VCE Physics Units 1&2 Complete Study Guide

Complete study guide · Units 1&2 · AceGuides

This guide follows the VCAA VCE Physics Study Design (Units 1 and 2 accredited from 2023; Units 3 and 4 from 2024). It covers every key knowledge dot point in Unit 1 (How is energy useful to society?) and Unit 2 (How does physics help us to understand the world?), plus the key science skills that are assessed in every unit.

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About this guide

How to use this guide

Each section matches one part of the study design. Read the explanation, then cover the worked example and try it yourself before reading the working. Every section ends with "Check your understanding" questions; full worked solutions are in the Worked solutions section near the end. When you can do every question in a section without looking, tick that section off.

- **Bold words** are terms you should be able to define in an exam.
- Blue boxes are exam tips. Amber boxes are common mistakes that lose marks.
- All numerical answers in this guide were checked by calculation. Answers are given to a sensible number of significant figures, usually matching the data.
- Use the official VCE Physics formula sheet (free on the VCAA website) alongside this guide. The study design says the formula sheet is part of the course, so practise with it from day one.

How Units 1 and 2 are assessed

Units 1 and 2 are assessed by your school, not by the VCAA. There is no VCAA exam for Units 1 and 2, and your school decides how to grade you. To pass each unit (an S result), you must show you have achieved all three outcomes in that unit and keep a logbook of your practical work.

Unit	Outcome	Area of Study	Typical school tasks
1	1	How are light and heat explained?	Practical report, data analysis, test
1	2	How is energy from the nucleus utilised?	Test, media analysis, physics response to an issue
1	3	How can electricity be used to transfer energy?	Practical report, circuit problem-solving test
2	1	How is motion understood?	Practical report, test, motion case study
2	2	Options (one of eighteen)	Physics-referenced response, poster, report
2	3	How do physicists investigate questions?	Report of your own investigation (poster, report or presentation)

Most schools also run an end-of-semester or end-of-year exam that copies the style of the VCE Units 3 and 4 exam: multiple-choice questions followed by short-answer and extended-answer questions, with the formula sheet supplied. The practice exam in this guide is built that way.

Exam tip: Units 1 and 2 do not count directly towards your ATAR, but Units 3 and 4 Physics assume this content. Motion, forces, energy, momentum, circuits and the key science skills all come back in Year 12, so time spent here pays off twice.

Looking ahead

VCAA lists this study design as accredited from 2023 (Units 1 and 2) and 2024 (Units 3 and 4). At the time of writing (October 2026) it is the study design in force, and we are not aware of a replacement start date. If VCAA announces a new study design, the core physics in this guide (waves, thermal physics, nuclear physics, circuits, motion, forces, energy and momentum) is standard content that is very likely to carry over. Check the VCAA Physics page each year.

A 10-week revision plan

Week	Focus	Tasks
1	Light and EM radiation	Read section 1, learn Snell's law, do Q1.1–Q1.7
2	Thermal energy and climate	Section 2, practise Q = mcΔT and Q = mL problems
3	Nuclear radiation	Section 3, decay equations, half-life and dose
4	Nuclear energy	Section 4, binding energy curve, write a viability paragraph
5	Circuits	Sections 5 and 6, series/parallel and safety devices
6	Motion	Section 7, constant acceleration equations and graphs
7	Forces and torque	Section 8, free-body diagrams every day
8	Energy and momentum	Section 9, collisions, springs, efficiency
9	Options and investigation	Sections 10 and 11, plan your investigation report
10	Exam practice	Practice exam under timed conditions, then mark it honestly

Contents

1. Light and electromagnetic radiation (Unit 1, Area of Study 1)
2. Thermal energy and climate (Unit 1, Area of Study 1)
3. Radiation from the nucleus (Unit 1, Area of Study 2)
4. Nuclear energy (Unit 1, Area of Study 2)
5. Electric circuits (Unit 1, Area of Study 3)
6. Using electricity safely (Unit 1, Area of Study 3)
7. Describing motion (Unit 2, Area of Study 1)

8. Forces, Newton's laws and equilibrium (Unit 2, Area of Study 1)
9. Energy, momentum and the motion case study (Unit 2, Area of Study 1)
10. The options: physics in society (Unit 2, Area of Study 2)
11. Scientific investigation and key science skills (Unit 2, Area of Study 3 and all units)
12. Exam technique
13. Practice exam
14. Worked solutions
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1. Light and electromagnetic radiation

Unit 1, Area of Study 1 asks: how are light and heat explained? This section covers the wave model of light. Section 2 covers thermal energy and how heat and light link together in climate.

Electromagnetic waves are transverse and travel at c

A **wave** transfers energy from one place to another without transferring matter. There are two broad types.

- A **mechanical wave** needs a medium (solid, liquid or gas) to travel through. Sound, water waves and waves on a rope are mechanical.
- An **electromagnetic (EM) wave** is a changing electric and magnetic field that does not need a medium. EM waves can travel through a vacuum, which is how sunlight reaches Earth.

A **transverse wave** vibrates at right angles to the direction the wave travels. A **longitudinal wave** vibrates parallel to the direction of travel (sound in air is longitudinal). **All EM waves are transverse, and all travel at the same speed in a vacuum**: $c = 3.0 \times 10^{8}$ m s^{-1}.

Describing a wave

Quantity	Symbol	Meaning	Unit
Amplitude	A	Maximum displacement from the rest position	m (or the unit of whatever is vibrating)
Wavelength	λ	Distance between two neighbouring points in phase (crest to crest)	m
Period	T	Time for one complete wave to pass a point	s
Frequency	f	Number of complete waves passing a point per second	Hz (s^{-1})
Speed	v	Distance a crest travels per second	m s^{-1}

The wave equation links them: **$v = f\lambda$**, so $\lambda = v/f = vT$, and $f = 1/T$.

Worked example 1.1. A Melbourne FM radio station broadcasts at 103.5 MHz. Find the wavelength and period of the radio waves.

1. Convert: $f = 103.5\ \text{MHz} = 103.5 \times 10^6\ \text{Hz}$.
2. $\lambda = c/f = (3.0 \times 10^8) \div (103.5 \times 10^6) = 2.9\ \text{m}$.
3. $T = 1/f = 1 \div (103.5 \times 10^6) = 9.7 \times 10^{-9}\ \text{s}$.

> **Common mistake:** Forgetting prefixes. M = 10^6, G = 10^9, k = 10^3, n = 10^{-9}, μ = 10^{-6}. Write the power of ten in the very first line of working so you can't lose it.

Why wavelength changes but frequency does not

The **frequency is set by the source** (how fast it vibrates). The **speed is set by the medium**. Since $\lambda = v/f$, when a wave enters a new medium and its speed changes, its wavelength must change too, while its frequency stays the same. Light slows down in glass, so its wavelength gets shorter in glass.

Worked example 1.2. Red light of wavelength 650 nm in air enters water (refractive index 1.33). Find its wavelength in water.

1. The frequency does not change. The speed in water is $v = c/n$, so it is 1.33 times smaller.
2. $\lambda_{water} = \lambda_{air}/n = 650 \div 1.33 = 489\ \text{nm}$.

Light from the Sun

The Sun emits EM radiation across the spectrum, but almost all of its energy arrives as **ultraviolet (UV), visible light and infrared (IR)**. Roughly speaking, about half the energy is IR, a bit under half is visible and a small amount is UV. The atmosphere absorbs most of the dangerous short-wavelength UV (mainly in the ozone layer).

The electromagnetic spectrum

All parts of the spectrum travel at c in a vacuum. Moving from radio to gamma, wavelength decreases, frequency increases and the energy carried by each photon increases.

Region	Typical wavelength	Typical uses in society
Radio	over 1 m (up to km)	AM/FM radio, TV broadcast, two-way radio
Microwave	about 1 mm to 1 m	Mobile phones, Wi-Fi, radar,

		microwave ovens
Infrared	about 700 nm to 1 mm	Remote controls, thermal imaging, heaters, optical fibre data
Visible	about 400 nm (violet) to 700 nm (red)	Vision, photography, lasers, lighting
Ultraviolet	about 10 nm to 400 nm	Sterilising equipment, detecting forged notes, vitamin D production
X-ray	about 0.01 nm to 10 nm	Medical imaging, airport security, crystal structure studies
Gamma	below about 0.01 nm	Cancer radiotherapy, sterilising medical equipment, tracers

Exam tip: A useful memory aid from long to short wavelength is "Rabbits Mate In Very Unusual eXpensive Gardens" (radio, microwave, infrared, visible, UV, X-ray, gamma). Boundaries between regions are not sharp, so examiners accept approximate wavelengths.

Refraction and Snell's law

Refraction is the change in direction of a wave as it crosses a boundary into a medium where it travels at a different speed. The **refractive index** of a medium is $n = c/v$. Air has $n \approx 1.00$, water 1.33, glass about 1.5, diamond 2.42. Angles are always measured from the **normal**, a line at 90° to the boundary.

Snell's law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$, and also $n_1 v_1 = n_2 v_2$.

- Going into a higher n (slower) medium, light bends **towards** the normal.
- Going into a lower n (faster) medium, light bends **away from** the normal.

Worked example 1.3. Light in air hits a glass block ($n = 1.52$) at 40° to the normal. Find the angle of refraction and the speed of light in the glass.

1. $n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightarrow 1.00 \times \sin 40° = 1.52 \times \sin\theta_2$
2. $\sin\theta_2 = 0.6428 \div 1.52 = 0.4229$, so $\theta_2 = 25.0°$.
3. $v = c/n = (3.0 \times 10^8) \div 1.52 = 2.0 \times 10^8$ m s^{-1}.

Common mistake: Measuring the angle from the surface instead of the normal. If a

question says "the ray makes 30° with the surface of the water", the angle of incidence is 90° − 30° = 60°. Also check your calculator is in degrees.

Total internal reflection and the critical angle

When light goes from a higher-n medium into a lower-n medium (for example glass to air), it bends away from the normal. As the angle of incidence increases, the refracted ray gets closer to the surface. At the **critical angle** θ_c, the refracted ray travels along the boundary ($\theta_2 = 90°$). For any angle larger than θ_c, no light leaves: it is all reflected back inside. This is **total internal reflection (TIR)**.

Two conditions for TIR: (1) light must travel from higher n to lower n, and (2) the angle of incidence must be greater than the critical angle.

Critical angle: $n_1 \sin\theta_c = n_2 \sin 90°$, so $\sin\theta_c = n_2/n_1$.

Worked example 1.4. Find the critical angle for glass (n = 1.52) to air.

1. $\sin\theta_c = 1.00 \div 1.52 = 0.658$
2. $\theta_c = 41.1°$. Light hitting the inside glass–air surface at more than 41.1° is totally internally reflected.

Optical fibres for communication

An **optical fibre** is a thin strand of very pure glass or plastic. It has a **core** with a slightly higher refractive index surrounded by **cladding** with a slightly lower refractive index. Light (usually infrared) entering the core hits the core–cladding boundary at angles greater than the critical angle and is totally internally reflected again and again along the fibre.

Worked example 1.5. A fibre has core n = 1.48 and cladding n = 1.46. Find the critical angle at the core–cladding boundary.

1. $\sin\theta_c = 1.46 \div 1.48 = 0.9865$
2. $\theta_c = 80.6°$. Light must hit the boundary almost parallel to the fibre's axis (at more than 80.6° to the normal) to stay inside.

Advantages of optical fibres over copper wire for communication: much higher data rates (bandwidth), very low signal loss over long distances, immune to electrical interference, hard to tap secretly, lighter and made from abundant silica. Disadvantages: more fragile, harder to join (splice), and they cannot carry electrical power. Australia's National Broadband Network and the undersea cables linking Australia to the world carry data as pulses of infrared light in optical fibres.

Exam tip: The cladding is there so that TIR happens at a clean, protected boundary. If the cladding is scratched or the fibre is bent too sharply, light hits the boundary at less than the

critical angle and leaks out, weakening the signal.

Dispersion: prisms, lenses and rainbows

White light is a mixture of all visible wavelengths. The refractive index of glass or water is slightly **different for each wavelength**: violet light has a higher n than red light, so violet slows down more and bends more. When white light refracts into a prism, each colour bends by a different amount and the colours spread out. This is **dispersion**.

- In a **prism**, dispersion happens at both surfaces, spreading the spectrum further.
- In a **lens**, dispersion means different colours focus at slightly different points, giving coloured fringes around images. This is called **chromatic aberration**.

Rainbows form when sunlight enters spherical raindrops. Light refracts (and disperses) on entering the drop, reflects off the back surface of the drop, then refracts (and disperses) again as it leaves. Red light leaves at about 42° to the incoming sunlight and violet at about 40°. You see a rainbow when the Sun is behind you and rain is in front; red appears on the outside of the bow because it reaches your eye from drops higher in the sky.

Common mistake: Saying the reflection inside a raindrop is total internal reflection. In the primary rainbow the reflection at the back of the drop is a partial reflection: the angle is less than the critical angle and most light passes out of the back of the drop.

Mirages

On a hot day, the air right above a road is much hotter than the air above it. Hot air is less dense and has a slightly lower refractive index. Light from the sky travelling down towards the road passes through layers of steadily decreasing n, so it bends gradually away from the normal, curving upwards. When the angle becomes large enough it is totally internally reflected (or curves back up) and enters your eye travelling upwards. Your brain assumes light travels in straight lines, so you see an image of the sky on the road, which looks like a puddle of water. This is an **inferior mirage**.

Check your understanding

Q1.1 Microwave ovens operate at 2.45 GHz. Calculate the wavelength of the microwaves. (2 marks)

Q1.2 A sound wave has a period of 0.020 s and travels at 340 m s^{-1}. Find its frequency and wavelength. (2 marks)

Q1.3 Light in water (n = 1.33) hits the water–air surface at 30° to the normal. Find the angle of refraction in air. (2 marks)

Q1.4 Calculate the critical angle for diamond (n = 2.42) in air, and use it to explain why cut diamonds sparkle. (3 marks)

Q1.5 Explain why the frequency of light stays the same when it enters glass, but its wavelength changes. (2 marks)

Q1.6 Explain, with reference to refraction, why a glass prism separates white light into colours. (3 marks)

Q1.7 Explain how a mirage of "water" forms on a hot road. (3 marks)

End of free sample

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