1 Introduction

Have you ever wondered:

- What's the minimum energy required to think?
- Why quantum computers can beat classical computers?
- How to teleport?
- Where noise comes from, and how to remove it?
- Why cameras have a resolution limit, and how to exceed it?
- What determines the size and shape of an antenna?
- How to make an invisibility cloak?
- What causes magnetism?
- How atoms are used to tell time and navigate?
- How electrons are used to weigh kilograms?
- Why superconductors have no resistance?

The Physics of Information Technology will answer these (and many other) questions. Familiar devices that detect, transmit, process, store, and deliver information use a range of surprisingly fundamental physical principles, and operate at their limits. The goal of this book is to explore how such devices function, how they can be used, what the limits on their performance are, and how they might be improved. This will require developing familiarity with the physical governing equations for a range of types of behavior, and with the mathematical tools necessary to manipulate these equations. An important aim is to equip the reader to work out quantitative answers to questions such as these.

A note about pedagogy: reading about physics is as satisfying as reading about food or exercise. It can be useful, but there is no substitute for experience solving problems. Each chapter has problems that apply and develop the preceeding ideas, ranging from trivial calculations to open research questions. Since another goal of this book is to help develop problem-solving skills, consulting the supplied answers before a problem is attempted is entirely counter-productive because the real problems that will come after this book don't come with such handy answers.

And a note about epistemology: it is important to keep in mind the distinction between truth and models. I will be describing models for a variety of types of behavior; these are the product of both experimental observations and theoretical inferences. A good model should compactly explain what you already know and allow you to predict new things that you did not know, but it does not necessarily contain any guide to an underlying "truth." Some physicists believe that there is an ultimate answer that these models are approaching, and some violently disagree, yet all agree on the usefulness of the current set of models and on how to manipulate them. *Truth* and *Meaning* are concepts that one may choose to associate with these models, but their presence or absence does not affect the models' use. At most, they do guide what you choose to think about. This distinction is very important because, when faced with unexpected claims or results, there is a danger of seeing particular models as privileged correct answers rather than judging evidence on its merits. Many areas in this book have been the subject of battles that illustrate the conflict that can occur when beliefs are stronger than evidence.