Module 10 Classical mechanics

Recommended total teaching time: 10.5 hours

• 9.5 × 60-minute periods of theory

• 1 × 60-minute periods of practical work

Planning support for this module

Practical lessons

This module includes the following practical lessons:

* Lesson 10.10 Linear elastic collision between trolleys – conservation of momentum

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.

There are no practicals considered non-essential within this module. All effort should be taken to ensure that students experience this practical:

* Lesson 10.10 Linear elastic collision between trolleys – conservation of momentum

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

* Describe the three laws of motion of classical mechanics and give examples of each.
* Identify forces acting on an object.
* Construct free-body diagrams representing forces such as the force due to gravity (weight), the normal force, tension, friction, drag and applied forces acting on an object.
* Determine the resultant force acting on an object in one dimension.
* Solve problems using of the laws of classical mechanics and $a=\frac{F\_{net}}{m}$.
* Describe the concepts of momentum and impulse.
* Describe the principle of conservation of momentum.
* Solve problems involving momentum, impulse, the conservation of momentum and collisions in one dimension using $p=mv and ∑mv\_{before}=∑mv\_{after}.$
* Analyse the area under a force–time graph using geometric methods.

Science as a human endeavour

* Appreciate the significant contributions of scientists such as Isaac Newton and Émilie du Châtelet.
* Explore historical models and theories used to describe motion and force, and how evidence was used to build upon and improve on earlier understandings.
* Consider how knowledge of forces and motion has led to improvements in car safety through the development of technologies such as seatbelts, crumple zones and airbags.
* Appreciate that the laws of motion proposed by Isaac Newton provided an explanation for a range of previously unexplained physical phenomena, which were confirmed by multiple experiments performed by a multitude of scientists.

Science inquiry

* Investigate a linear elastic collision between two objects.

Lessons in this module

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| Lesson | Curriculum links | Recommended teaching time |
| Lesson 10.1 Measuring forces | **Science understanding*** Identify forces acting on an object.
* Construct free-body diagrams representing forces such as the force due to gravity (weight), the normal force, tension, friction, drag and applied forces acting on an object.
* Determine the resultant force acting on an object in one dimension.
 | 60 minutes(1 period) |
| Lesson 10.2 Newton’s first law of motion | **Science understanding*** Describe the three laws of motion of classical mechanics and give examples of each.
* Solve problems using of the laws of classical mechanics and $a=\frac{F\_{net}}{m}$.

**Science as a human endeavour*** Appreciate the significant contributions of scientists such as Isaac Newton and Émilie du Châtelet.
* Explore historical models and theories used to describe motion and force, and how evidence was used to build upon and improve on earlier understandings.
* Appreciate that the laws of motion proposed by Isaac Newton provided an explanation for a range of previously unexplained physical phenomena, which were confirmed by multiple experiments performed by a multitude of scientists.
 | 30 minutes(0.5 period) |
| Lesson 10.3 Newton’s second law of motion | **Science understanding*** Describe the three laws of motion of classical mechanics and give examples of each.
* Solve problems using of the laws of classical mechanics and $a=\frac{F\_{net}}{m}$.
 | 60 minutes(1 period) |
| Lesson 10.4 Newton’s third law of motion | **Science understanding*** Describe the three laws of motion of classical mechanics and give examples of each.
* Solve problems using of the laws of classical mechanics and $a=\frac{F\_{net}}{m}$.
 | 60 minutes(1 period) |
| Lesson 10.5 Force, weight and gravity | **Science understanding*** Identify forces acting on an object.
* Determine the resultant force acting on an object in one dimension.
 | 60 minutes(1 period) |
| Lesson 10.6 Friction | **Science understanding*** Identify forces acting on an object.
* Determine the resultant force acting on an object in one dimension.
* Solve problems using of the laws of classical mechanics and $a=\frac{F\_{net}}{m}$.
 | 60 minutes(1 period) |
| Lesson 10.7 Terminal velocity and drag | **Science understanding*** Identify forces acting on an object.
* Determine the resultant force acting on an object in one dimension.
 | 30 minutes(0.5 period) |
| Lesson 10.8 Momentum and impulse | **Science understanding*** Describe the concepts of momentum and impulse.
* Analyse the area under a force–time graph using geometric methods.
* Solve problems involving momentum, impulse, the conservation of momentum and collisions in one dimension using $p=mv and ∑mv\_{before}=∑mv\_{after}.$
 | 90 minutes(1.5 periods) |
| Lesson 10.9 Conservation of momentum | **Science understanding*** Describe the principle of conservation of momentum.
* Solve problems involving momentum, impulse, the conservation of momentum and collisions in one dimension using $p=mv and ∑mv\_{before}=∑mv\_{after}.$

**Science as a human endeavour*** Consider how knowledge of forces and motion has led to improvements in car safety through the development of technologies such as seatbelts, crumple zones and airbags.
 | 60 minutes(1 period) |
| Lesson 10.10 Practical: Linear elastic collision between trolleys – conservation of momentum | **Science inquiry*** Investigate a linear elastic collision between two objects.
 | 60 minutes(1 period) |

Advice for teaching this module

General teaching tips

The concepts covered in Unit 2, Topic 1 Linear motion and waves are allocated 25 notional hours. From this, it is suggested that Module 10 be allocated 10.5 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

**I do, we do, you do**

There is a significant amount of calculations present in the middle and end of this unit with free body diagrams and conservation of momentum. While worked examples are provided it is worth spending some time demonstrating to students how to do these questions and working through some together. The revision chapter at the end of the unit will provide many good questions to use.

**Real world learning**

Newton’s three laws should be quizzed through both mathematical and language based questions. If a student can explain the law and spot applications in context then they will be able to apply it to future questions in Unit 3.

Differentiation support

Ideas and strategies for supporting students

Students who struggle with mathematics will have difficulty with free body diagrams and conservation of momentum calculations. For conservation of momentum consider giving students a template that they can fill in for scaffolding to begin their problems. They will still need to read and process the data, but some assistance with starting the calculations is often enough to get them to the end.

For free body diagrams, getting students to practice writing summary equations of forces will benefit their approach to solving for unknown values.

Ideas and strategies for challenging students

Consider providing research opportunities for students who are advancing faster than the class. Rocket physics provides for an excellent further learning opportunity in conservation of momentum, and will introduce students to calculus if they have not already engaged with it. Getting students to consider more complex systems for free-body diagrams will deepen understanding of this content as well.

Starter activity: Defying gravity with a toothpick

Approximate time: 10 minutes

Notes for the teacher

This is a very easy demonstration to set up in the lab as well.

Video at: <https://www.youtube.com/watch?v=3kX24bf7Xlg>

Instructions for students

Watch the following video.

Amazing Toothpick Gravity Trick: <https://www.youtube.com/watch?v=3kX24bf7Xlg>

* 1. Provide a suggestion for how you think this setup works. You should revisit the video after Lesson 10.5 to see if your explanation is correct. Note: the video says the word ‘energy’ but that is incorrect. There is no energy moving through this system. You will learn about energy in Module 11.

Helpful hints

* The topic is forces. It may have something to do with that.

Answers

1. The downwards force from the weight causes the rope to apply sideways force on the toothpick. This keeps the vertical toothpick in place, and the gap between the horizontal toothpick and table is slightly smaller than the toothpick. This applies an upwards force to the toothpick, while the mass pulls down keeping the forces balanced. If the bottle was further away from the table, the system would fall over.