1.8: Where Do We Go from Here?

Learning Objectives

By the end of this section, you will be able to:

- Recognize the organization and major topics of the chapters in the book
- Know where to find more detailed or advanced material in the book

Having placed the study of electricity & magnetism into the context of wireless technology, particularly Amateur Radio, we would now like to understand in more detail how the basic principles of electromagnetism can be used to develop such useful technology. This section outlines the rest of the book's chapters and provides some motivation for their content and arrangement. However, like the first chapter, the remainder of the book will continue to serve two purposes: (1) provide a conceptual and quantitative understanding of the physics and (2) explain how this physics can be used at a basic level to explain how radios and radio waves can be used for wireless applications. Along the way, we hope to cover much of the technical material that is included on the Amateur Radio Technician exam in a way that you not only learn the answers to the test questions but actually understand why they are correct.

The book is divided into two parts. If we liken the book's content to a good meal, then Chapter 1 is the appetizer, and Part I is the main course, including entrées and dessert! Part II then provides learners who are still hungry for more to indulge in some of the finer tastes of the theory and provides some generous second helpings of quantitative details.

Part I: Main Course

Part I consists of Chapters 1–13. These chapters introduce the fundamental principles and concepts of electricity and magnetism and some of their practical applications. They are best read in order. To begin the entrées, Chapter 2 formally introduces the idea of electric charge, electric field, and electric force. Chapter 3 takes a complementary perspective using an energy-based approach, including the concepts of electric potential energy and electric potential (voltage). Chapters 2 and 3 are a basic introduction to electrostatics, or in other words, electrical systems that are constant in time. Chapter 4 describes the relationship between the electric field and electric potential and also discusses some practical applications of the associated physical principles. Chapter 5 introduces the concept of moving charge, commonly called electric current, and the related concept of electric resistance in a simple electrical conduction model. Chapter 6 combines the ideas of potential, resistance, and voltage to analyze some basic direct-current (DC) circuits and discusses their applications. Resistors dissipate electrical energy, but other devices can store electrical energy. Chapter 7 introduces such a device, the capacitor, describes how it works, and discusses how to analyze some simple capacitor circuits and resistor-capacitor (R-C) circuits and their applications.

Chapter 8 then introduces magnetism, including the concept of the magnetic field, and describes how these fields are generated by moving charges or currents. In this chapter, all the magnetic fields are constant in time, providing a basic introduction to magnetostatics. Chapter 9 introduces the concept of electromagnetic induction. It starts to show the connection between magnetic and electric fields, describing how a changing magnetic field can induce an electric field and, therefore, when charges are present, an electric current. Chapter 10 introduces a new device, the inductor, which can store energy in a magnetic field. It also discusses how to analyze some simple resistor-inductor (R-L) circuits. It concludes with a discussion of inductor-capacitor (L-C) circuits and resistor-inductor-capacitor (R-L-C) circuits, which are examples of the simplest kinds of oscillatory circuits that can vary their electrical quantities regularly in time. Creating time-varying electrical circuits is essential for generating the signals at different frequencies needed for transceivers and repeaters.

We're now getting closer to our final course of the meal! Chapter 11 describes electromagnetic waves and their basic properties. But how are such waves generated in practice? Chapter 12 provides a basic answer to this question by describing how some basic antennas work, including how electrical signals are transmitted from radios to antennas using feed lines. Chapter 13 introduces concepts related to the propagation of electromagnetic waves, and discusses how they propagate in the Earth's environment.

Finally, we are reaching dessert. Chapter 14 introduces the more realistic conduction model known as band theory. This theory can explain the behavior of semiconductor materials, which are critical for the operation of modern solid-state electronic devices like electrical diodes, light-emitting diodes (LEDs), photovoltaic (solar) cells, and transistors. These devices are commonly used to create solid-state radios and supporting equipment.

Part II: Finer Tastes & Second Helpings

Part II consists of material that provides more detail or advanced approaches to topics introduced in Part I. Chapter 16 describes quantitative methods for calculating the electric field from a distribution of electric charges, thereby justifying some of the results introduced in Chapter 2 and should be accessible after covering that chapter. Chapter 17 describes how to use Gauss's Law to calculate the electric fields for charge distributions, which may be easier to understand after the discussion of flux in Chapter 11. Gauss's Law is a more mathematically sophisticated technique but turns out to be easier to deploy for some symmetric charge distributions. Chapter 18 describes quantitative methods for calculating the magnetic field from a distribution of currents, thereby justifying some of the results introduced in Chapter 7, which should be accessible after covering that chapter. It also discusses the use of Ampère's Law to more easily calculate magnetic fields for current distributions with certain symmetries. Lastly, the chapter discusses additional practical examples of magnetic fields, including electric motors, the Hall effect, and other applications. Chapter 19 introduces tools to analyze circuits with alternating-current (AC) circuits and discusses how electrical resonance can occur in these circuits. Chapter 20 provides a more detailed description of Maxwell's equations and their implications than described in Part I.

Chapter 21 provides a formal theory for the propagation of electromagnetic signals through transmission (feed) lines, extending the introduction provided in Chapter 13, which should be accessible after covering that chapter. It describes how coaxial cables operate, how to calculate the standing wave ratio, and how to minimize losses in feed lines. Chapter 22 provides a more formal and rigorous theory for generating and detecting electromagnetic waves and predicting the radiation patterns from simple antennas. It should also be accessible after covering Chapter 13. Finally, Chapter 23 goes beyond the physics into the important topic of how information is transmitted using radio waves through signal modulation, including amplitude modulation (AM), frequency modulation (FM), and other methods. This chapter is mostly independent of the other chapters in the book but may also be more complicated in some parts.

Consult with your instructor regarding your need to know the content of Part II, but also feel free to explore it yourself. Your banquet of electromagnetism awaits!
