Contents

Contents

UNIT 4: REVOLUTIONS IN MODERN PHYSICS

How to use this book

The *Pearson Physics 12 Queensland Skills and Assessment* book takes an intuitive, self-paced approach to science education that ensures every student has opportunities to practise, apply and extend their learning through a range of supportive and challenging activities.

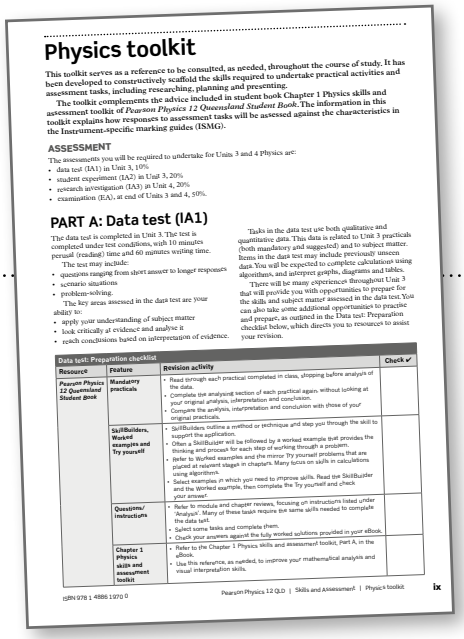
This resource has been developed by highly experienced and expert author teams, with leading Queensland specialists who have a working understanding of what teachers are looking for to support teaching and learning across the new Queensland Certificate of Education (QCE).

Fully written to the new QCAA Physics 2019 General Senior Syllabus, the skills and assessment book is organised into units, with the unit openers outlining the unit objectives that are addressed. The skills and assessment book is further organised into topics. Each topic addresses all of the subject matter and mandatory practicals from the syllabus.

All activities are closely linked to the material in the *Pearson Physics 12 Queensland Student Book*, creating a complete teaching, learning and assessment program. At the same time, the skills and assessment book has been designed so it can be used independently of the student book, providing flexibility in when and how students and teachers are able to engage with it.

Toolkit

A complementary toolkit supports development of the skills and techniques needed to undertake practical investigations, the data test, student experiment and research investigation. It also includes checklists and helpful hints to assist in fulfilling all assessment requirements and to support further development of study skills.



Physics toolkit

This toolkit serves as a reference to be consulted, as needed, throughout the course of study. It has been developed to constructively scaffold the skills required to undertake practical activities and assessment tasks, including researching, planning and presenting.

The toolkit complements the advice included in student book Chapter 1 Physics skills and assessment toolkit of *Pearson Physics 12 Queensland Student Book*. The information in this toolkit explains how responses to assessment tasks will be assessed against the characteristics in the Instrument-specific marking guides (ISMG).

ASSESSMENT

The assessments you will be required to undertake for Units 3 and 4 Physics are:
- data test (IA1) in Unit 3, 10%
- student experiment (IA2) in Unit 3, 20%
- research investigation (IA3) in Unit 4, 20%
- examination (EA), at end of Units 3 and 4, 50%.

PART A: Data test (IA1)

The data test is completed in Unit 3. The test is completed under test conditions, with 10 minutes perusal (reading) time and 60 minutes writing time.

The test may include:
- questions ranging from short answer to longer responses
- scenario situations
- problem-solving.

The key areas assessed in the data test are your ability to:
- apply your understanding of subject matter
- look critically at evidence and analyse it
- reach conclusions based on interpretation of evidence.

Tasks in the data test use both qualitative and quantitative data. This data is related to Unit 3 practicals (both mandatory and suggested) and to subject matter. Items in the data test may include previously unseen data. You will be expected to complete calculations using algorithms, and interpret graphs, diagrams and tables.

There will be many experiences throughout Unit 3 that will provide you with opportunities to prepare for the skills and subject matter assessed in the data test. You can also take some additional opportunities to practise and prepare, as outlined in the Data test: Preparation checklist below, which directs you to resources to assist your revision.

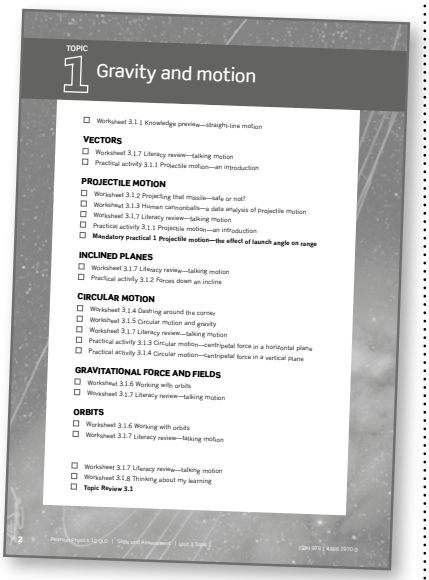
Data test: Preparation checklist

Resource	Feature	Revision activity	Check ✓
Pearson Physics 12 Queensland Student Book	Mandatory practicals	• Read through each practical completed in class, stopping before analysis of the data. • Complete the analysing section of each practical again, without looking at your original analysis, interpretation and conclusion. • Compare the analysis, interpretation and conclusion with those of your original practicals.	
	SkillBuilders, Worked examples and Try yourself	• SkillBuilders outline a method or technique and step you through the skill to support the application. • Often a SkillBuilder will be followed by a worked example that provides the thinking and process for each step of working through a problem. • Refer to Worked examples and the mirror Try yourself problems that are located at relevant stages in chapters. Many focus on skills in calculations using algorithms. • Select examples in which you need to improve skills. Read the SkillBuilder and the Worked example, then complete the Try yourself and check your answer.	
	Questions/ instructions	• Refer to module and chapter reviews, focusing on instructions listed under 'Analysis'. Many of these tasks require the same skills needed to complete the data test. • Select some tasks and complete them. • Check your answers against the fully worked solutions provided in your eBook.	
	Chapter 1 Physics skills and assessment toolkit	• Refer to the Chapter 1 Physics skills and assessment toolkit, Part A, in the eBook. • Use this reference, as needed, to improve your mathematical analysis and visual interpretation skills.	

ISBN 978 1 4886 1970 0 Pearson Physics 12 QLD | Skills and Assessment | Physics toolkit ix

Topic opener

The book is split into two units with 2–3 topics per unit, as per the syllabus. While the unit opener provides an overview of the syllabus outcomes for each unit, the topic opener gives a succinct overview of the content in the book for each topic, organised by key content area. Each topic opener is presented in a handy checklist format to allow you to track your progress.



TOPIC 1 Gravity and motion

- ☐ Worksheet 3.1.1 Knowledge preview—straight-line motion

VECTORS
- ☐ Worksheet 3.1.7 Literacy review—talking motion
- ☐ Practical activity 3.1.1 Projectile motion—an introduction

PROJECTILE MOTION
- ☐ Worksheet 3.1.2 Projecting that missile—safe or not?
- ☐ Worksheet 3.1.3 Human cannonballs—a data analysis of projectile motion
- ☐ Worksheet 3.1.7 Literacy review—talking motion
- ☐ Practical activity 3.1.1 Projectile motion—an introduction
- ☐ **Mandatory practical 1 Projectile motion—the effect of launch angle on range**

INCLINED PLANES
- ☐ Worksheet 3.1.7 Literacy review—talking motion
- ☐ Practical activity 3.1.2 Forces down an incline

CIRCULAR MOTION
- ☐ Worksheet 3.1.4 Dashing around the corner
- ☐ Worksheet 3.1.5 Circular motion and gravity
- ☐ Worksheet 3.1.7 Literacy review—talking motion
- ☐ Practical activity 3.1.3 Circular motion—centripetal force in a horizontal plane
- ☐ Practical activity 3.1.4 Circular motion—centripetal force in a vertical plane

GRAVITATIONAL FORCE AND FIELDS
- ☐ Worksheet 3.1.6 Working with orbits
- ☐ Worksheet 3.1.7 Literacy review—talking motion

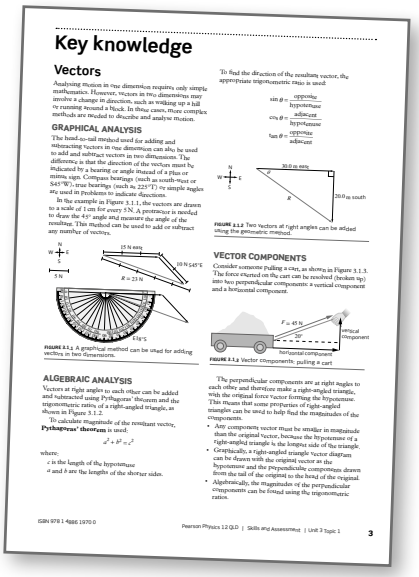
ORBITS
- ☐ Worksheet 3.1.6 Working with orbits
- ☐ Worksheet 3.1.7 Literacy review—talking motion

- ☐ Worksheet 3.1.7 Literacy review—talking motion
- ☐ Worksheet 3.1.8 Thinking about my learning
- ☐ **Topic Review 3.1**

2 Pearson Physics 12 QLD | Skills and Assessment | Unit 3 Topic 1 ISBN 978 1 4886 1970 0

Key knowledge

Each topic begins with a key knowledge section. The key knowledge consists of a set of succinct summary notes that cover the subject matter for each topic of the syllabus. This section is highly illustrative and written in a straightforward style to assist students of all abilities in focusing on the salient points. Key terms are bolded for ease of navigation and are reflected in the student book glossary. The key knowledge also serves as a ready reference when completing worksheets and practical activities, and it provides a handy set of revision and study notes.



Key knowledge

Vectors

Analysing motion in one dimension requires only simple mathematics. However, vectors in two dimensions may involve a change in direction, such as walking up a hill or running around a block. In these cases, more complex methods are needed to describe and analyse motion.

GRAPHICAL ANALYSIS

The head-to-tail method used for adding and subtracting vectors in one dimension can also be used to add and subtract vectors in two dimensions. The difference is that the direction of the vectors must be indicated by a bearing or angle instead of a Plus or minus sign. Compass bearings (such as south-west or S45°W) or true bearings (such as 225°T) or simple angles are used in problems to indicate directions.

In the example in Figure 3.1.1, the vectors are drawn to a scale of 1 cm for every 5 N. A protractor is needed to draw the 45° angle and measure the angle of the resultant. This method can be used to add or subtract any number of vectors.

FIGURE 3.1.1 A graphical method can be used for adding vectors in two dimensions.

To find the direction of the resultant vector, the appropriate trigonometric ratio is used:

$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$

$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$

$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$

FIGURE 3.1.2 Two vectors at right angles can be added using the geometric method.

VECTOR COMPONENTS

Consider someone pulling a cart, as shown in Figure 3.1.3. The force exerted on the cart can be resolved (broken up) into two perpendicular components: a vertical component and a horizontal component.

FIGURE 3.1.3 Vector components: pulling a cart

ALGEBRAIC ANALYSIS

Vectors at right angles to each other can be added and subtracted using Pythagoras' theorem and the trigonometric ratios of a right-angled triangle, as shown in Figure 3.1.2.

To calculate magnitude of the resultant vector, **Pythagoras' theorem** is used:

$$a^2 + b^2 = c^2$$

where:
c is the length of the hypotenuse
a and b are the lengths of the shorter sides.

The perpendicular components are at right angles to each other and therefore make a right-angled triangle, with the original force vector forming the hypotenuse. This means that some properties of right-angled triangles can be used to help find the magnitudes of the components.

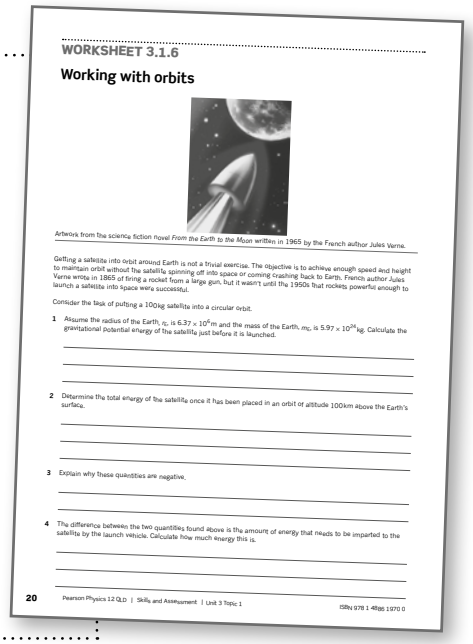
- Any component vector must be smaller in magnitude than the original vector, because the hypotenuse of a right-angled triangle is the longest side of the triangle.
- Graphically, a right-angled triangle vector diagram can be drawn with the original vector as the hypotenuse and the perpendicular components drawn from the tail of the original to the head of the original.
- Algebraically, the magnitudes of the perpendicular components can be found using the trigonometric ratios.

ISBN 978 1 4886 1970 0 Pearson Physics 12 QLD | Skills and Assessment | Unit 3 Topic 1 3

Worksheets

A diverse offering of instructive and self-contained worksheets is included in each topic. Common to all topics are the initial 'Knowledge preview' worksheets to activate prior knowledge; a 'Literacy review' worksheet to explicitly build language and the application of scientific terminology; and, finally, a 'Thinking about my learning' worksheet, which encourages students to reflect on their learning and identify areas for improvement. Other worksheets, with their range of activities and tasks, focus on the application of subject matter to assist in the consolidation of learning and the making of connections between subject matter.

Worksheets may be used for formative assessment and are clearly aligned to the syllabus. A range of questions, building from foundation to challenging, is included in the worksheets, which are written to reflect the Marzano and Kendall taxonomy instructional verbs.



WORKSHEET 3.1.6

Working with orbits

Artwork from the science fiction novel *From the Earth to the Moon* written in 1965 by the French author Jules Verne.

Getting a satellite into orbit around Earth is not a trivial exercise. The objective is to achieve enough speed and height to maintain orbit without the satellite spinning off into space or coming crashing back to Earth. French author Jules Verne wrote in 1865 of firing a rocket from a large gun, but it wasn't until the 1950s that rockets powerful enough to launch a satellite into space were successful.

Consider the task of putting a 100kg satellite into a circular orbit.

1 Assume the radius of the Earth, r_E, is 6.37×10^6m and the mass of the Earth, m_E, is 5.97×10^{24}kg. Calculate the gravitational potential energy of the satellite just before it is launched.

2 Determine the total energy of the satellite once it has been placed in an orbit or altitude 100km above the Earth's surface.

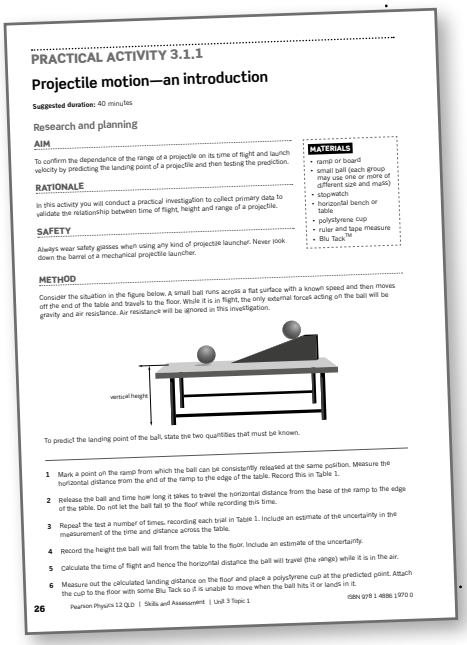
3 Explain why these quantities are negative.

4 The difference between the two quantities found above is the amount of energy that needs to be imparted to the satellite by the launch vehicle. Calculate how much energy this is.

ISBN 978 1 4886 1970 0

Practical activities

Practical activities take a highly scaffolded approach from beginning to completion and give students the opportunity to complete practical work related to the subject matter covered in the syllabus. Practical activities include a rich assortment of tasks that maximise learning opportunities and build experience in performing calculations and analysis of data, which are necessary for the data test. Every mandatory practical in the syllabus is featured, as well as many suggested practicals. As with the worksheets, the practical activities include a range of questions building from foundation to challenging, written to reflect the Marzano and Kendall taxonomy instructional verbs.



PRACTICAL ACTIVITY 3.1.1

Projectile motion—an introduction

Suggested duration: 40 minutes

Research and planning

AIM

To confirm the dependence of the range of a projectile on its time of flight and launch velocity by predicting the landing point of a projectile and then testing the prediction.

RATIONALE

In this activity you will conduct a practical investigation to collect primary data to validate the relationship between time of flight, height and range of a projectile.

SAFETY

Always wear safety glasses when using any kind of projectile launcher. Never look down the barrel of a mechanical projectile launcher.

METHOD

Consider the situation in the figure below. A small ball runs across a flat surface with a known speed and then moves off the end of the table and travels to the floor. While it is in flight, the only external forces acting on the ball will be gravity and air resistance. Air resistance will be ignored in this investigation.

MATERIALS
- ramp or board
- small ball (each group may use one or more of different size and mass)
- stopwatch
- horizontal bench or table
- polystyrene cup
- ruler and tape measure
- Blu Tack™

vertical height

To predict the landing point of the ball, state the two quantities that must be known.

1 Mark a point on the ramp from which the ball can be consistently released at the same position. Measure the horizontal distance from the end of the ramp to the edge of the table. Record this in Table 1.

2 Release the ball and time how long it takes to travel the horizontal distance from the base of the ramp to the edge of the table. Do not let the ball fall to the floor while recording this time.

3 Repeat the test a number of times, recording each trial in Table 1. Include an estimate of the uncertainty in the measurement of the time and distance across the table.

4 Record the height the ball will fall from the table to the floor. Include an estimate of the uncertainty.

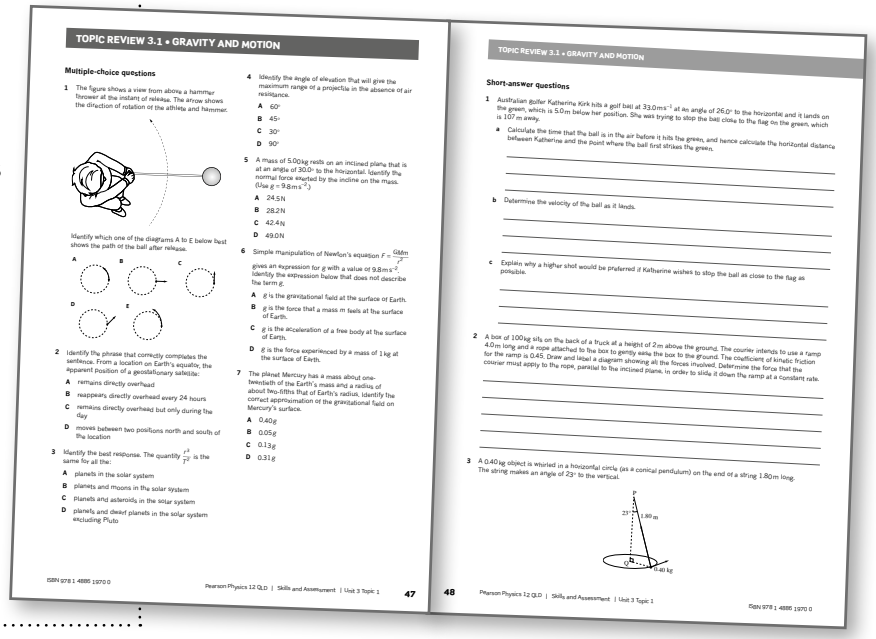
5 Calculate the time of flight and hence the horizontal distance the ball will travel (the range) while it is in the air.

6 Measure out the calculated landing distance on the floor and place a polystyrene cup at the predicted point. Attach the cup to the floor with some Blu Tack so it is unable to move when the ball hits it or lands in it.

ISBN 978 1 4886 1970 0

Topic review questions

Each topic concludes with a comprehensive set of question items consisting of multiple-choice and short-answer responses. Topic reviews provide an experience of subject matter and skills across the breadth of the topic. They also reflect the cognitive verbs used in the syllabus subject matter dot points. These items indicate the highest level of thinking that will be assessed on the external examination.



TOPIC REVIEW 3.1 • GRAVITY AND MOTION

Multiple-choice questions

1 The figure shows a view from above a hammer thrower at the instant of release. The arrow shows the direction of rotation of the athlete and hammer.

Identify which one of the diagrams A to E below best shows the path of the ball after release.

A B C D E

2 Identify the phrase that correctly completes the sentence. From a location on Earth's equator, the apparent position of a geostationary satellite:
- A remains directly overhead
- B reappears directly overhead every 24 hours
- C remains directly overhead but only during the day
- D moves between two positions north and south of the location

3 Identify the best response. The quantity $\frac{r^3}{T^2}$ is the same for all the:
- A planets in the solar system
- B planets and moons in the solar system
- C planets and asteroids in the solar system
- D planets and dwarf planets in the solar system excluding Pluto

4 Identify the angle of elevation that will give the maximum range of a projectile in the absence of air resistance.
- A 60°
- B 45°
- C 30°
- D 90°

5 A mass of 5.00kg rests on an inclined plane that is at an angle of 30.0° to the horizontal. Identify the normal force exerted by the incline on the mass. (Use $g = 9.8\,m\,s^{-2}$.)
- A 24.5N
- B 28.2N
- C 42.4N
- D 49.0N

6 Simple manipulation of Newton's equation $F = \frac{GMm}{r^2}$ gives an expression for g with a value of $9.8\,m\,s^{-2}$. Identify the expression below that does not describe the term g.
- A g is the gravitational field at the surface of Earth.
- B g is the force that a mass m feels at the surface of Earth.
- C g is the acceleration of a free body at the surface of Earth.
- D g is the force experienced by a mass of 1kg at the surface of Earth.

7 The planet Mercury has a mass about one-twentieth of the Earth's mass and a radius of about two-fifths that of Earth's radius. Identify the correct approximation of the gravitational field on Mercury's surface.
- A $0.40g$
- B $0.05g$
- C $0.13g$
- D $0.31g$

TOPIC REVIEW 3.1 • GRAVITY AND MOTION

Short-answer questions

1 Australian golfer Katherine Kirk hits a golf ball at $33.0\,m\,s^{-1}$ at an angle of 26.0° to the horizontal and it lands on the green, which is 5.0m below her position. She was trying to stop the ball close to the flag on the green, which is 107m away.

a Calculate the time that the ball is in the air before it hits the green, and hence calculate the horizontal distance between Katherine and the point where the ball first strikes the green.

b Determine the velocity of the ball as it lands.

c Explain why a higher shot would be preferred if Katherine wishes to stop the ball as close to the flag as possible.

2 A box of 100kg sits on the back of a truck at a height of 2m above the ground. The courier intends to use a ramp 4.0m long and a rope attached to the box to gently ease the box to the ground. The coefficient of kinetic friction for the ramp is 0.45. Draw and label a diagram showing all the forces involved. Determine the force that the courier must apply to the rope, parallel to the inclined plane, in order to slide it down the ramp at a constant rate.

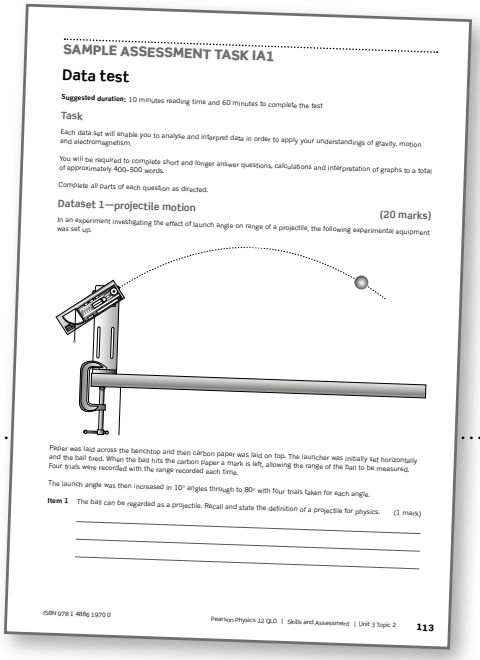
3 A 0.40kg object is whirled in a horizontal circle (as a conical pendulum) on the end of a string 1.80m long. The string makes an angle of 23° to the vertical.

P 23° 1.80 m Q 0.40 kg

ISBN 978 1 4886 1970 0

Sample assessment tasks

Sample assessment tasks for the data test, student experiment and research investigation provide opportunities for students to practise responding to these assessment tasks. The activities are designed to support students by guiding and scaffolding them through each aspect of these assessments.



SAMPLE ASSESSMENT TASK IA1

Data test

Suggested duration: 10 minutes reading time and 60 minutes to complete the test

Task

Each data set will enable you to analyse and interpret data in order to apply your understandings of gravity, motion and electromagnetism.

You will be required to complete short and longer answer questions, calculations and interpretation of graphs to a total of approximately 400–500 words.

Complete all parts of each question as directed.

Dataset 1—projectile motion (20 marks)

In an experiment investigating the effect of launch angle on range of a projectile, the following experimental equipment was set up.

Paper was laid across the benchtop and then carbon paper was laid on top. The launcher was initially set horizontally and the ball fired. When the ball hits the carbon paper a mark is left, allowing the range of the ball to be measured. Four trials were recorded with the range recorded each time.

The launch angle was then increased in 10° angles through to 80° with four trials taken for each angle.

Item 1 The ball can be regarded as a projectile. Recall and state the definition of a projectile for physics. (1 mark)

ISBN 978 1 4886 1970 0 Pearson Physics 12 QLD | Skills and Assessment | Unit 3 Topic 2 113

Icons and features

Every mandatory practical is supported by a complementary SPARKlab alternative practical.

The *Pearson Physics Skills and Assessment* book icons in the student book indicate the best time to engage with an activity from the skills and assessment book. These activities can be used for practice, application and revision of subject matter.

The type of activity is indicated by the following icons in the student book:

Worksheet (WS)

Practical activity (PA)

Mandatory practical (MP)

Topic review (TR)

Sample Assessment Task (SAT)

The **safety icon** highlights significant hazards, indicating caution is needed.

The **safety glasses icon** highlights that protective eyewear is to be worn during the practical activity.

Rate my learning

This innovative feature assists students to reflect on their learning and appears at the end of most worksheets, practical activities and sample assessment tasks. It provides students with the opportunity for self-reflection and self-assessment. Students are encouraged to consider how they can continue to improve, and to identify areas of focus for further skill and subject matter development. This tool is based on Marzano and Kendall's taxonomy.

RATE MY LEARNING				
• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

Teacher support

Fully worked solutions, suggested answers and responses to the worksheets, practical activities, mandatory practicals, topic reviews and sample assessment tasks are provided for teachers through the Teacher Support subscription. Risk assessments, expected results and handy hints for all practical activities are also provided.

Series overview

Student book

Pearson Physics 12 Queensland Student Book has been developed by experienced Queensland teachers to address all the requirements of the new QCAA Physics 2019 General Senior Syllabus. The series features the very latest developments and applications of physics, literacy, and instructional design to ensure the content and concepts are fully accessible to all students.

Skills and assessment book

The *Pearson Physics 12 Skills and Assessment* book gives students the edge in preparing for all forms of assessment. Specifically prepared to provide opportunities to consolidate, develop and apply subject matter and science inquiry skills, this resource features a toolkit, key knowledge summaries, worksheets, practical activities and guidance, assessment practice and topic review sets.

Reader+ the next generation eBook

Reader+ is our next generation eBook. Students can read, take notes, save bookmarks and more in the one seamless experience. Integrated multimedia (audio/video) and interactive activities enhance and extend the learning experience.

In addition, Reader+ provides the digital-only Chapter 1 Physics skills and assessment toolkit, along with interactives and visual media to help consolidate understanding of concepts and ideas.

Teacher support

Pearson Physics 12 Queensland Teacher Support provides:

- complete answers, fully worked solutions or suggested answers to all tasks in the student book and the skills and assessment book
- expected results, common mistakes, suggested answers and full safety notes and risk assessments for all practical activities
- teaching, learning and assessment programs.

Pearson

Access your digital resources at **pearsonplaces.com.au**
Browse and buy at **pearson.com.au**

ISBN 978 1 4886 1970 0