N5

National 5 PHYSICS

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BrightRED Study Guide

Curriculum for Excellence

N5

PHYSICS

REVISED AND UPDATED FOR SQA CHANGES

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INTRODUCING NATIONAL 5 PHYSICS

The National 5 Physics course will help you to develop and apply skills for learning, skills for life and skills for work.

Physics is about gaining a knowledge and understanding of how things work, and applying this knowledge to explain and improve the world around us. The skills and knowledge developed by physicists are needed across all sectors of society. As our knowledge and understanding of physics increases, this leads to new technology and improvements in the way that we live in the world.

THE NATIONAL 5 PHYSICS COURSE

The National 5 Physics course encourages you to become:

- a more confident learner
- a responsible citizen with an informed understanding of the impact of technological developments on society resulting from physics, such as the internet, renewable energy and nuclear medicine
- someone who can analyse and understand new information and apply skills to solve problems.

The National 5 Physics course provides opportunities for you to acquire the knowledge and skills relevant to current physics topics. It is designed to help you to understand and investigate the world in an engaging and enjoyable way.

The National 5 Physics course covers many of the major areas of physics. It will give you an insight into the underlying nature of our world and its place in the universe. From the sources of power that we use, to the exploration of space, it covers a range of applications and relationships that have been discovered through experiment and calculation, including those used in modern technology. An experimental and investigative approach is used to develop knowledge and understanding of physics concepts. You will be able to develop a deeper understanding of physics, and describe and interpret physical phenomena using mathematical skills. You will be able to develop scientific methods of research to explore issues in physics and draw conclusions.

The National 5 Physics course has an external assessment and an internal assessment.

THE EXTERNAL ASSESSMENT

The external assessment comes at the end of the course and has two components.

Component 1 – Question Paper (80% of total mark)

This is made up of a two-hour question paper in which:

- 20 marks are allocated to an 'objective test' that contains 20 multiple choice questions
- 90 marks are allocated to the 'written paper' which includes questions requiring a mixture of short (restricted) and extended answers.

Most of the marks will be given for applying knowledge and understanding. The other marks will be awarded for applying scientific enquiry, analytical thinking and problem-solving skills. A Data sheet containing relevant data and formulae will be provided.

The question paper will be written and marked by the Scottish Qualification Authority (SQA).

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Component 2 – Assignment (20% of total mark)

The assignment will be an in-depth study of a physics topic you have chosen. There will be 20 marks awarded for the assignment and the majority of these will be awarded for applying scientific enquiry and analytical thinking skills. The other marks will be awarded for applying knowledge and understanding related to the topic.

The assignment is carried out under conditions controlled by your teacher and marked by the SQA. To prepare for the controlled assessment, you will choose, research and investigate an appropriate topic, focusing on the applications and impact on society or the environment.

During the assessment of the assignment you will present evidence of:

- the process you have gone through
- your physics knowledge and understanding relating to the topic
- the application of the topic
- a balanced evaluation of the impact on society or the environment
- a reasoned conclusion.

INTERNAL ASSESSMENT

During your period of study you will be assessed on a range of skills.

Here is the range of skills tested:

- demonstrating knowledge and understanding by making statements, describing information, providing explanations and integrating knowledge
- applying knowledge of physics to new situations, interpreting information and solving problems
- planning, designing and safely carrying out experimental/practical investigations to test given hypotheses or to illustrate particular effects
- selecting information and presenting information appropriately in a variety of forms
- processing information (using calculations and units where appropriate)
- making predictions based on evidence and information
- drawing valid conclusions and giving explanations supported by evidence/justification
- identifying sources of uncertainty and suggesting improvements to experiments/practical investigations
- communicating findings and information.

COURSE CONTENT

The National 5 Physics course consists of three units.

In each unit, you will develop skills of scientific enquiry, investigation and analytical thinking, along with the required knowledge and understanding.

You will also research issues and communicate your findings, while developing skills of scientific literacy.

- Unit 1 – Electricity and energy
- Unit 2 – Waves and radiation
- Unit 3 – Dynamics and space

This book will guide you through the content and skills you need to succeed at National 5 Physics. So, let's get started!

ONLINE

This book is supported by the BrightRED Digital Zone - head to www.brightredbooks.net/N5Physics for videos, quizzes, games and more!

ELECTRICITY AND ENERGY

CONSERVATION OF ENERGY

The key concepts to learn in this topic are:

- the principles of conservation of energy and loss of energy
- energy transfer between stores
- the principle of heat energy (E_h)
- how to perform calculations with gravitational and elastic potential energy (E_p) and kinetic energy (E_k) including situations involving conservation of energy.

ENERGY CONSERVATION AND LOSS

Energy is never destroyed but is always *transformed* (changed) into other *stores* (types) of energy. For example, gravitational potential energy is often transformed into kinetic energy as shown in the diagram of a skateboarder rolling down a hill.

The skateboarder's potential energy transforms into kinetic energy as he rolls down the hill

Heat energy is always produced whenever potential energy is transformed into other stores of energy – whether or not heat energy is wanted. For example, in a car, energy from fuel is transformed by the engine into useful kinetic energy but it is also wasted or lost as heat energy.

A bouncing ball illustrates how energy is transformed.

What happens when the ball is dropped?

As the ball falls, if air resistance is ignored, then all of the gravitational E_p is transformed into E_k.

$E_p \rightarrow E_k$

What happens when the ball stops going up?

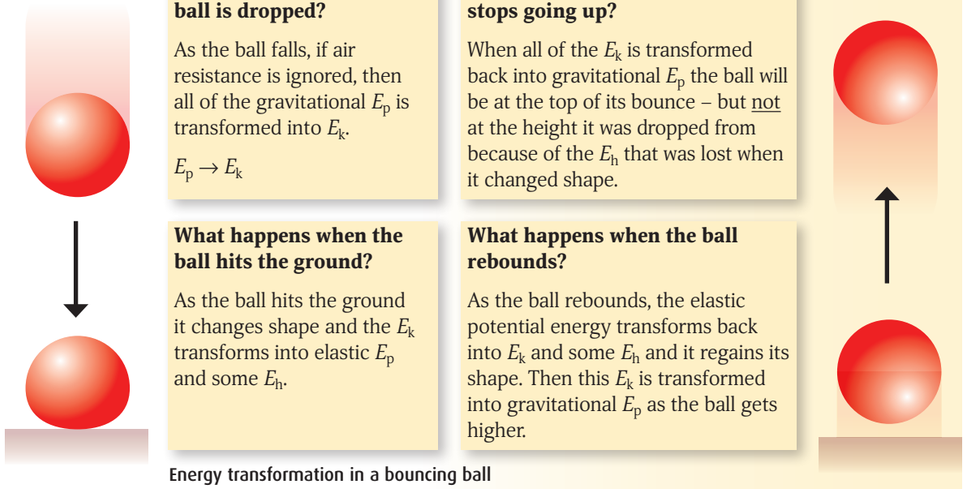
When all of the E_k is transformed back into gravitational E_p the ball will be at the top of its bounce – but <u>not</u> at the height it was dropped from because of the E_h that was lost when it changed shape.

What happens when the ball hits the ground?

As the ball hits the ground it changes shape and the E_k transforms into elastic E_p and some E_h.

What happens when the ball rebounds?

As the ball rebounds, the elastic potential energy transforms back into E_k and some E_h and it regains its shape. Then this E_k is transformed into gravitational E_p as the ball gets higher.



Energy transformation in a bouncing ball

Each time the ball bounces, the lost energy means that the ball will rebound to a lower height until eventually it loses all of its energy.

VIDEO LINK

Check out the 'Potential and Kinetic Energy' clip at www.brightredbooks.net/N5Physics

ENERGY CALCULATIONS

To calculate gravitational potential energy use:

$E_p = mgh$

To calculate kinetic energy use:

$E_k = \frac{1}{2}mv^2$

EXAMPLE:

This example illustrates how to calculate speeds, height and lost energy.

(a) A 600 g ball is dropped to the ground from a vertical height of 4 m. Calculate the speed of the ball just as it collides with the ground. Ignore air resistance.

Energy is transformed from potential energy into kinetic energy as the ball falls.

$E_p \rightarrow E_k$ and $mgh = \frac{1}{2}mv^2$

so $v = \sqrt{2gh} = \sqrt{2 \times 9{\cdot}8 \times 4} = 8{\cdot}9\ m\,s^{-1}$

(b) When the ball rebounds, it leaves the ground with a speed of $7{\cdot}4\ m\,s^{-1}$. Calculate the height the ball will return to.

This time E_k is transformed into E_p. So $v = \sqrt{2gh}$ rearranges to $h = \frac{v^2}{2g}$

$h = \frac{7{\cdot}4^2}{2 \times 9{\cdot}8}$

$h = 2{\cdot}8\ m$

(c) Calculate the energy lost when the ball collides with the ground.

Before the collision $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 0{\cdot}6 \times 8{\cdot}9^2 = 23{\cdot}8\ J$

After the collision $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 0{\cdot}6 \times 7{\cdot}4^2 = 16{\cdot}4\ J$

Energy lost during collision = E_k before – E_k after collision
= 23·8 – 16·4
= 7·4 J

ONLINE TEST

Take the 'Conservation of Energy' test at www.brightredbooks.net/N5Physics

DON'T FORGET

Because $E_p \rightarrow E_k$, to determine the final speed at which E_p is transformed into E_k the equation $v = \sqrt{2gh}$ can be used.

DON'T FORGET

To calculate the final rebound height the equation $h = \frac{v^2}{2g}$ can be used.

DON'T FORGET

Remember, 'lost' energy is usually transformed into sound and heat. Sometimes this heat energy can cause the ball to become warm. This is especially noticeable in sports, such as squash and tennis, where there are lots of rebounds.

THINGS TO DO AND THINK ABOUT

Here are some other examples of everyday energy transformations:

The movement of a clock pendulum

Water that is stored in a reservoir and then flows downwards through pipes to a generator in a hydroelectric power station

1. Think of some examples of energy transformations that are going on around you.
2. Consider the energy losses which may occur in these transfers. Why are processes less than 100% efficient in terms of useful energy?

ELECTRICITY AND ENERGY

PRESSURE

The key concepts to learn in this topic are:

- that pressure is the force per unit area exerted on a surface
- the use of an appropriate relationship to solve problems involving pressure, force and area.

DEFINING PRESSURE

Pressure occurs when a force is applied to a surface. Whenever a force is applied to an object, pressure is exerted on the object. For example, the force can be caused by a hammer striking a nail, or by a molecule of a gas colliding with the walls of its container.

The relationship for pressure connects the force and the surface area of the object.

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

$$p = \frac{F}{A}$$

where p = pressure (Pa), F = force (N) and A = area (m^2)

The units for pressure are pascal (Pa) or newtons per square metre, (Nm^{-2}) and $1\,Pa = 1\,Nm^{-2}$.

The *larger* the force, the *greater* the pressure; the *larger* the area, the *smaller* the pressure. For example, a person standing on snow exerts a pressure on the snow through their feet because the feet are in contact with the ground. The area of the feet in contact with the snow is small, so the pressure on the snow is great and the person sinks into the snow.

If the person stands on skis, the area in contact with the snow is much greater, so the pressure on the snow is smaller and the person stays on the surface.

Sinking into snow

Staying on surface of snow

Other examples of situations in which pressure is important are:

- a sharp knife is used for cutting vegetables – the edge of the knife is very narrow, so a very small area is in contact with the vegetables; the pressure is very large and cutting is easier
- a camel has very large feet to spread the force of its weight over a large surface area – this prevents it sinking into soft sand in the desert
- farm tractors have very wide tyres to increase the area of each tyre that is in contact with the ground – this reduces the pressure of the heavy tractor on the soil.

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DON'T FORGET

Larger force means greater pressure; larger area means smaller pressure.

VIDEO LINK

Head online and watch the clip showing how polystyrene cups are affected by strong water pressure at www.brightredbooks.net/N5Physics

EXAMPLE 1

A 40 000 kg container rests on the trailer of a lorry.

(a) Calculate the force exerted by the container on the trailer.

The weight of the container causes a force on the trailer.

$F = mg = 40\,000 \times 9{\cdot}8 = 392\,000\,N$

(b) The area of the container surface in contact with the trailer is 21 m^2. Calculate the pressure exerted on the trailer by the container.

$p = \frac{F}{A} = \frac{392\,000}{21} = 18\,667\,Pa$

EXAMPLE 2

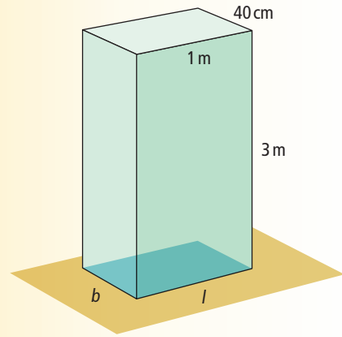
A block of mass 45 kg has dimensions 3 m by 1 m by 40 cm. What is the greatest pressure that the block can exert on a flat horizontal surface?

The greatest pressure is exerted through the smallest face of the cube.

smallest area = $l \times b = 1 \times 0{\cdot}4 = 0{\cdot}4\,m^2$

$F = mg = 45 \times 9{\cdot}8 = 441\,N$

$p = \frac{F}{A} = \frac{441}{0{\cdot}4} = 1102{\cdot}5\,Pa$



DON'T FORGET

Area must always be given in square metres, so remember to convert centimetres or millimetres.

ONLINE TEST

For a test on pressure, visit www.brightredbooks.net/N5Physics

THINGS TO DO AND THINK ABOUT

1. Using this knowledge about pressure, think of how to investigate:
   - the size of the pressure exerted by a drawing pin on a noticeboard
   - the pressure between a pencil and the paper it writes on.

   (Hint: think of how you would measure any of the required information needed to calculate the pressure. Make sure that you consider safety measures for any practical work.)

WAVES AND RADIATION

LIGHT

The key concepts to learn in this topic are:

- to identify the normal, angle of incidence and angle of refraction, in ray diagrams showing refraction
- to describe refraction in terms of change of wavelength and change of direction (where the angle of incidence is greater than 0°).

DON'T FORGET

- The normal is a line (usually dotted) drawn at 90° to the edge where the light enters the glass.
- The angle of incidence is the angle between the incident ray and the normal.
- The angle of refraction is the angle between the refracted ray and the normal.

DON'T FORGET

You should be able to recognise the angles of incidence and refraction in diagrams.

DON'T FORGET

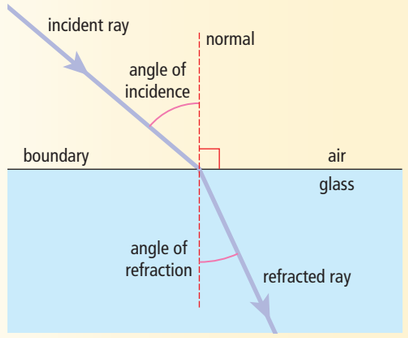
When the angle of incidence is 0°, the direction of the refracted ray is unchanged.

An unusual effect of refraction

REFRACTION

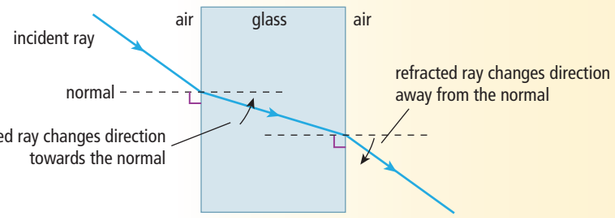
Refraction is the change in speed of light when it travels from one material to another.

When light travels from a *less dense to a more dense* material (such as from air into glass), its *wavelength decreases*, it *slows down* and changes direction (or refracts) *towards the normal*. When light travels from a *more dense to a less dense* material (from glass into air), its *wavelength increases*, it *speeds up* and changes direction *away from the normal*.

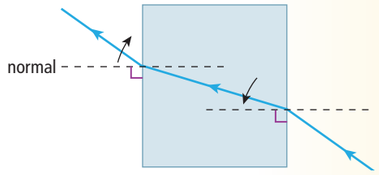


Refraction of light

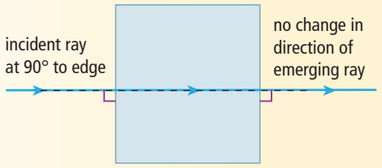
The amount of refraction depends on the type of materials used.



This diagram illustrates the changes in direction of refracted light



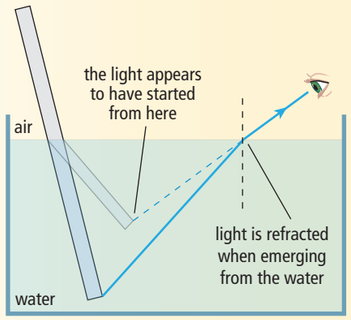
This diagram illustrates that the ray of light would have exactly the same path if it were directed into the glass from the reverse direction.



When the angle of incidence is 0°, the light ray passes straight through

The refraction of light can cause some unusual effects. For example, when observing a straight stick that is partly submerged in water, it appears bent.

The explanation involves the refraction of light. When light from the submerged part of the stick reaches the surface, it is refracted away from the normal. When this light enters our eyes, the image of the stick appears to be closer to the surface than it should be.



The visual effect of refraction

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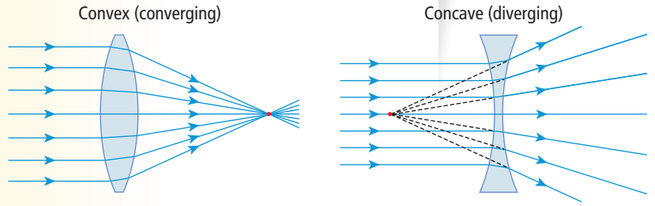
Lenses

Convex and **concave** lenses are used to refract light for particular applications. Lenses are used in optical instruments, including spectacles, cameras, microscopes and telescopes.

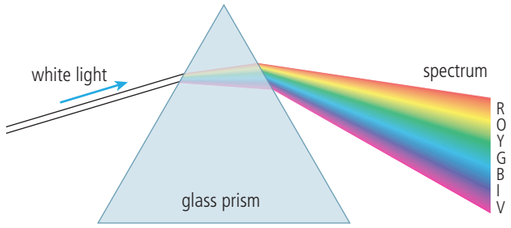


Prisms

A **prism** is a three-dimensional triangular piece of glass (or transparent plastic) which is used to refract light.

Different colours of light are refracted by different amounts. A ray of white light directed into a prism will be refracted to show the different colours of the visible spectrum.

Prisms can be used to analyse a light source to determine the colours of light present in the incident ray.



Light of different colours is refracted by different amounts

REFRACTION EXAMPLES

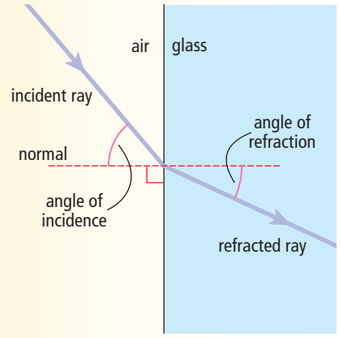
EXAMPLE 1

Light passes from air into glass. This process is called refraction.

(a) Explain what is meant by refraction.

Refraction is the change of speed and wavelength of waves when they travel from one material into another.

(b) Draw a labelled diagram showing the path of a ray of light being refracted as it passes into a glass block. Label the incident ray, the refracted ray, the normal, the angle of incidence and the angle of refraction.



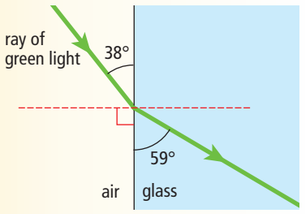
EXAMPLE 2

A ray of green light is incident on a glass block as shown.

Calculate the angle of incidence and angle of refraction.

angle of incidence = 90° – 38° = 52°

angle of refraction = 90° – 59° = 31°



THINGS TO DO AND THINK ABOUT

Refraction of light in glass has many uses in optical instruments, some of which have had a great impact on society.

1. Research the effects on light rays when they pass through convex and concave lenses.
2. Find out how refraction in the glass lenses used in spectacles allows wearers who are short or long sighted to be able to see clearly.

VIDEO LINK

Have a look at how refraction works by watching the 'Bill Nye the Science Guy on Light Bending and Bouncing' video at www.brightredbooks.net/N5Physics

ONLINE TEST

Take the 'Light' test online at www.brightredbooks.net/N5Physics

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Curriculum for Excellence

N5 PHYSICS

Paul Van der Boon

This BrightRED Study Guide is just the thing you need to tackle your course and gain the exam skills essential to succeed at National 5 Physics. Written by trusted subject expert and experienced Physics teacher Paul Van der Boon, this book is packed with brilliant examples, tasks and advice. It is the ultimate companion to your studies.

- **Contains all of the essential course information**, arranged in easily digestible topics.
- **Designed in full colour, highly illustrated, accessible and engaging** to make sure all that study sticks!
- ***Don't forget!*** pointers offer advice on key facts and on how to avoid common mistakes.
- ***Things to do and think about*** sections at the end of each topic allow for further practice and research.
- **Worked examples** show you how to approach a range of concepts and questions.
- **A glossary of key terms** helps you really learn and revise important course concepts.

Let BrightRED lead you to success in your National 5 studies and beyond!

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