HIGHER, FASTER, STRONGER

Overview of chapter

Table 1.1 summarises the content and skills covered in this chapter, and Table 1.2 lists the learning outcomes required by the exam specification. The latter are also listed as 'Achievements' in the final section of the chapter in the Student Book.

Table 1.1 Summary of the chapter *Higher, Faster, Stronger*

Outline and reference to student materials			Key points	Skills	Notes
Section 1.1 Biomechanics	Introductory video and reading		Scope of physics in analysing and improving performance		
Section 1.2 Describing motion	Analysing speed record data	Activity 1 Additional Sheet 1	Plotting and extrapolating a graph Average speed	Application of number	GCSE revision
	Discussion of distance and direction	Activity 2 Additional Sheet 2	Idea of vectors		GCSE revision
	Calculations with velocity and acceleration	Additional Sheet 3 Activity 3	Equations for uniformly accelerated motion Free fall	Application of number	GCSE revision
Section 1.3 Motion graphs	Finding instantaneous velocity and acceleration using ticker tape, video clips, software ...	Activity 4	Analysis using small time intervals	Practical work Use of ICT Application of number	
	... and graphs	Additional Sheet 4 Activity 5 Additional Sheet 5	Gradients of displacement–time and velocity–time graphs	Application of number	Optional extension: differentiation
	Analysing graphical records of motion to find overall change of displacement and change of velocity	Activity 6 Additional Sheets 6 and 7	Area under velocity–time and acceleration–time graphs Equations for uniformly accelerated motion	Use of ICT Application of number	Optional extension: integration
	Timing free fall to determine *g*	Activity 7	Free fall	Practical skills Application of number	Core practical
Section 1.4 Force and acceleration	Calculations with force, mass and acceleration Use of force sensor and graphing software	Additional Sheet 8 Additional Sheet 4	Force, mass and acceleration Newton I and II Weight and gravitational field	Use of ICT Application of number	GCSE revision
	Drawing and labelling diagrams to show pairs of forces	Activity 8 Activity 9	Newton III Equilibrium	Application of number	
Section 1.5 Momentum	Analysing collisions using momentum Relating momentum conservation to Newton II and III	Activity 10	Momentum Conservation of linear momentum	Practical work Application of number	
Section 1.6 Summing up Part 1	Use of key terms from Part 1	Activity 11		Study skills Communication	

Outline and reference to student materials			Key points	Skills	Notes
Section 2.1 Hanging on	Measuring and calculating forces in equilibrium	Activity 12 Activity 13 Activity 14 Activity 15 Additional Sheet 9 Activity 16 Activity 17	Vectors and scalars Equilibrium of forces Free-body diagrams Combining vectors in 2D by calculation and by drawing Resolving vectors into components		
Section 2.2 On the ropes	Obtaining and analysing force-extension measurements	Activity 18	Stiffness Hooke's law Non-Hookean behaviour	Practical work Application of number	GCSE revision
Section 2.3 Balancing	Applying principle of moments to extended objects in equilibrium	Activity 19 Activity 20	Principle of moments Centre of gravity	Application of number Practical work	
Section 2.4 Summing up Part 2	Use of key terms from Part 2	Activity 21		Study skills Communication	
Section 3.1 Energy return shoes	Discussions of 'scientific' advertising and of 'energy vocabulary'	Additional Sheet 10 Activity 22 Activity 23	Energy transfer and conservation Kinetic and potential energy Ways in which society uses science to inform decision making	Communication	GCSE revision
	Calculating 'energy return' when jumping ...	Activity 24	Work done by force Efficiency Gravitational potential energy	Practical work Application of number	GCSE revision
	... and running	Activity 25 Additional Sheet 4	Kinetic energy	Application of number	GCSE revision
Section 3.2 Speed skiing	Calculations relating speed to distance moved along slope		Work done when force not along direction of motion	Application of number	
Section 3.3 Pumping iron	Measurement of power in physical activities	Activity 26 Activity 27	Power	Practical work Use of ICT Application of number	GCSE revision
Section 3.4 Summing up Part 3	Use of key terms from Part 3	Activity 28		Study skills	
Section 4.1 Bungee jumping	Analysis of bungee jump in terms of energy	Activity 29	Energy stored in distorted materials Area under force–displacement graph Energy conservation	Practical work Application of number	
Section 4.2 Pole vaulting	Calculations relating to pole vault records		Energy conservation Material properties	Application of number	
Section 4.3 Summing up Part 4	Use of key ideas from Part 4			Study skills Application of number	

Outline and reference to student materials			Key points	Skills	Notes
Section 5.1 Ski jumping	Exploration of factors affecting range of ski jump	Activity 30 Activity 31 Activity 32	Motion of a horizontally launched projectile Independence of vertical and horizontal motion	Practical work Application of number	
Section 5.2 Throwing	Exploration of factors affecting range of shot-put	Activity 33	Range of a projectile launched at an angle	Application of number Use of ICT	Optional extension work
Section 5.3 Summing up Part 5	Use of key ideas from Part 5	Activity 34 Activity 35		Practical work Application of number	
Section 6.1 Summing up the chapter	Use of key ideas from the whole chapter	Activity 36 Activity 37		Study skills Communication Application of number	
Section 6.2 Questions on the whole chapter	Questions and calculations	Additional Sheet 11		Application of number	Consolidation and revision
Section 6.3 Achievements	Chapter tests	Additional Sheets 12, 13, 14, 15		Communication Application of number	Questions illustrate style of external test

Table 1.2 Learning outcomes specified for *Higher, Faster, Stronger*

	Statement from Examination Specification	Section(s) in this chapter
1	know and understand the distinction between base and derived quantities and their SI units	1.2, 1.4, 1.5, 2.3, 3.1
2	demonstrate their knowledge of practical skills and techniques for both familiar and unfamiliar experiments	1.3, 1.4, 1.5, 2.1, 2.2, 2.3
3	be able to estimate values for physical quantities and use their estimate to solve problems	1.4, 3.1, 3.3, 4.3
5	be able to communicate information and ideas in appropriate ways using appropriate terminology	3.1, 3.3, 3.4, 5.3
9	be able to use the equations for uniformly accelerated motion in one dimension: $s = \frac{(u+v)t}{2}$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$	1.2, 1.3
10	be able to draw and interpret displacement/time, velocity/time and acceleration/time graphs	1.3
11	know the physical quantities derived from the slopes and areas of displacement/time, velocity/time and acceleration/time graphs, including cases of non-uniform acceleration, and understand how to use the quantities	1.3
12	understand scalar and vector quantities, and know examples of each type of quantity and recognise vector notation	1.2, 2.1
13	be able to resolve a vector into two components at right angles to each other by drawing and by calculation	2.1
14	be able to find the resultant of two coplanar vectors at any angle to each other by drawing, and at right angles to each other by calculation	2.1
15	understand how to make use of the independence of vertical and horizontal motion of a projectile moving freely under gravity	5.1, 5.2
16	be able to draw and interpret free-body force diagrams to represent forces on a particle or on an extended but rigid body	2.1, 2.3
17	be able to use the equation $\sum F = ma$, and understand how to use this equation in situations where m is constant (Newton's second law of motion), including Newton's first law of motion where $a = 0$, objects at rest or travelling at constant velocity Use of the term *terminal velocity* is expected	1.4, 2.1
18	be able to use the equations for gravitational field strength $g = F/m$ and weight $W = mg$	1.4
19	CORE PRACTICAL 1: Determine the acceleration of a freely falling object	1.3
20	know and understand Newton's third law of motion and know the properties of pairs of forces in an interaction between two bodies	1.4
21	understand that momentum is defined as $p = mv$	1.5
22	know the principle of conservation of linear momentum, understand how to relate this to Newton's laws of motion and understand how to apply this to problems in one dimension	1.5
23	be able to use the equation for the moment of a force, moment of force = Fx where x is the perpendicular distance between the line of action of the force and the axis of rotation	2.3
24	use the concept of centre of gravity of an extended body and apply the principle of moments to an extended body in equilibrium	2.3
25	be able to use the equation for work $\Delta W = F\Delta s$ including calculations when the force is not along the line of motion	3.1, 3.2
26	be able to use the equation $E_k = \frac{1}{2}mv^2$ for the kinetic energy of a body	3.1
27	be able to use the equation $\Delta E_{grav} = mg\Delta h$ for the difference in gravitational potential energy near the Earth's surface	3.1, 4.1, 4.2
28	know, and understand how to apply, the principle of conservation of energy including use of work done, gravitational potential energy and kinetic energy	3.1, 4.1, 4.2
29	be able to use the equations relating power, time and energy transferred or work done $P = E/t$ and $P = W/t$	3.3
30	be able to use the equations efficiency = $\frac{\text{useful energy output}}{\text{total energy input}}$ and efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	3.2

This chapter uses the context of sport to cover some work on motion, forces and energy. Much of this work involves revision and extension of material from GCSE.

The chapter is designed to be taught before *Good Enough to Eat* (which introduces some basic ideas about solid materials) and *Spare Part Surgery* (which develops some more advanced ideas about solid materials). However, *Good Enough to Eat* could be taught in parallel with Parts 3 to 5 of this chapter.

There is quite a bit of GCSE revision as well as some new material. If you are confident that your students already have a firm grasp of GCSE material, it would be wise only to spend a short time on the revision activities or to omit them entirely. However, going over familiar ground can be valuable, particularly in activities that help develop students' skills in using ICT and in working with others. There are many good ICT resources available to enhance this chapter; our recommendations are listed in the Technician Notes along with details of suppliers.

Part 1 of the chapter shows how graphs and equations are used in the science of biomechanics to describe and analyse uniform and non-uniform motion, for example of a sprinter. Conservation of linear momentum is introduced. In Part 2, the equilibrium of forces in rock climbing and gymnastics and the elastic behaviour of climbing ropes are used to introduce vector diagrams and calculations, the principle of moments, and force–extension graphs. Part 3 introduces ideas of work and of kinetic and potential energy in order to look into some of an advertiser's claims for training shoes, applies the same ideas to speed skiing, and then extends them to include power in order to analyse weight training and other physical activities.

In Part 4, energy and elastic behaviour are brought together in a study of bungee jumping and pole vaulting. Part 5 looks at ski jumping and shot-putting, revisiting ideas about motion and vectors from Parts 1 and 2 in order to analyse the motion of projectiles.

Part 6 looks back over the whole chapter and helps students to draw together the physics. A recurring theme in the chapter is that of using graphs to display data and to deduce further information from gradients and areas.

As each part of this chapter builds on work from earlier parts, and ideas are continually being revisited, revised and extended, it would be best if the whole chapter could be taught by one teacher. However, if necessary, Part 2 could be taught in parallel with Part 1 and, once Parts 1 and 2 are finished, Part 5 could be taught separately from Parts 3 and 4.