3.2 *Wave Impedance*

1. What is wave impedance?
2. Give an expression for wave impedance as a function of distance.
3. How can we use this expression to solve the two-interface problem?

12.3.3 *Special Cases: Half-Wave and Quarter-Wave Layer*

1. Describe the design, construction and impedance properties of a half-wave layer.
2. Describe the design, construction and impedance properties of a quarter-wave layer.

12.3.4 *The Multilayer Problem: Impedance Transformation*

1. What are the advantages of adding additional layers to half- or quarter-wave devices?

12.4 *Plane Wave Propagation in General Directions*

1. How does one represent the propagation constant k as a vector?
2. Give an expression for the electric field of a wave with propagation constant k at position r .

12.5 *Plane Wave Reflection at Oblique Incidence Angles*

1. Sketch the problem geometry for reflected and transmitted waves in the oblique-incidence problem?
2. What is the plane of incidence?
3. Describe the two wave polarizations associated with the oblique-incidence problem.
4. What are p - and s - polarizations?
5. What are Snell's laws of reflection and transmission?
6. State the conditions that must be satisfied when deriving the reflection and transmission coefficients for the oblique-incidence problem.
7. Give the reflection and transmission coefficients for the oblique-incidence problem for both TE- and TM-polarization.
8. How does the oblique incidence problem simplify if, as here, the problem geometry is uniform in the direction perpendicular to the plane of incidence?

12.6 *Total Reflection and Total Transmission of Obliquely Incident Waves*

1. What is total internal reflection and what is its engineering significance?
2. When can total internal reflection occur?
3. What is the critical angle?
4. What is total transmission and what is its engineering significance?
5. When can total transmission occur?
6. What is Brewster's angle?

12.7 *Wave Propagation in Dispersive Media*

1. What is dispersion?
2. What is an $\omega - \beta$ diagram?
3. What is the significance of ω/β and $\frac{\partial\omega}{\partial\beta}$?

4. What are phase velocity and group velocity?
5. What form does the $\omega - \beta$ curve of a dispersion-free medium take?

12.8 Pulse Broadening in Dispersive Media

1. How is a Gaussian pulse affected by propagation through a dispersive medium?
2. What is the dispersion parameter and what is its significance?
3. What is a chirped signal?