

Contents

How to use this Book	vii	Chapter 4 Dynamics	21
Chapter 1 Physical Quantities and Units	1	Introduction	21
Physical quantities	1	Newton's laws of motion	21
SI units (Système International d'unités)	2	Conservation of momentum	24
Estimating physical quantities	2	The deduction of the principle from Newton's third law	24
Scientific equations	3	The use of the principle of conservation of momentum	25
Vectors and scalars	3	Elastic and inelastic collisions	25
Combining vectors	3	<i>Progress Check</i>	27
Resolution of vectors	4	Chapter 5 Forces, Density and Pressure	28
<i>Progress Check</i>	5	Types of force	28
Chapter 2 Measurement Techniques	6	Forces in fluids	28
Introduction	6	Resistive forces	29
Record taking	6	Centre of gravity	29
Graphical work	7	Turning forces	30
Analogue scales and digital displays	7	Equilibrium	30
Experimental uncertainty	7	The principle of moments	31
Precision and accuracy	8	Density	32
Choice of measuring instrument	8	Pressure	32
Calibration curves	9	Atmospheric pressure	32
Estimating uncertainties	10	Pressure due to a column of liquid of constant density	33
<i>Progress Check</i>	10	<i>Progress Check</i>	33
<i>Examination Questions I</i>	12	<i>Examination Questions II</i>	36
Chapter 3 Kinematics	14	Chapter 6 Work, Energy and Power	37
Distance and displacement	14	Work and energy	37
Speed and velocity	14	Work	37
Acceleration	14	Energy	37
Graphs for motion	15	Examples of work done or energy supplied	38
Distance–time graphs	15	Power	40
Velocity–time graphs	15	Efficiency	40
Derivation of equations of motion for uniformly accelerated motion in a straight line	15	<i>Progress Check</i>	42
Weight	16	<i>Examination Questions III</i>	43
Measurement of the acceleration of free fall, g	17	Chapter 7 Deformation of Solids	47
The effect of air resistance on a falling body	17	Introduction	47
Objects moving under gravity in two dimensions	18	Tension and compression	47
<i>Progress Check</i>	20	Springs	47

iv Contents

Elastic and plastic deformation of a material	48	Chapter 12 Direct Current (D.C.) Circuits	82
The Young modulus	48	Introduction	82
Categories of materials	50	Electromotive force, e.m.f. and potential difference, p.d.	83
Strain energy	51	Internal resistance	83
<i>Progress Check</i>	52	Kirchhoff's laws	83
<i>Examination Questions IV</i>	53	Kirchhoff's first law	84
Chapter 8 Waves	56	Kirchhoff's second law	84
Introduction	56	Combinations of resistors	84
Wave motion	56	Resistors in series	84
Wave terminology	57	Resistors in parallel	85
Energy transfer by a progressive wave	58	Electrical circuits	85
Transverse and longitudinal waves	59	Warning of common mistakes	85
Experimental techniques	60	Sample circuits	86
The electromagnetic spectrum	61	The effect of a voltmeter being used	86
The Doppler effect	62	The potentiometer	87
<i>Progress Check</i>	63	<i>Progress Check</i>	89
		<i>Examination Questions VI</i>	90
Chapter 9 Superposition	64	Chapter 13 Nuclear Physics: Part A	93
Introduction	64	Introduction	93
Stationary waves	64	Structure of the atom	93
Diffraction	66	Discovery of the nucleus of atoms	93
Interference	66	Isotopes	94
The diffraction grating	68	Definitions and data	94
<i>Progress Check</i>	69	Nuclear reactions	95
<i>Examination Questions V</i>	70	Experiments with radioactive materials	96
Chapter 10 Electric Fields: Part A	72	Properties of alpha (α), beta (β) and gamma (γ) radiations	97
Electric field definition	72	Antiparticles	98
Electric field diagrams	72	Fundamental particles	98
Potential difference	73	Beta decay	99
The movement of charges in electric fields	73	<i>Progress Check</i>	100
<i>Progress Check</i>	75	<i>Examination Questions VII</i>	101
Chapter 11 Current of Electricity	76	Chapter 14 Physical Quantities, Units and Measurement Techniques	103
Charge and current	76	Amount of substance	103
Introduction	76	Experimental techniques	103
Conductors and insulators	76	Chapter 15 Motion in a Circle	104
Potential difference	77	Angular measure	104
Resistance	78	Angular velocity	104
Equation summary	78	The relationship between angular velocity ω and speed v	104
Current–potential difference (I – V) characteristics	79	Small angle approximations for angles	105
1. A wire at a constant temperature	79	Circular motion	105
2. A filament lamp	79	Acceleration at constant speed	105
3. A semiconductor diode	79	Acceleration in circular motion at constant speed	106
Temperature characteristics	79	The force required for a centripetal acceleration	106
Ohm's law	79	<i>Progress Check</i>	108
Electrical resistivity	80		
<i>Progress Check</i>	80		

Chapter 16	Gravitational Field	109	Chapter 21	Ultrasound	149
Introduction	109		The piezo-electric transducer	149	
Gravitational field strength	109		Ultrasound scanning	149	
Newton's law of gravitation	109		Absorption coefficients	151	
The relationship between g and G	110		<i>Progress Check</i>	152	
Gravitational potential	110				
Space travel	111		Chapter 22	Communicating Information	153
Circular orbits	112		The principles of modulation	153	
Geostationary satellites	112		Introduction	153	
<i>Progress Check</i>	114		Signal modulation	153	
<i>Examination Questions VIII</i>	114		Bandwidth	153	
			Comparison between amplitude modulation (AM) and frequency modulation (FM)	155	
Chapter 17	Ideal Gases	117	Frequencies and wavelengths used in telecommunications	156	
Introduction	117		Digital information	156	
The equation of state for an ideal gas	117		Sampling rates	156	
Standard temperature and pressure, S.T.P.	118		Modes of communication	158	
The kinetic theory of gases	118		Attenuation	158	
The Boltzmann constant, k	119		Comparison of channels of communication	159	
<i>Progress Check</i>	120		Satellite communication	160	
			Satellite orbits	160	
Chapter 18	Temperature	121	<i>Progress Check</i>	162	
Introduction	121		<i>Examination Questions XI</i>	163	
Thermal equilibrium	121				
Measurement of temperature	121		Chapter 23	Electric Fields: Part B	164
The potential divider in use	122		Introduction	164	
The thermistor	123		Coulomb's law	164	
Temperature scales	124		The electric field strength at a distance r from a point charge	164	
<i>Progress Check</i>	125		Electrical potential	165	
			Comparison between electric fields and gravitational fields	165	
Chapter 19	Thermal Properties of Materials	126	The definition of electrical potential	166	
Specific heat capacity	126		<i>Progress Check</i>	168	
Change of state	127				
Melting	127		Chapter 24	Capacitance	169
Boiling and evaporation	128		Introduction	169	
Internal energy	129		The definition of capacitance	169	
The first law of thermodynamics	130		Capacitors in series and in parallel	169	
<i>Progress Check</i>	132		Capacitors in parallel	169	
<i>Examination Questions IX</i>	133		Capacitors in series	170	
			The energy stored in a charged capacitor	172	
Chapter 20	Oscillations	136	<i>Progress Check</i>	173	
Introduction	136				
Patterns of oscillation	136		Chapter 25	Sensing Devices	174
Wave terminology	137		Sensing devices	174	
Angular frequency (ω)	138		The light-dependent resistor	174	
The definition of simple harmonic motion (SHM)	138		The negative temperature coefficient thermistor	175	
Damped oscillations	140		The piezo-electric transducer	175	
Forced oscillations and resonance	141		Strain gauges	175	
<i>Progress Check</i>	144		<i>Progress Check</i>	177	
<i>Examination Questions X</i>	144				

vi Contents

Chapter 26	Electronics	178
The operational amplifier (op-amp)		178
The properties of an op-amp		178
The op-amp as a comparator		178
Adjusting the gain of an op-amp		179
The non-inverting amplifier		179
Output devices		180
<i>Progress Check</i>		181
Chapter 27	Magnetic Fields	182
Introduction		182
Concept of a magnetic field		182
Making magnets		183
Magnetic flux density		184
The current balance		185
The force on a charge q moving with velocity v in a magnetic field		185
Magnetic field patterns of electric currents in wires and forces on the wires		187
The Hall probe		188
Velocity selection		189
A comparison between the effect on charges in electric and magnetic fields		189
Magnetic resonance imaging, MRI		190
Introduction		190
Precession of nuclei		190
Nuclear resonance		191
The MRI scanner		191
<i>Progress Check</i>		192
Chapter 28	Electromagnetic Induction	194
Introduction		194
Experiments on electromagnetic induction		194
Definitions of terms used in electromagnetic induction		195
Faraday’s law of electromagnetic induction		195
The a.c. generator, often called an alternator		195
Lenz’s law		196
<i>Progress Check</i>		198
Chapter 29	Alternating Currents	199
Introduction		199
Power in an a.c. circuit		199
The transformer		200
The theory of a transformer		201
Transformer Losses		203
Rectification		204
Half-wave rectification		204
Full-wave rectification		204
Smoothing the output from a rectifier circuit		205
<i>Progress Check</i>		206
<i>Examination Questions XII</i>		207
Chapter 30	Quantum Physics	211
Introduction		211
The photoelectric effect		211
The Planck constant, h		212
Wave-particle duality		213
Spectra		213
Band theory		214
Variation of resistance with temperature		215
Variation of resistance with intensity of light		215
Absorption spectra		216
The production and use of X-rays		216
Introduction		216
The production of X-rays		216
The use of X-rays		217
Computed tomography (CT) scan		218
<i>Progress Check</i>		220
Chapter 31	Nuclear Physics: Part B	221
Energy and mass		221
Nuclear binding energy		221
Variation of binding energy with nucleon number		222
Nuclear fission		223
Activity and half-life		223
Half life		224
<i>Progress Check</i>		225
<i>Examination Questions XIII</i>		225
Appendix A	Quick tips on exam preparation	228
Appendix B	Physical quantities: symbols, definitions and equations	231
Appendix C	SI units, symbols and definitions	233
Appendix D	Answers to Progress Check questions	235
Index		244