

# Contents

|   |    |
|---|----|
| <b>1. Mathematical Foundation for Wave Physics</b> .....          | 1  |
| 1.1 Introduction to the Concepts .....                            | 1  |
| 1.2 Important Integrals .....                                     | 5  |
| 1.3 Complex Numbers .....   | 7  |
| 1.4 The Dirac Delta Function .....                                | 9  |
| 1.5 Fourier Analysis .....  | 11 |
| 1.6 Hilbert Space .....   | 17 |
| Problems .....  | 24 |
| Further Reading .....   | 31 |
| <b>2. Oscillations of Mechanical and Electrical Systems</b> ..... | 33 |
| 2.1 The Systems and Their Equations .....                         | 33 |
| 2.2 Natural Motion of Systems .....                               | 36 |
| 2.3 Forced Motion .....   | 41 |
| 2.4 Forced Motion and the Green's Function .....                  | 44 |
| 2.5 Oscillators .....   | 46 |
| 2.6 Summary .....   | 48 |
| Problems .....  | 49 |
| Further Reading .....   | 53 |
| <b>3. Waves on Stretched Strings</b> .....                        | 55 |
| 3.1 Equation of Motion of a String .....                          | 55 |
| 3.2 Natural Motion of a String .....                              | 58 |
| 3.3 The Normal Modes .....  | 60 |
| 3.4 Forced Motion of a Stretched String .....                     | 67 |
| 3.5 Green's Functions for a Stretched String .....                | 71 |
| Problems .....  | 78 |
| Further Reading .....   | 85 |
| <b>4. Electromagnetic Waves</b> .....                             | 87 |
| 4.1 Maxwell's Equations in Integral Form .....                    | 87 |
| 4.2 Maxwell's Equations in Differential Form .....                | 88 |
| 4.3 Plane Electromagnetic Waves in Free Space .....               | 92 |
| 4.4 Distributed Electromagnetic Systems – Cavities .....          | 98 |

|           |   |            |
|-----------|---|------------|
| 4.5       | The Vector Potential and Related Solutions<br>of Maxwell's Equations . . . . .  | 103        |
| 4.6       | Dipole Radiation . . . . .  | 107        |
| 4.7       | Electromagnetism and the Green's Function . . . . .                             | 110        |
|           | Problems . . . . .  | 117        |
| 4.A       | Appendix . . . . .  | 124        |
|           | Further Reading . . . . .   | 127        |
| <b>5.</b> | <b>Light – Physical Optics, Refraction . . . . .</b>                            | <b>129</b> |
| 5.1       | The Nature and Generation of Light . . . . .                                    | 129        |
| 5.2       | Diffraction . . . . .   | 133        |
| 5.3       | X-ray Diffraction . . . . .   | 139        |
| 5.4       | EM Waves in Dielectrics. Refraction . . . . .                                   | 141        |
| 5.5       | The Magic Rule in Three Dimensions . . . . .                                    | 147        |
|           | Problems . . . . .  | 151        |
|           | Further Reading . . . . .   | 156        |
| <b>6.</b> | <b>Wave Mechanics . . . . .</b>   | <b>157</b> |
| 6.1       | Origin of Schroedinger's Wave Equation . . . . .                                | 157        |
| 6.2       | Postulates of Wave Mechanics . . . . .  | 161        |
| 6.3       | Motion of a Free Particle.<br>The Heisenberg Uncertainty Principle . . . . .    | 171        |
| 6.4       | Wave-Particle Duality and Loss of Determinism . . . . .                         | 179        |
| 6.5       | Driven Motion and the Green's Function<br>for the Harmonic Oscillator . . . . . | 181        |
| 6.6       | Scope of Quantum Mechanics . . . . .  | 191        |
|           | Problems . . . . .  | 206        |
|           | Further Reading . . . . .   | 215        |
| <b>7.</b> | <b>Nonlinear Waves on Water – Solitons . . . . .</b>                            | <b>217</b> |
| 7.1       | Linear Surface Waves on Water . . . . .   | 218        |
| 7.2       | Dispersion. Group Velocity . . . . .  | 221        |
| 7.3       | Nonlinear Waves . . . . .   | 223        |
| 7.4       | Solitons . . . . .  | 229        |
| 7.5       | Inverse Scattering . . . . .  | 233        |
|           | Problems . . . . .  | 241        |
|           | Further Reading . . . . .   | 246        |
| <b>8.</b> | <b>Nonlinear Phenomena – Chaos . . . . .</b>                                    | <b>249</b> |
| 8.1       | Nonlinear Physics – Chaos and Order . . . . .                                   | 250        |
|           | Further Reading . . . . .   | 264        |
| 8.2       | Quantum Chaos . . . . .   | 265        |
|           | <b>Hints for Solution . . . . .</b>   | <b>277</b> |
|           | <b>Index . . . . .</b>  | <b>285</b> |