

# CONTENTS

<i>List of figures</i>	vii
<i>List of tables</i>	xi
<i>Preface</i>	xiii
<i>Acknowledgements</i>	xvii
<b>Part 1</b>	
<b>Physical states</b>	<b>1</b>
1 Introduction	3
2 Gases	12
3 Liquids	29
4 Solids	51
<b>Part 2</b>	
<b>Force, pressure, energy and electricity</b>	<b>65</b>
5 Force and pressure	67
6 Energy	83
7 Electricity	103
<b>Part 3</b>	
<b>Scientific transferable skills</b>	<b>117</b>
8 Data analysis	119
9 Numerical calculations	148
10 Report writing	167
<i>Appendix 1 Health questionnaire</i>	191
<i>Appendix 2 Example consent form</i>	195

<i>Appendix 3 Thermal equivalents of oxygen</i>	197
<i>Appendix 4 Scientific journals in exercise and sport</i>	199
<i>Appendix 5 Measurement concepts</i>	201
<i>Key terms</i>	203
<i>Index</i>	210

## FIGURES

3.1	The relationship between depth and pressure in a stationary liquid	32
3.2	The principle of a barometer	33
3.3	A hydrometer, an instrument used for measuring the specific gravity of a liquid	36
3.4	The relationship between pressure in a flowing liquid and the pressure gradient	37
3.5	Schematic showing the variables that affect the rate of flow of a liquid through a tube	38
3.6	The pH scale and related values	43
3.7	Blood speed and pressure in an obstructed artery	47
4.1	Increased internal energy of a solid through heating	53
4.2	The four types of crystal	57
4.3	The heat balance of the human body through heat gain and heat loss	58
5.1	Composing forces with the parallelogram technique	72
5.2	Force measurement in vertical and two horizontal planes with a force plate	73
5.3	A manometer	73
5.4	An isokinetic dynamometer	76
5.5	The torque–angle relationship during maximal voluntary isometric contractions of the knee extensor muscles	76
5.6	The torque–angular velocity relationship during maximal voluntary knee extension exercise	77

5.7	Typical force traces recorded for a running trial in vertical (a) and horizontal (b and c) directions with a force plate	78
5.8	An elastic collision between a ball and the ground	79
6.1	Adenosine triphosphate (ATP) which provides the human body with energy in a form that can be directly used	87
6.2	Work done in dragging a sledge between two points	90
6.3	Power maintained during a range of physical activities in comparison with other familiar power consumers	92
6.4	Storage of potential energy during the running action whilst the foot is in contact with the floor	95
6.5	A cycle ergometer used for measuring work done in exercise tests	97
6.6	A power curve over time recorded during cycle ergometry	100
6.7	Schematic of the relationship between energy, work, power and efficiency	101
7.1	A gold-leaf electroscope showing the effects of a positive potential	106
7.2	The triboelectric series	106
7.3	An electric current circuit	109
7.4	An electrocardiogram (ECG) trace showing the PQRST complex of electrical activity	113
8.1	Flow diagram of the process of scientific investigation	122
8.2	Histogram showing the frequency of observation of the range of heart rates	130
8.3	Graphical representation of standard deviation in relation to individual heart rate observations	134
8.4	Graphical representation of a standard normal curve	136
8.5	Scatter plot of years training against 100 m sprint time	138
8.6	Evaluation of statistical errors	141
8.7	Area of normal distributions defined as alpha ( $\alpha$ ) and beta ( $\beta$ )	142
9.1	A right-angled triangle	150
9.2	Resolving force components	152
9.3	Projectile motion of a ball	155

9.4	Straight line graph	156
9.5	Velocity–time graph	156
9.6	Curved graph with tangent	157
9.7	Constant velocity–time graph	158
9.8	Calculation of displacement: graphical integration	159
9.9	The trapezium rule	160
9.10	Velocity–time traces	161
10.1	Proportion of participants who consider either the swimming, cycling or running event the most important in an Olympic distance triathlon (an example of a pie chart)	181
10.2	Proportion of carbohydrate and fat sources during exercise prior to and following a training intervention (an example of a column chart)	182
10.3	Proportion of fat used during exercise after 2, 4, 6, 8 and 10 weeks of training (mean and standard deviation) (an example of a bar chart, or histogram)	182
10.4	Blood glucose concentration during 120 minutes of heavy exercise following ingestion of either 100 g of carbohydrate (10 % solution) or placebo 1 hour prior to exercise (mean and standard deviation) (an example of a line graph)	182
10.5	Relationship between time to exhaustion and blood glucose concentration after 30 min of exercise (an example of a scatter plot)	183

# TABLES

1.1	The seven base SI units	5
1.2	Units derived from the seven base SI units	7
1.3	Symbols for the non-SI units for time	7
1.4	Unit multiples	8
6.1	Typical amount of energy stored within a 70 kg human body (~15 % body fat) in different forms	87
6.2	Amount of various foods that provide 1000 kJ	88
8.1	Experimental designs used in the study of exercise and sport	126
8.2	Characteristics of the different types of data	128
8.3	Calculation of descriptive statistics based upon resting heart rate (HR, $\text{beats}\cdot\text{min}^{-1}$ ) from 30 female participants	129
8.4	Calculation of variance, standard deviation and mean absolute deviation based upon resting heart rate (HR, $\text{beats}\cdot\text{min}^{-1}$ ) from 30 female participants	133
8.5	Calculation of derived values based upon training duration (years) and performance times (seconds) of male 100 m sprinters	139
10.1	Individual and group training, anthropometric and physiological characteristics for eight well-trained runners (an example of a table)	181
10.2	A summary of the content of each section of a scientific report	188