

# Contents

Flow diagram . . . . .	inside front cover
Editors' preface . . . . .	v
Author's preface . . . . .	vii
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 The electromagnetic spectrum . . . . .	1
1.2 The history of light waves and photons . . . . .	3
<b>2 MAXWELL'S EQUATIONS AND ELECTROMAGNETIC WAVES</b>	<b>9</b>
2.1 Maxwell's equations . . . . .	10
2.2 The existence of electromagnetic waves . . . . .	13
2.3 Flow of energy in plane waves in free space . . . . .	22
2.4 Propagation of plane waves in dielectric and conducting media . . . . .	24
2.5 Reflection at boundaries . . . . .	27
2.6 Radiation pressure . . . . .	35
PROBLEMS: CHAPTER 2 . . . . .	39

<b>3</b>	<b>CLASSICAL TREATMENT OF THE GENERATION AND INTERACTION OF ELECTROMAGNETIC WAVES</b>	<b>40</b>
3.1	The generation of electromagnetic waves . . . . .	40
3.1.1	The potentials $\phi$ and $\mathbf{A}$ . . . . .	42
3.1.2	The radiation from an oscillating dipole . . . . .	46
3.1.3	Magnetic dipole and electric quadrupole radiation . . . . .	50
3.1.4	The radiation from an accelerating charge . . . . .	53
3.1.5	Synchrotron radiation . . . . .	55
3.1.6	Bremsstrahlung . . . . .	59
3.1.7	The radiation from a 'classical' atom . . . . .	61
3.1.8	Cerenkov radiation . . . . .	65
3.2	Refraction . . . . .	67
3.2.1	Free electron gas . . . . .	67
3.2.2	A gas of 'classical' atoms . . . . .	71
3.2.3	Refraction in liquids and solids . . . . .	75
3.2.4	Propagation in anisotropic media . . . . .	77
3.2.5	Non-linear effects . . . . .	82
	PROBLEMS: CHAPTER 3 . . . . .	84
<b>4</b>	<b>THE INTRODUCTION OF QUANTUM IDEAS</b>	<b>87</b>
4.1	Radiation in thermal equilibrium . . . . .	88
4.2	Einstein's $A$ and $B$ coefficients . . . . .	96
4.3	The calculation of transition probabilities . . . . .	103
4.4	Selection rules . . . . .	108
4.4.1	Angular momentum and parity of atomic states . . . . .	108
4.4.2	Angular momentum and parity associated with a photon in an electric dipole transition . . . . .	111
4.4.3	Selection rules for electric dipole transitions . . . . .	114
4.5	Optically forbidden transitions . . . . .	117
	PROBLEMS: CHAPTER 4 . . . . .	123
<b>5</b>	<b>COHERENCE</b>	<b>125</b>
5.1	What is coherence? . . . . .	125
5.2	Temporal and spatial coherence . . . . .	129
5.3	The measurement of coherence . . . . .	134
5.4	Coherence of light from real sources . . . . .	138
5.4.1	Spatial coherence of the light from a small or distant source . . . . .	138
5.4.2	Temporal coherence . . . . .	143
5.4.3	The coherence volume . . . . .	144

5.5	Intensity correlations . . . . .	146
5.5.1	Chaotic light . . . . .	147
5.5.2	Photon correlations . . . . .	150
	PROBLEMS: CHAPTER 5 . . . . .	154
<b>6</b>	<b>LASERS</b>	<b>155</b>
6.1	A simple two-level system . . . . .	157
6.2	Multi-level systems . . . . .	168
6.2.1	The ruby laser . . . . .	169
6.3	Level widths and mode selection . . . . .	172
6.4	Particular masers and lasers . . . . .	180
6.4.1	The ammonia maser . . . . .	183
6.4.2	Gas discharge lasers . . . . .	185
6.4.3	Dye lasers . . . . .	188
6.4.4	Semi-conductor lasers . . . . .	194
	PROBLEMS: CHAPTER 6 . . . . .	196
<b>7</b>	<b>THE PROPERTIES AND USES OF LASER LIGHT</b>	<b>198</b>
7.1	Properties of laser light . . . . .	199
7.1.1	Spectral line width . . . . .	199
7.1.2	Directionality . . . . .	202
7.1.3	Coherence . . . . .	204
7.1.4	The generation of short pulses . . . . .	206
7.2	Laser techniques and applications . . . . .	208
7.2.1	Frequency doubling . . . . .	208
7.2.2	Doppler-free spectroscopy . . . . .	210
7.2.3	Holography . . . . .	215
7.2.4	Communications . . . . .	220
7.2.5	Measurement of distance and velocity . . . . .	222
7.2.6	Heating and cutting . . . . .	222
	PROBLEMS: CHAPTER 7 . . . . .	224
<b>8</b>	<b>THE SCATTERING AND ABSORPTION OF ELECTROMAGNETIC RADIATION</b>	<b>225</b>
8.1	Scattering of radiation by free electrons . . . . .	227
8.1.1	Thomson scattering . . . . .	227
8.1.2	Compton scattering . . . . .	230
8.2	Scattering and absorption of radiation by atoms and mole- cules . . . . .	234
8.2.1	Rayleigh scattering . . . . .	234

8.2.2	Inelastic scattering and absorption . . . . .	238
8.2.3	Raman scattering . . . . .	240
8.2.4	The photoelectric effect . . . . .	243
8.2.5	Pair production . . . . .	246
8.3	Scattering and absorption of radiation by solids and liquids . . . . .	250
8.3.1	Brillouin scattering . . . . .	250
8.3.2	Photoconduction and photoemission . . . . .	253
	PROBLEMS: CHAPTER 8 . . . . .	260
<b>9</b>	<b>THE DETECTION OF ELECTROMAGNETIC RADIATION</b> . . . . .	<b>261</b>
9.1	Detection of infrared radiation . . . . .	262
9.1.1	Bolometers and thermocouples . . . . .	262
9.1.2	Photoconduction detectors . . . . .	265
9.2	Detection of visible radiation . . . . .	266
9.2.1	Photoemission detectors . . . . .	266
9.2.2	Photography and Xerography . . . . .	270
9.3	The detection of ultraviolet, X, and $\gamma$ -radiation . . . . .	271
9.3.1	Gas ionization counters . . . . .	272
9.3.2	Scintillation detectors . . . . .	280
9.3.3	Semiconductor detectors . . . . .	292
9.3.4	Cerenkov shower detectors . . . . .	295
	PROBLEMS: CHAPTER 9 . . . . .	296
Appendix A	Some useful formulas in vector calculus . . . . .	297
Appendix B	The birth of the photon . . . . .	300
Appendix C	Quantum mechanical treatment of the radiation field . . . . .	305
Appendix D	Additional reading . . . . .	317
Appendix E	Answers to selected problems . . . . .	319
INDEX	. . . . .	327
FUNDAMENTAL CONSTANTS AND CONVERSION FACTORS		
inside back cover		