

# CONTENTS

<b>1. Review of Oscillations</b>	<b>1</b>
1.1 Introduction, 1	
1.2 Mass–Spring System, 1	
1.3 Energy Tossing in Mechanical Oscillations, 7	
1.4 Other Mechanical Oscillation Systems, 10	
1.5 Electromagnetic Oscillation, 15	
1.6 Damped Oscillation, 17	
1.7 Forced Oscillation, 20	
<b>2. Wave Motion</b>	<b>26</b>
2.1 Introduction, 26	
2.2 Creation of Waves on a String, 26	
2.3 Sinusoidal (Harmonic) Waves, 30	
2.4 Wave Differential Equation, Partial Differentiation, 33	
2.5 Nonsinusoidal Waves, 38	
2.6 Phase and Group Velocities, Dispersion, 40	
2.7 Superposition of Two Waves, Beats, 43	
<b>3. Some Mathematics</b>	<b>50</b>
<b>4. Mechanical Waves</b>	<b>57</b>
4.1 Introduction, 57	
4.2 Mass–Spring Transmission Line, 58	
4.3 Derivation of Wave Equation, 59	
4.4 Energy Carried by Waves, 63	
4.5 Momentum Carried by Waves, 66	
4.6 Transverse Waves on a String, 69	
<b>5. Sound Waves in Solids, Liquids, and Gases</b>	<b>77</b>
5.1 Introduction, 77	
5.2 Sound Velocity Along a Solid Rod, 77	
5.3 Rigorous Derivation of Sound Velocity Along a Solid Rod, 80	

5.4	Sound Waves in Liquids, 83	
5.5	Sound Waves in Gases, 86	
5.6	Intensity of Sound Waves in Gases, 90	
<b>6.</b>	<b>Wave Reflection and Standing Waves</b>	<b>95</b>
6.1	Introduction, 95	
6.2	Reflection at a Fixed Boundary, Standing Waves, 95	
6.3	Reflection at a Free Boundary, 100	
6.4	Theory of Wave Reflection, Mechanical Impedance, 103	
<b>7.</b>	<b>Spherical and Cylindrical Waves; Waves in Nonuniform Media, and Multidimensional Waves</b>	<b>112</b>
7.1	Introduction, 112	
7.2	Conservation of Energy Flow, Spherical Waves, 112	
7.3	Cylindrical Waves, 115	
7.4	Nonuniform Wave Medium, 116	
7.5	Multidimensional Waves, 119	
<b>8.</b>	<b>Doppler Effect of Sound Waves and Shock Waves</b>	<b>124</b>
8.1	Introduction, 124	
8.2	Stationary Sound Source and Moving Observer, 124	
8.3	Moving Sound Source and Stationary Observer, 128	
8.4	General Expression for Doppler-Shifted Frequency, 129	
8.5	Shock Waves, 131	
<b>9.</b>	<b>Electromagnetic Waves</b>	<b>135</b>
9.1	Introduction, 135	
9.2	Wave Equation for an LC Transmission Line, 136	
9.3	Coaxial Cable, 143	
9.4	Poynting Vector, 152	
9.5	Plane Electromagnetic Waves in Free Space, 156	
9.6	Reflection of Electromagnetic Waves, 161	
9.7	Electromagnetic Waves in Matter, 167	
<b>10.</b>	<b>Radiation of Electromagnetic Waves</b>	<b>187</b>
10.1	Introduction, 187	
10.2	Fields Associated with Stationary Charge and Charge Moving with a Constant Velocity, 187	
10.3	Radiation Fields Due to an Accelerated (or Decelerated) Charge, 191	
10.4	Radiation from an Oscillating Dipole and Dipole Antenna, 196	

<b>11. Interference and Diffraction</b>	<b>203</b>
11.1 Introduction, 203	
11.2 Interference Between Two Harmonic Waves, 203	
11.3 Young's Experiment, 206	
11.4 Multislit Structure, 211	
11.5 Optical Interference in Thin Films, 218	
11.6 Diffraction I (Fraunhofer diffraction), 223	
11.7 Resolution of Optical Devices, 226	
11.8 Diffraction II (Fresnel diffraction), 228	
<b>12. Geometrical Optics</b>	<b>240</b>
12.1 Introduction, 240	
12.2 Reflection and Refraction, 240	
12.3 Total Reflection, 248	
12.4 Reflection at Spherical Surfaces (Mirrors), 250	
12.5 Spherical Aberration of Mirrors, 255	
12.6 Refraction at Spherical Surfaces, 256	
12.7 Lenses, 258	
12.8 Chromatic Aberration, 261	
12.9 Optical Instruments, 263	
12.10 Physical Meaning of Focusing, 265	
<b>13. Fourier Analyses and Laplace Transformation</b>	<b>274</b>
13.1 Introduction, 274	
13.2 Sum of Harmonic Functions, 274	
13.3 Fourier Series, 277	
13.4 Fourier Spectrum, 280	
13.5 Operator Method, 284	
13.6 Laplace Transform, 288	
<b>14. Particle Nature of Light</b>	<b>295</b>
14.1 Introduction, 295	
14.2 Photoelectric Effect and Einstein's Photon Theory, 295	
14.3 Hydrogen Atom, 298	
14.4 De Broglie Wave, 301	
<b>15. Nonlinear Waves</b>	<b>303</b>
15.1 Introduction, 303	
15.2 Nonlinear Wave Equations, 306	
15.3 Characteristics, 314	
15.4 Self-Similarity, 318	

<b>16. Solitons and Shocks</b>	<b>327</b>
16.1 Introduction, 327	
16.2 FPU Recurrence, 329	
16.3 Properties of Solitons, 330	
16.4 Shocks, 337	
<b>Appendix A</b>	<b>340</b>
<b>Appendix B</b>	<b>342</b>
<b>Bibliography</b>	<b>347</b>
<b>Index</b>	<b>349</b>