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OCR
Oxford Cambridge and RSA

GCSE (9–1)
Transition Guide

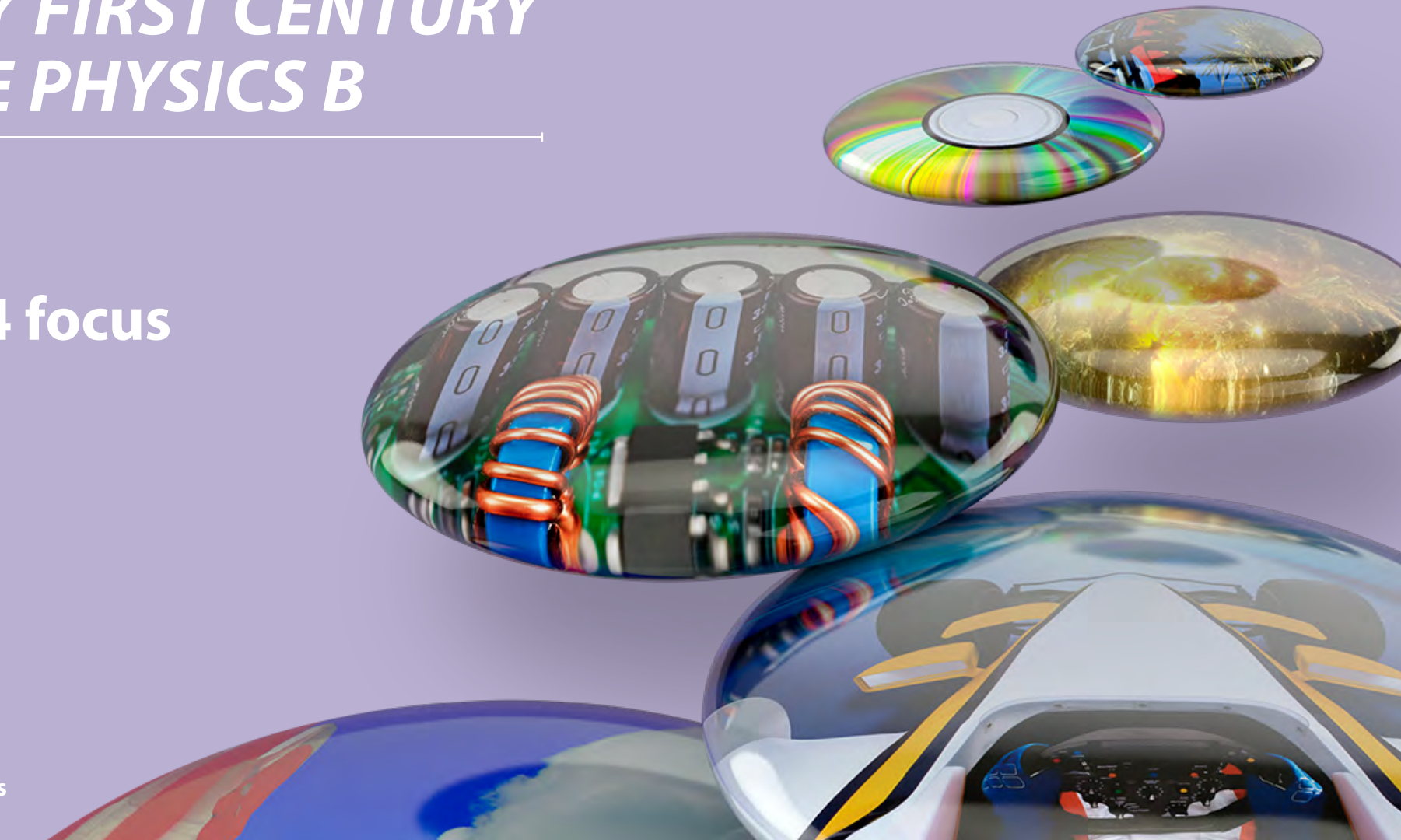
TWENTY FIRST CENTURY SCIENCE PHYSICS B

J259
For first teaching in 2016

KS3 – KS4 focus

Waves

Version 1



www.ocr.org.uk/physics

GCSE (9–1)

GATEWAY SCIENCE PHYSICS B

Key Stage 3 to 4 Transition guides focus on how a particular topic is covered at the different key stages and provide information on:

- Differences in the demand and approach at the different levels;
- Useful ways to think about the content at Key Stage 3 which will help prepare students for progression to Key Stage 4;
- Common student misconceptions in this topic.

Transition guides also contain links to a range of teaching activities that can be used to deliver the content at Key Stage 3 and 4 and are designed to be of use to teachers of both key stages. Central to the transition guide is a Checkpoint task which is specifically designed to help teachers determine whether students have developed deep conceptual understanding of the topic at Key Stage 3 and assess their 'readiness for progression' to Key Stage 4 content on this topic. This checkpoint task can be used as a summative assessment at the end of Key Stage 3 teaching of the topic or by Key Stage 4 teachers to establish their students' conceptual starting point.

Key Stage 3 to 4 Transition Guides are written by experts with experience of teaching at both key stages.

Key Stage 3 Content

- Reflection and absorption of sound
- Sound needs a medium; the speed of sound changes with the medium
- Sound waves are longitudinal
- Human auditory range
- Light travels through a vacuum; speed of light
- Transmission of light through materials; absorption, diffuse scattering and reflection at surfaces
- Ray models to explain imaging in mirrors, refraction and action of convex lenses in focusing
- Colours and the different frequencies of light; dispersion
- Differential colour effects in absorption and diffuse reflection.

Key Stage 4 Content

- Describe waves using amplitude, wavelength, frequency and period
- For waves in a medium, describe evidence that it is the wave and not the medium that travels
- Describe the difference between transverse and longitudinal waves
- Recall and apply: wave speed (m/s) = frequency (Hz) x wavelength (m)
- Describe how the speed, frequency and wavelength of ripples on water and the speed of sound in air may be measured
- Describe the effects of reflection, refraction, transmission and absorption of waves at surfaces
- Describe how to measure refraction through a prism and reflection off a plane mirror
- Recall that waves travel in different substances at different speeds, which may vary with wavelength
- Explain how refraction is related to differences in the speed
- Use ray diagrams to illustrate reflection, refraction and dispersion, and to illustrate the similarities and differences between convex and concave lenses
- Explain how colour is related to differential absorption, transmission and scattering

Comment

At Key Stage3 learners need to be aware of the nature of sound and light waves and waves on water. This is largely descriptive, with learners only needing to give examples of frequencies when referring to sound waves. At Key Stage 4, the learners must be able to describe wave motion in terms of a number of quantities and be familiar with the relevant units. The most difficult of these for learners to understand is frequency, as the other quantities are easy to describe physically, but frequency requires a description of the waves passing a point per second. Learners also sometimes confuse changing frequency with changing volume in the case of sound waves. This can be because of musical examples, for example playing louder as pitch increases, but the frequency response of the ear can also have an effect, as the perceived volume of sound is less at lower and higher frequencies but much greater at middle range frequencies. Both the independence of frequency and volume (amplitude) and the ear's varying response to frequency can be demonstrated for learners with a loudspeaker, signal generator and oscilloscope.

Learners also have some difficulty with the idea of waves carrying energy but the medium itself not moving. This is associated with their experience on beaches, where waves break onto the beach and water clearly moves further up the beach as the waves come in. Use of a ripple tank and discussion of what happens in a pool with a wave machine should help clarify this situation, as it is clear that water does not all move to one end of the tank and a floating object executes 'circular' motion without moving along with the waves.

When discussing light in terms of rays, there are a number of misconceptions which learners have. Firstly, they are often unaware that we are only taking certain rays from any given point, although this point is emitting/reflecting rays of light in many directions; we are only selecting the rays which are useful to us as their paths are predictable. Secondly, learners frequently put arrows on rays in the wrong direction, especially when discussing the eye. This is partly due to our use of language (looking at something seems to imply an active process) but historically it was a moot point whether something went into the eye or left it and so learners are simply in this tradition. An emphasis that light rays travel in straight lines except at boundaries between materials and that rays start out at the object and go to the image (which might be in the eye) at KS3 helps to overcome these difficulties later. Care should be taken by the teacher to draw such diagrams on the board carefully and to use a ruler to bring out the need for care in drawing and the importance of straight lines.

When dealing with the idea that refraction occurs due to a change in speed as light moves from one material to another, learners are sometimes confused as they have heard that the velocity of light is a constant. It should be emphasised that the velocity of light in a vacuum is constant but that it can change as light travels through a material.

Learners will also sometimes show confusion when discussing the colour of objects in terms of differential absorption or transmission of light waves of differing colour. It is not unusual, for example, for learners to say that an object looks green because it absorbs green light, rather than that is absorbs all other colours but reflects or transmits green light. This misunderstanding can be difficult to overcome but emphasis that what we see is the light which gets to our eye should help.

Learners also have considerable difficulty when discussing different types of image. They are usually happy with the idea of real images, as these can be demonstrated to them with a lens and piece of card. However, the concept of a virtual image invariably causes difficulties, even with more able learners. The best way to deal with this is to use plane mirrors as the position of the image can be clearly demonstrated using ray tracing.

Activities

Speed of sound

Education Scotland

Resources: http://www.educationscotland.gov.uk/resources/s/sound/speedofsound.asp?strReferringChannel=resources&strReferringPageID=tcm:4-248287-64

This is an animation that illustrates the different velocities of sound in differing materials. If a length of about 10000m is chosen then more able learners can calculate the velocity for the different materials.

The reflection of light

Schoolphysics

Resources: http://www.schoolphysics.co.uk/age11-14/Light/experiments/reflection_.doc

This is a worksheet giving a variety of experiments which learners can carry out related to the laws of reflection and the nature and position of the image produced by plane mirrors.

Signal generator

National STEM Learning Centre

Resources: https://www.stem.org.uk/elibrary/resource/28842/signal-generator

A short video explaining the 3 states of matter and their properties. It is engaging and narrated well.

Transmission of Sound

Designmate

Resources: https://www.youtube.com/watch?v=GkNJvZINSEY&nohtml5=False

This animation covers all aspects of sound transmission and is probably best used in sections as the work is covered or as a resource during revision.

Overview

The following tasks have been designed to highlight learners' understanding of the material covered in the waves topics of Key Stage 3. The tasks have been chosen to test key areas of understanding and can be used either as a starting point, in which the teacher marks the papers to determine weaknesses in learners' prior understanding, or as a way for learners to revise the information that they should already know, in which case learners could discuss the questions in groups or peer mark each other's work when given the appropriate answers.

An alternative approach would be to give learners the individual tasks as the various topics occur during teaching. In this case the amount of understanding being assessed is much smaller.

The first task is intended to assess learners' understanding of the difference between transverse and longitudinal waves in what is probably an unfamiliar context. The key idea is that the directions of the 'particle' motions are different for each type of wave.

The second task is intended to assess learners' understanding of the effects of amplitude and wavelength on the sound they hear. The first part gives learners a chance to show visually what happens when pitch and volume are changed, whilst the second part of the task asks them to verbalise their understanding. Teachers should be able to identify not only where there are misunderstandings but also what the misunderstandings are.

The final task is intended to give learners a chance to show their understanding of the differential absorption and transmission of light on colours of objects. Care should be taken here to ensure that learners understand that what they see is the remaining light and not the absorbed light (i.e. red objects look red because they reflect or transmit red light, not because they absorb it).

Checkpoint Task
http://www.ocr.org.uk/Images/305589-waves-checkpoint-task.doc

Activities

Formation of images using convex and concave lenses

Schoolphysics

Resources: http://www.schoolphysics.co.uk/animations/Light%20and%20optics%20animations/Lens_diagram/index.html

This animation shows ray diagrams for lenses. It is possible to change the size of the object, the object distance and the focal length and see how this changes the diagrams. Using negative focal lengths also illustrates concave lenses.

Bending of light

University of Colorado

Resources: http://phet.colorado.edu/sims/html/bending-light/latest/bending-light_en.html

This is an animation to illustrate refraction. It includes refraction at plane surfaces and dispersion, and the light can be shown as either a ray or as wave fronts..

Wave machine

National STEM Centre

Resources: https://www.stem.org.uk/elibrary/resource/27031/wave-machine

This video gives instructions on how to make a jelly baby wave machine. This is excellent for illustrating and discussing the ideas of amplitude, wavelength, etc., and for showing that only energy is transmitted by the wave..

GCSE Revision – Types of Waves

YouTube

Resources: https://www.youtube.com/watch?v=w2s2fZr8sqQ

A revision video illustrating longitudinal and transverse waves and the idea that waves transfer energy and not matter..

Dispersion

Khanacademy

Resources: https://www.khanacademy.org/science/physics/geometric-optics/reflection-refraction/v/dispersion

An animation covering the idea of dispersion and the reasons for it. The discussion is at a good level and might be appropriate for more able learners.

Speed of light

Jefferson Lab

Resources: http://education.jlab.org/frost/speed_of_light.html

A video that illustrates how to measure the speed of light using a microwave oven and a bar of chocolate. The method is not usual at KS4 but the physics is all at an appropriate level. More able learners should have little difficulty in understanding.

Resources, links and support

Science Spotlight – Our termly update Science Spotlight provides useful information and helps to support our Science teaching community. Science Spotlight is designed to keep you up-to-date with Science here at OCR, as well as to share information, news and resources. Each issue is packed full with a series of exciting articles across the whole range of our Science qualifications: www.ocr.org.uk/qualifications/by-subject/science/science-spotlight/

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Contact the team: science@ocr.org.uk

Continue the discussion on the science community forum: http://social.ocr.org.uk/

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To find out more about GCSE and A Level reform please visit: http://www.ocr.org.uk/qualifications/gcse-and-a-level-reform

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