Module 9 Linear motion

Recommended total teaching time: 9.5 hours

• 7.5 × 60-minute periods of theory

• 2 × 60-minute periods of practical work

Planning support for this module

Practical lessons

This module includes the following practical lessons:

* Lesson 9.6 Displacement–time and velocity–time graphs for a ball on an incline
* Lesson 9.9 Acceleration due to gravity by linearising time–displacement graphs

Consult with your lab technician on the minimum time prescribed by your school before you intend to run the practical lessons, so that materials can be ordered and prepared in time.

If your timetable does not allow enough time to complete all the practicals in this module, the following can be excluded without impact on student achievement of science understanding objectives:

* Lesson 9.9 Acceleration due to gravity in Earth’s surface.

It is suggested that you ask students to watch the practical demonstration videos as homework before the practical lessons occur.

Module subject matter

Science understanding

* Contrast vectors and scalars, and use these terms to categorise physical quantities, e.g. velocity and speed.
* Symbolise vectors graphically and algebraically, e.g. $F, \tilde{F} and \vec{F}$.
* Calculate resultant vectors through the addition and subtraction of two vectors in one dimension.
* Describe the concepts of displacement, velocity and acceleration.
* Compare instantaneous and average velocity.
* Interpret linear motion graphs to describe the motion of an object, referring to the
	+ intercepts, gradients and uncertainties (using minimum and maximum lines of best fit) of displacement–time and velocity–time graphs
	+ areas under velocity–time and acceleration–time graphs using simple geometry.
* Solve problems relating to uniformly accelerated motion in one dimension using $v=u+at, s=ut+\frac{1}{2}at^{2} and v^{2}=u^{2}+2as$.
* Interpret experimental data to determine the value of acceleration due to gravity on the Earth’s surface.

Science inquiry skills

* Investigate situations that involve displacement–time and velocity–time graphs.
* Linearise a dataset that suggests a non-linear relationship (e.g.$ t^{2} versus s$) and calculate the equation of the linear trend line.

Lessons in this module

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| Lesson | Curriculum links | Recommended teaching time |
| Lesson 9.1 Vectors and scalars | **Science understanding*** Contrast vectors and scalars, and use these terms to categorise physical quantities, e.g. velocity and speed.
* Symbolise vectors graphically and algebraically, e.g. $F, \tilde{F} and \vec{F}$
 | 30 minutes(0.5 period) |
| Lesson 9.2 Distance and displacement | **Science understanding*** Calculate resultant vectors through the addition and subtraction of two vectors in one dimension.
* Describe the concepts of displacement, velocity and acceleration.
 | 60 minutes(1 period) |
| Lesson 9.3 Speed and velocity | **Science understanding*** Describe the concepts of displacement, velocity and acceleration.
* Compare instantaneous and average velocity.
 | 60 minutes(1 period) |
| Lesson 9.4 Graphs of linear motion – constant velocity | **Science understanding*** Interpret linear motion graphs to describe the motion of an object, referring to the
	+ intercepts, gradients and uncertainties (using minimum and maximum lines of best fit) of displacement–time and velocity–time graphs
	+ areas under velocity–time and acceleration–time graphs using simple geometry.
 | 60 minutes(1 period) |
| Lesson 9.5 Graphs of uniformly accelerated motion | **Science understanding*** Describe the concepts of displacement, velocity and acceleration.
* Interpret linear motion graphs to describe the motion of an object, referring to the
	+ intercepts, gradients and uncertainties (using minimum and maximum lines of best fit) of displacement–time and velocity–time graphs
	+ areas under velocity–time and acceleration–time graphs using simple geometry.
 | 60 minutes(1 period) |
| Lesson 9.6 Practical: Displacement–time and velocity–time graphs for a ball on an incline | **Science inquiry*** Investigate situations that involve displacement–time and velocity–time graphs.
 | 60 minutes(1 period) |
| Lesson 9.7 Equations of motion | **Science understanding*** Solve problems relating to uniformly accelerated motion in one dimension using $v=u+at, s=ut+\frac{1}{2}at^{2} and v^{2}=u^{2}+2as$
 | 90 minutes(1.5 periods) |
| Lesson 9.8 Acceleration due to gravity | **Science understanding*** Interpret experimental data to determine the value of acceleration due to gravity on the Earth’s surface.
 | 60 minutes(1 period) |
| Lesson 9.9 Practical: Acceleration due to gravity by linearising time–displacement graphs | **Science understanding** * Interpret experimental data to determine the value of acceleration due to gravity on the Earth’s surface.

**Science inquiry*** Linearise a dataset that suggests a non-linear relationship (e.g.$ t^{2} versus s$) and calculate the equation of the linear trend line.
 | 60 minutes(1 period) |

Advice for teaching this module

General teaching tips

The concepts covered in Unit 2, Topic 1 Linear motion and force are allocated 25 notional hours. From this, it is suggested that Module 9 be allocated 9.5 hours. This includes time for conducting practicals but does not include time for assessments.

No time is allocated for science inquiry skills. It is suggested that you integrate teaching of inquiry skills into your science understanding, science as a human endeavour and science inquiry teaching. Skill drills, worked examples, real-world science features and data drills placed throughout this module help to facilitate this.

It is suggested that students complete the Prior knowledge quiz for this module as homework before the module’s first lesson so that you have time to review the level of student background knowledge before commencing the new module. This information should inform your teaching throughout the module.

Recommended teaching strategies

**Demonstrate physical concepts**

Using carts – digital or ticker tape – will significantly enhance the learning of the concepts of displacement, velocity, and acceleration.

**Kinematic learning**

Endeavour to have students physically walk out graphs to enhance the transition of abstract data into internal knowledge.

**Alternative approaches**

Ensure students see both mathematical and graphical approaches to solving vector sums, as this will benefit them when they reach Unit 3 Topic 1 – Gravity and Motion.

Differentiation support

Ideas and strategies for supporting students

Getting students who are having difficulty with understanding the connection between the mathematical and language definitions of concepts to attempt things physically and helping them visualise scenarios using basic stick-figure drawings can benefit significantly. Encourage these students to focus on step by step processes rather than getting hung up on needing to know how to complete the whole problem before starting. Create structures using Polya’s problem solving method that students can refer to.

Ideas and strategies for challenging students

Students who are high achieving and are studying specialist mathematics may like to use their vector notation or calculus approaches. Encourage them to self-check their work against the answers to ensure that they are applying the skills validly. Several challenge tasks within the lesson modules will provide significant development for them.

Starter activity: Rates all the way down

Approximate time: 10 minutes

Notes for the teacher

This activity should emphasise to students that for anything that can be measured, how fast it changes can be important as well.

Explain to students that we feel up to about the fourth rate of change of displacement (the jerk – how fast your acceleration changes).

Instructions for students

Answer the following.

* 1. Define the concept of “rate of change of displacement” – you may remember this from junior science.
	2. Define the concept “rate of change of velocity”.
	3. Research what the “rate of change of acceleration” is called.
	4. How many “rates of change” come after this?

Helpful hints

* Try to do at least question ‘a’ and ‘b’ without any web searching!

Answers

1. Velocity
2. Acceleration
3. Jerk
4. Technically infinite, but the next four named ones are snap, crackle, pop, lock.