Preface

Oscillatory and wave phenomena are encountered in almost all branches of physics: mechanics, geophysics, electromagnetism, optics, quantum physics, etc. Some of them were first observed in antiquity, but their scientific study only started in the 17^{th} Century. The phenomena include mechanical vibrations and waves, electromagnetic vibrations and waves, matter waves, etc. Electromagnetic vibrations and waves were discovered in the 19^{th} Century, while matter waves were discovered in the 20^{th} Century. Each branch of physics has its own concepts, and even its own proper mathematical language. Nevertheless, all types of vibrations and waves share several common properties: modes, similar forms of energy, superposition, interference, diffraction, etc.

The purpose of this book is to study oscillatory and wave phenomena at the undergraduate level. It was not conceived with the intended application as a textbook for a specific physics course. Some sections, indicated by an asterisk (*), may prove difficult and may be omitted without loss of continuity.

Chapter 1 introduces the basic concepts and studies some examples of vibrations of mechanical and electromagnetic systems with one or several degrees of freedom. Chapter 2 studies the superposition of vibrations and introduces Fourier analysis. Chapter 3 analyzes forced vibrations and resonances. Chapter 4 introduces the basic notions of waves in infinite media: wave equations and their solutions, energy density and energy transfer, etc. Chapter 5 is devoted to the study of mechanical waves (elastic waves, sound and surface waves). In Chapter 6, we summarize the basic laws of electromagnetism and analyze the electromagnetic waves in insulators, conductors and plasmas. Reflection and refraction are studied in Chapter 7, interference and diffraction are studied in Chapter 8 and finally standing waves and waveguides, in Chapter 9. This book shall not study the emission of waves or optical setups.

The required mathematical techniques are introduced as the need arises. Appendix A aids understanding by summarizing the principal mathematical formulas, integrals and vector analysis. We tried to use clear notations by assigning similar symbols for the various physical quantities: a boldfaced symbol for a vector quantity, an italic symbol for a scalar quantity or a component of a vector quantity, an underlined symbol for a complex quantity, and script symbol for a curve, a surface, a volume and some special quantities. Physical quantities of the same type are referred to by symbols with different indexes: for instance, $f_{(Fr)}$, $f_{(ez)}$, $\mathbf{F}_{(E)}$, etc., for the different types of force. The energy is designated by U to avoid confusion with the components of the electric field $\mathbf{E}$. The frequency is represented by $\tilde{\nu}$, instead of the usual Greek symbol ν, to avoid its confusion with the velocity v.

A unit vector is often represented by $\mathbf{e}$, while the unit vectors of the axes are represented by $\mathbf{e}_x$, $\mathbf{e}_y$ and $\mathbf{e}_x$. In order to write summations in a condensed form, we sometimes designate the Cartesian coordinates x, y and z by x_1, x_2 and x_3 respectively, and the components of a vector $\mathbf{V}$ by $V_1 \equiv V_x$, $V_2 \equiv V_y$ and $V_3 \equiv V_z$. The partial derivative of $u(x, y, z, t)$ with respect to time is represented by $\dot{u}$ or $\partial_t u$ and its partial derivatives by $\partial_x u$ for $\partial u/\partial x$, $\partial^2_{xt}u$ for $\partial^2 u/\partial x\, \partial t$, etc. We also use the notation $\partial_i u$ for the partial derivatives $\partial u/\partial x_i$ and $\partial_i V_j$ for $\partial V_j/\partial x_i$ (i and j = 1, 2, 3).

Each chapter ends with a *Summary* section for the principal results of the chapter, and a section entitled *Problem solving suggestions*, which contains remarks or possible errors to be avoided, approximation methods and further clarifications. For training students, each chapter contains some *examples* that are worked out in detail and two kinds of exercises: *conceptional questions*, a selection of discussion questions designed to develop the understanding of the physical concepts, often without a need for calculations; and *problems*, which are ordered according to the sections of the chapter and arranged in approximate levels of difficulty (an asterisk (*) indicates a problem of some difficulty, two asterisks (**) indicates a problem with some connectional or computational difficulties. The answers to most of the problems are given in a special addendum entitled *Answers to the Problems*, which enables students to check their results.

I hope that this text makes the subject more accessible for students, and that it is utilized as a good teaching aid for professors.

T. BÉCHERRAWY
November 2011