

PiXL Independence:

Physics – Student Booklet

KS5

Topic – Waves and Quantum Physics

Contents:

- I. Level 1 - Multiple Choice Quiz – 20 credits
- II. Level 2 - 5 questions, 5 sentences, 5 words – 10 credits each
- III. Level 3 - Physics in The News – 100 credits
- IV. Level 4 - Scientific Poster – 100 credits
- V. Level 5 - Video summaries – 50 credits each
- VI. Level 1 Answers

PiXL Independence – Level 1
Multiple Choice Questions
A Level Physics – Waves and Quantum Physics

INSTRUCTIONS

Score: /20

- Read the question carefully.
- Circle the correct letter.
- Answer all questions.

-
1. 2 points on a progressive wave are $\frac{1}{3}$ of a wavelength apart. The distance between the two points is 2cm. If the speed of the wave is 10 ms^{-1} what is the frequency of the wave?
 - a. 5Hz
 - b. 20Hz
 - c. 167Hz
 - d. 1500Hz

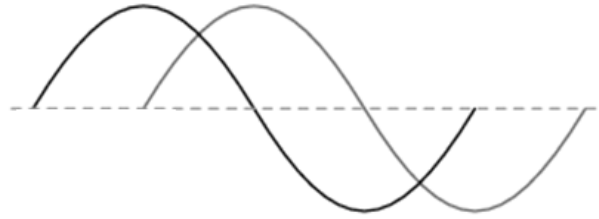
 2. Which of the following waves cannot be polarized?
 - a. Visible light
 - b. Radio waves
 - c. Ultrasonic
 - d. Gamma

 3. A guitar string of length 80cm vibrates with a third harmonic frequency of 305Hz. What is the wavelength of the wave?
 - a. 244cm
 - b. 53.3cm
 - c. 16.2cm
 - d. 3.80cm

 4. How does the diffraction pattern of monochromatic light passing through a single slit change if the width of the single slit is increased?

	Width of central maximum	Intensity of central maximum
a.	decreases	unchanged
b.	increases	unchanged
c.	decreases	increases
d.	increases	decreases

5. What is the approximate phase difference between the waves below?



- a. 2π
 - b. $3\pi/2$
 - c. π
 - d. $\pi/2$
6. When comparing X rays with visible light, which statement is correct?
- a. X-rays travel faster in a vacuum
 - b. X rays have a higher frequency
 - c. Only X rays can be polarised
 - d. X rays do not show diffraction effects
7. Which set of conditions would cause the interference maxima produced by a double slit experiment at a distance of 1.5m from the sources to be closest together?
- a. Yellow light 580nm from the sources 2mm apart
 - b. Water waves of wavelength 20mm from sources 1m apart
 - c. Ultrasonic wave of wavelength 1.5cm from sources 40mm apart
 - d. Violet light of wavelength 380nm from sources 6mm apart
8. Which of the following describes the type of wave produced on a stretched guitar string after it has been plucked?
- a. Stationary, longitudinal, electromagnetic
 - b. Stationary, transverse, mechanical
 - c. Progressive, longitudinal, electromagnetic
 - d. Progressive, transverse, mechanical
9. What are the conditions for total internal reflection of light to occur?
- a. The light is travelling from a less optically dense medium to a more optically dense medium at an angle equal to the critical angle
 - b. The light is travelling between media of equal optical densities at an angle greater the critical angle
 - c. The light is travelling between media of equal optical densities at an angle equal to the critical angle
 - d. The light is travelling from a more optically dense medium to a less optically dense medium at an angle greater than the critical angle

10. Two waves are in phase and coherent interfere. Which row correctly states the path difference and corresponding interference?

	Path difference	interference
a.	λ	destructive
b.	$\lambda/2$	constructive
c.	3λ	destructive
d.	4λ	constructive

11. The density of a nylon guitar string of diameter $1.0 \times 10^{-3}\text{m}$ is $1.15 \times 10^3 \text{kgm}^{-1}$. What is the mass per unit length, μ of the nylon string?

- a. 1.15 kg m^{-1}
- b. $1.15 \times 10^6 \text{ kg m}^{-1}$
- c. $3.6 \times 10^{-3} \text{ kg m}^{-1}$
- d. $9.0 \times 10^{-4} \text{ kg m}^{-1}$

12. Two light wave sources with the same frequency and with a constant phase difference are said to be

- a. Polarised
- b. Diffracted
- c. Coherent
- d. Longitudinal

13. A 6cm diffraction grating has 20 000 slits. What is the separation of the slits?

- a. $3 \times 10 \mu\text{m}$
- b. 0.33 mm
- c. 3 nm
- d. 33 km

14. The speed of light in a material is $1.7 \times 10^8 \text{ms}^{-1}$. What is the refractive index of the material?

- a. 0.57
- b. 1.43
- c. 1.76
- d. 2.31

15. In the photoelectric effect which of the following increase when the intensity of the light incident on the metal plate is increased?

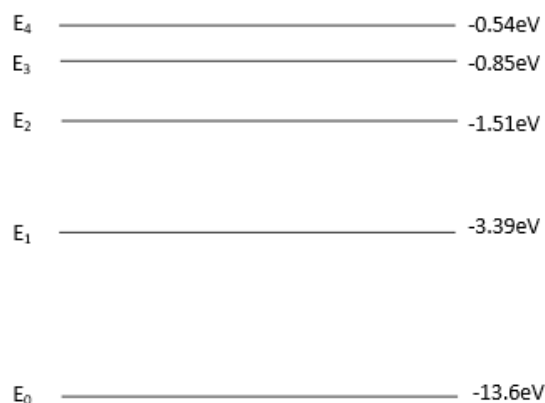
- a. The frequency of the photons
- b. The maximum kinetic energy of the photoelectrons
- c. The number of photons emitted per second
- d. The threshold frequency

16. The power of a light bulb is 60W and the wavelength of the light emitted by the bulb is 520nm. What is the number of photons emitted by the bulb each second?
- 3.82×10^{19}
 - 1.57×10^{20}
 - 1.15×10^8
 - 1.74×10^{21}

17. What is the energy in electron volts of a photon of ultra violet light of frequency 7.9×10^{14} Hz?
- 3.27eV
 - 1.48 eV
 - 37.9×10^4 eV
 - 8.38×10^{-38} eV

18. What is the frequency of the photons emitted when an electron falls to the ground state (-10.4eV) from the -5.4eV excited state?
- 7.55×10^{33} Hz
 - 3.8×10^{15} Hz
 - 1.21×10^{15} Hz
 - 8.2×10^{14} Hz

19. The energy levels of a hydrogen atom are drawn below. What type of light will be emitted following the transition of an electron from E_3 to E_1 ?



- X-ray
 - Ultra violet
 - Visible
 - Microwave
20. What is the de Broglie wavelength of a person of mass 60kg moving at a speed of 2ms^{-1} ?
- 7.95×10^{-32} m
 - 5.52×10^{-36} m
 - 3.68×10^{-44} m
 - 1.58×10^{42} m

PiXL Independence – Level 2

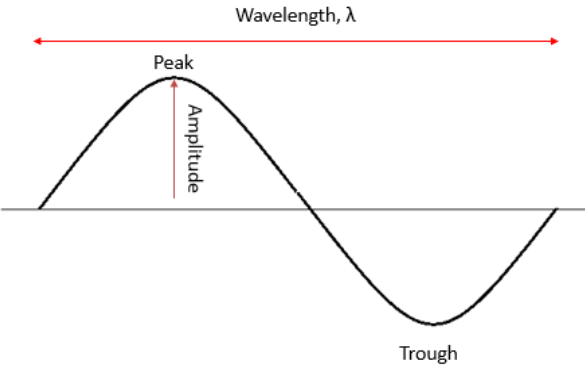
5 questions, 5 sentences, 5 words

A Level Physics – Waves and Quantum Physics

INSTRUCTIONS

- For each statement, use either the suggested website or your own text book to write a 5-point summary. In examinations, answers frequently require more than 1 key word for the mark, so aim to include a few key words.
- It is important to stick to 5 sentences. It is the process of selecting the most relevant information and summarizing it, that will help you remember it.
- Write concisely and do not elaborate unnecessarily, it is harder to remember and revise facts from a big long paragraph.
- Finally, identify 5 key words that you may have difficulty remembering and include a brief definition. You might like to include a clip art style picture to help you remember it.

Example: Wave properties

QUESTION:	What are the key features of longitudinal and transverse waves?			
Sources:	Website 1. https://www.youtube.com/watch?v=TfYcNvNnFU 2. https://www.youtube.com/watch?v=c38H6UKt3_I			
<ol style="list-style-type: none"> 1. Waves transfer energy and are either transverse for example electromagnetic waves or longitudinal for example sound. 2. A transverse wave has oscillations that are perpendicular to the direction of energy transfer and a longitudinal wave has oscillations that are parallel to the direction of energy transfer. 3. A sound wave consists of areas of alternate compression and rarefactions of the medium it is travelling through. 4. A transverse wave has peaks and troughs; one wavelength is the distance between two consecutive peaks. 5. The speed of a wave can be found using the wave speed equation $v = f\lambda$ 				
 <p>The diagram shows a single cycle of a transverse wave. A horizontal line represents the equilibrium position. A red double-headed arrow above the wave spans from one peak to the next, labeled 'Wavelength, λ'. A vertical red arrow points from the equilibrium line to the highest point of the wave, labeled 'Amplitude'. The highest point is labeled 'Peak' and the lowest point is labeled 'Trough'.</p>				
Transverse wave – oscillation at 90° to wave direction	Longitudinal wave - oscillation are parallel to wave direction	Amplitude – the distance between the equilibrium position and the highest point on the wave train	Electromagnetic waves – a spectrum of transverse waves that travel at $3.0 \times 10^8 \text{ms}^{-1}$ in a vacuum	Frequency – the number of oscillations per second

QUESTION 1:	What are stationary waves? What are their properties and how can a stationary or standing wave be set up?
Sources:	Website <ol style="list-style-type: none">1. https://www.youtube.com/watch?v=GSP5LgGtqwE2. https://phet.colorado.edu/en/simulation/wave-on-a-string3. https://www.youtube.com/watch?v=-n1d1rycvj4

--	--	--	--	--

--	--	--	--	--

QUESTION 2:	What is Snell's law of refraction at a boundary between two surfaces?			
Sources:	Website <ol style="list-style-type: none">1. https://www.youtube.com/watch?v=DR-8ZRCHCXI2. https://phet.colorado.edu/en/simulation/bending-light			

QUESTION 3:	Describe Thomas Young's double slit experiment and use the wave equation to show how changing the wavelength of the light effects the interference pattern observed on the screen at a distance D from the slits.
Sources:	Website – 1. https://www.youtube.com/watch?v=ijVG0fOueIM 2. Double Slit - Required Practical - A-level Physics - YouTube

--	--	--	--	--

--	--	--	--	--

QUESTION 4:	Describe the photoelectric effect and explain what the conclusions from the experiment reveal about the nature of light
Sources:	Website – <ol style="list-style-type: none">1. https://www.khanacademy.org/science/physics/quantum-physics/photons/v/photoelectric-effect2. https://phet.colorado.edu/en/simulation/legacy/photoelectric

--	--	--	--	--

--	--	--	--	--

QUESTION 5:	Describe the electron diffraction experiment and explain what evidence it provides for wave particle duality.
Sources:	Website 1. https://www.youtube.com/watch?v=Z8JuvprieaQ 2. https://phet.colorado.edu/en/simulation/davisson-germer

--	--	--	--	--

--	--	--	--	--

PiXL Independence – Level 3

Physics in The News

A Level Physics – Waves and Quantum Physics

Fake news

Sensationalized news stories have been around for some time but with the mass growth of social media, the problem seems to have grown in recent years.

Therefore, the ability to identify real information, track it back to the source article and make your own judgement is a very important skill. This activity will help you develop that skill.

Theory of general relativity proven 100 years after Einstein's prediction

News article <http://www.independent.co.uk/news/science/gravitaional-waves-albert-einstein-general-theory-of-relativity-a6867876.html>

Discussion article <https://www.nytimes.com/2016/02/12/science/ligo-gravitational-waves-black-holes-einstein.html>

Real article <https://www.ligo.caltech.edu/news/ligo20160211>

Task 2:

You need to produce a 1-page essay on the existence of gravitational waves and how they are proof of Einstein's theory of general relativity.

Essay section	Activity
Introduction	What is Einstein's theory of general relativity?
Describe	What are gravitational waves and how are they detected?
Explore	What cosmological events have the waves been used to detect?
Evaluate	Now that evidence of the existence of pairs of black holes has been obtained, what are scientist's suggesting is responsible for their existence?

PiXL Independence – Level 4

Scientific Posters

A Level Physics – Waves and Quantum Physics

Scientific Posters - Scientists communicate research findings in three main ways. Primarily, they write journal articles much like an experiment write up. These are very concise, appraise the current literature on the problem and present findings. Scientists then share findings at conferences through talks and scientific posters. During a science degree, you would practise all three of these skills.

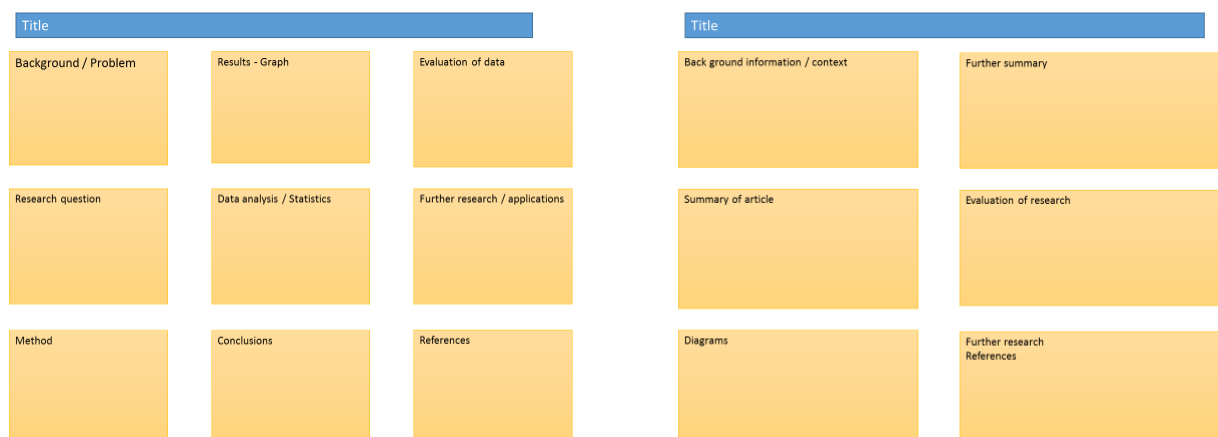
Scientific posters are a fine balance between being graphically interesting and attracting attention, as well as sharing just the right amount of text to convey a detailed scientific message. They are more detailed than a talk and less detailed than a paper.

Use this information to help structure your poster – <https://www.wikihow.com/Make-a-Scientific-Poster>

More detailed guidance is available at: <https://guides.nyu.edu/posters>

Creating your poster

It is easiest to create a poster in PowerPoint, however you need to add custom text boxes rather than using the standard templates.



Posters need to be eye catching, but readable from a distance. If you use PowerPoint, start with a 4:3 slide (for easier printing, it can then be printed on A3) and use a 14-16 pt font. The first box could be larger to draw people in. You can use a background image, but pick a simple one that is of high quality. Select 'text box fill' and select 'change the transparency' to maintain the contrast and partially show the picture.

You can experiment with different layouts and you should include images. Avoid a chaotic layout, posters are read from top left column downwards.

Remember to include the authors and references.

Finally, look at the examples given on the University of Texas website which also offers an evaluation of each <https://ugs.utexas.edu/our/poster/samples>

Demonstrating Quantum Phenomena using Thomas Young's double slit experiment

Background

Thomas Young was a British physicist who used his double slit experiment to demonstrate the interference of light waves passing through 2 slits on a screen at some distance from the slits. The interference pattern was evidence of light diffracting, a phenomenon exhibited only by waves, or so it was believed then.

Sources:

- <https://ed.ted.com/on/BZrHBexl>
- <https://www.youtube.com/watch?v=A9tKncAdlHQ>
- https://www.youtube.com/watch?v=M4_0oblwQ_U&t=9s

Use other sources as necessary.

Task:

Produce a scientific poster about the original double slit experiment carried out by Thomas Young in 1801. The experiment demonstrated the wave like nature of light which contradicted Isaac Newton's idea that light travelled in particles called corpuscles. Explain how this very experiment has since been used as evidence for wave particle duality by switching the light source for matter.

Recall	The experimental procedure for Thomas Young's double slit experiment.
Describe	Describe, using the double slit formula, how changing conditions such as the wavelength of the light source, the distance between the slits and screen and slit separation affects the fringe spacing.
Compare	Compare the conclusions made from Young's double slit experiment carried out with a light source to those when the experiment was carried out using electrons.
Evaluate	Evaluate the behavior of light and matter using this experiment and comment on how the results were affected when the electrons motion through the slits was measured.

PiXL Independence – Level 5

Video summaries

A-level Physics – Waves and Quantum Physics

Cornell Notes

At A level and University, you will make large amounts of notes, but those notes are only of use if you record them in a sensible way. One system for recording notes is known as the Cornell notes system. This method encourages you to select relevant information, rather than trying to write a transcript of everything said. More importantly, it forces you to spend a few minutes reviewing what you have written which has been scientifically proven to aid learning and memory retention.

The ideal is to write everything on one page, but some students may prefer to type and others will to handwrite their notes. Whichever option you use, remember the aim is to summarise and condense the content with a focus on the objectives that you are trying to learn and understand.

There are three main sections to the Cornell notes

- 1 **Cue/ Objectives** – This can be done before or after the lecture. You may have been provided with the objectives or you may need to decide what they were or you may want to make the link to your learning if this is an additional task or lecture you are viewing, such as this video.
- 2 **Notes** – In this space you record concisely, simply the things you are LESS likely to remember - **The NEW knowledge**.
- 3 **Summary** – The most important step that is carried out after the lecture or video. This helps to reinforce learning.

Background

The following TED talks present two topics that link to your learning. The first outlines the evidence for wave particle duality and how this has altered our understanding of the atom over time. The second describes the evidence for gravitational waves that were predicted by Einstein over one hundred years ago.

Source articles:

Video 1 - <https://ed.ted.com/lessons/particles-and-waves-the-central-mystery-of-quantum-mechanics-chad-orzel>

Video 2 - <https://ed.ted.com/lessons/what-are-gravitational-waves-amber-l-stuver>

Task:

You need to produce a set of Cornell notes for each of the videos given above.

Use the following objective to guide your note taking, this links to your learning.

Objectives

What are the main learning outcomes that have been shared with you?
This will help guide you to taking the RIGHT notes during the video.

Title
Date

Sketch down note and key words

Do not write in full sentences whilst you listen, put quick sketches, single words, mind maps, short hand etc.

To help train you for university, try not to pause the video because you could not pause a live lecture (However, a lecture may give more natural pauses for you to catch up).

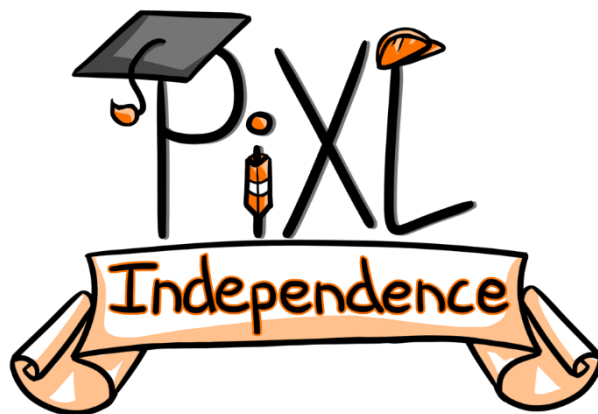
Summary (after the video)

What are your main points of learning from this video.

This is your chance to make sense of your notes.

Make clear connections to the things you need to know

Objectives:	Title:
	Date:
Summary:	



Commissioned by The PiXL Club Ltd.

This resource is strictly for the use of member schools for as long as they remain members of The PiXL Club. It may not be copied, sold, or transferred to a third party or used by the school after membership ceases. Until such time it may be freely used within the member school.

All opinions and contributions are those of the authors. The contents of this resource are not connected with, or endorsed by, any other company, organisation or institution.

PiXL Club Ltd endeavour to trace and contact copyright owners. If there are any inadvertent omissions or errors in the acknowledgements or usage, this is unintended and PiXL will remedy these on written notification.