Light: Man vs Machine

Key Stage 4 Programme

Pupil Name	
Handbook Designed by	Dr Moshtael

Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1			
2			
3			
4			
5			
6 (Feedback)			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1	Practical write up	
Tutorial 2	Visual impairments	
Tutorial 3	Optical illusions	
Tutorial 4	Experimental write up	
Tutorial 5	Experimental write up	

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

The Brilliant Club KS4 Programme – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Name of PhD Tutor	Dr Moshtael		
Title of Assignment			
Name of Pupil			
Name of School	North Cambridge Academy		
ORIGINAL MARK / 100		FINAL MARK / 100	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the PhD tutor should give an explanation in this section:

Learning Feedback Comment 1 –	
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 2 –	
What you did in relation to this Key Learning Priority	How you could improve in the future
Learning Feedback Comment 3 –	
What you did in relation to this Key Learning Priority	How you could improve in the future
Resilience Comment	
How you showed learning resilience during the course	How you could build learning resilience in the future

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Course Rationale

What is the nature of light? How can we wield its power? How do our eyes channel it? This course will attempt to address these questions. It is based on the research of Dr Moshtael into the use of technology to enhance the visual function of the partially sighted.

We will consider two complementary, but contradictory, models of light – as a wave and as a particle. We will see how we can manipulate it to capture images, both in a camera and in our eyes. Our exploration will enhance mathematical skill, by using the lens equation. It will also develop skills in experimental science, as we observe light in action: How it travels through a slit, how it moves through a lens and how it is detected.

We will combine all these skills to design and carry out an experiment to determine which is better: A camera or a human eye. Which has the best resolution? Which has the wider field of view? Which has the higher sensitivity? Experiments will be designed to make measurements for these quantities in both a camera and an eye. Scientific report writing will then be taught in order to report results in a scientific way.

By the end, you will see the light.

Mark Scheme Table

	Skills	1st (70-100)	2:1 (60-69)	2:2 (50-59)
Subject knowledge	Knowledge and Understanding	o All content included is relevant to the general topic and to the specific question/title o Good understanding of all the relevant topics. o Scientific terms are defined and used accurately throughout o Clear justification on how the content included is related to the specific issues that are the focus of the assignment	o Most of the content included is relevant to the general topic and to the specific question/title o Good understanding of most the relevant topics o Scientific terms are used accurately but not always clearly defined. o Adequate justification on how the content included is related to the specific issues that are the focus of the assignment	o Some of the content included is relevant to the general topic and to the specific question/title o Good understanding on some of the relevant topics but occasional confusion on others. o Scientific terms are used mostly accurately with occasional confusion and often not defined. o Some justification on how the content included is related to the specific issues that are the focus of the assignment
Critical thinking	Research and Evidence	o Use evidence/ calculations to support claims/assertions /ideas, consistently clearly and convincingly o Data is effectively analysed and appropriate assumptions/conclusions are reached	o Use evidence/ calculations to support claims/assertions/ ideas, mostly clearly and convincingly o Data is analysed and the assumptions/ conclusions that are reached are mostly appropriate	o Use evidence/ calculations to support claims/assertions/ ideas, at times clearly and convincingly o There is an attempt to analyse data is and draw assumptions/ conclusions
	Critical Evaluation	o Discussion moves beyond description to an assessment of the value or significance of what is described o Evaluative points are consistently explicit/ systematic/ reasoned/justified	o Discussion is mostly description but some assessment of the value or significance of what is described o Evaluative points are mostly explicit/systematic /reasoned/justified	o Discussion is only description with minimal assessment of the value or significance of what is described o Evaluative points are at times explicit/systematic /reasoned/justified

	Structure and Presentation	○ Ideas are presented in paragraphs and arranged in a logical structure that is appropriate for the assignment ○ The introduction clearly outlines how the essay/report will deal with the issues ○ The conclusion summarises all the main points clearly and concisely ○ All calculations, formulas and methods are clearly structured, clear to follow and correct ○ Tables and graphs are effectively constructed including appropriate headings, units and scales. ○ All sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure that is mostly appropriate for the assignment ○ The introduction adequately describes how the essay/report will deal with the issues ○ The conclusion summarises most of the main points clearly ○ Calculations, formulas and methods are mostly structured, clear to follow and correct ○ Most tables and graphs are well constructed ○ Most sources are referenced correctly in an agreed format	○ Ideas are presented in paragraphs and arranged in a structure ○ The introduction mentions how the essay/report will deal with the issues ○ The conclusion summarises some of the main points clearly ○ Calculations, formulas and methods are not always structured, clear to follow and correct. ○ Some tables and graphs are well constructed but contains some errors ○ Some sources are referenced correctly in the agreed format with occasional errors
Written communication	Language and Style	○ No spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style consistently clear, appropriate for scientific documents and easy to follow ○ Accurate and consistent use of technical language and vocabulary	○ Minimal spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout ○ Writing style mostly clear, appropriate for scientific documents and easy to follow ○ Some attempts of using technical language and vocab alary, but not always accurate	○ Some spelling, grammar or punctuation errors ○ Units and significant figures are presented accurately throughout with occasional errors ○ Writing style moderately clear, appropriate for scientific documents and easy to follow ○ Use of simple language and vocabulary effectively but struggles to use technical language

Glossary of Keywords

Word	Definition	In a sentence

Tutorial 1 – The nature of light

What is the Purpose of Tutorial 1?

- Review what you already know about light
- Increase understanding of the wave nature of light
- Be introduced to the particle nature of light

What do you know about light? What is it? How fast is it? How does it move? What happens when it hits an object?

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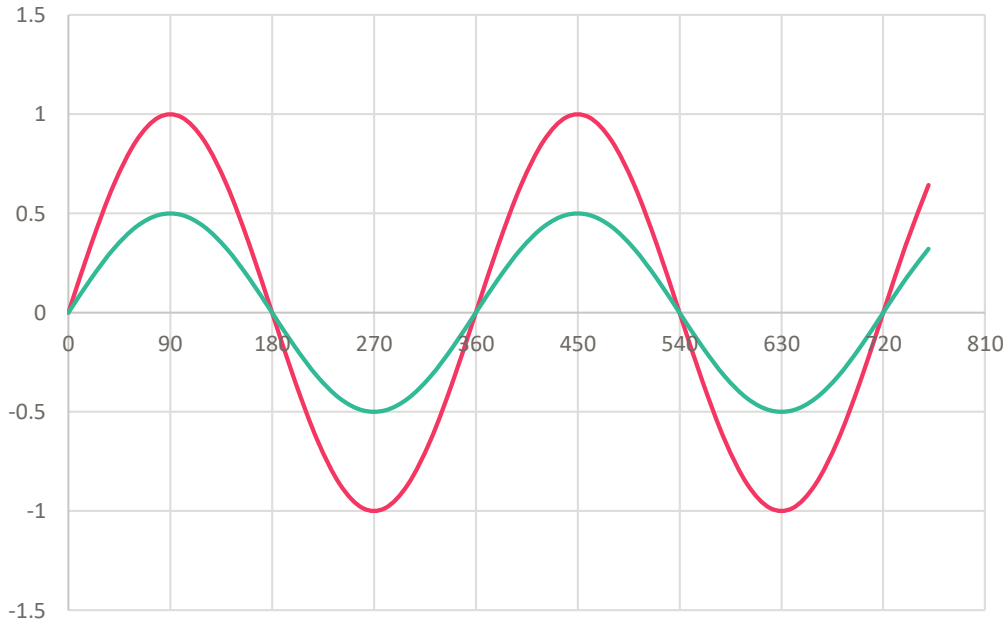
Wave nature

Draw a transverse wave and label it

When two waves meet each other, they **interfere**. Depending on their relative **phase** (whether or not they line up) they will experience either **constructive interference** or **destructive interference**.

These two waves constructively interfere, draw the resultant wave.



These two waves destructively interfere, draw the resultant wave.

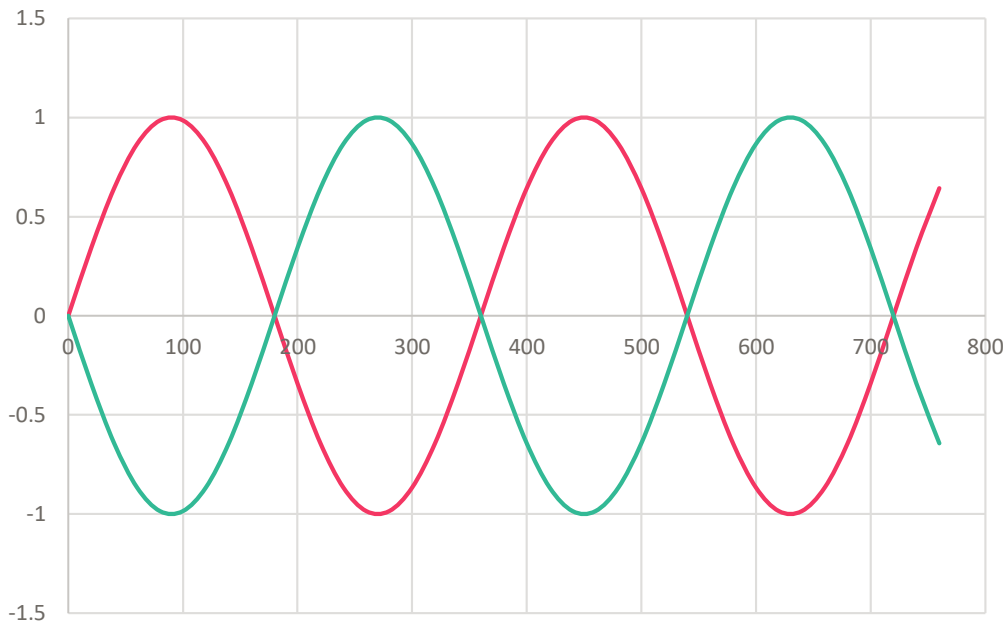


Figure 10-27. A photograph of the interference pattern of water waves from two point sources. Locate the nodal and antinodal regions.

The interference pattern above is made of waves of water. Light can also create an interference pattern like the one above by using a double slit.

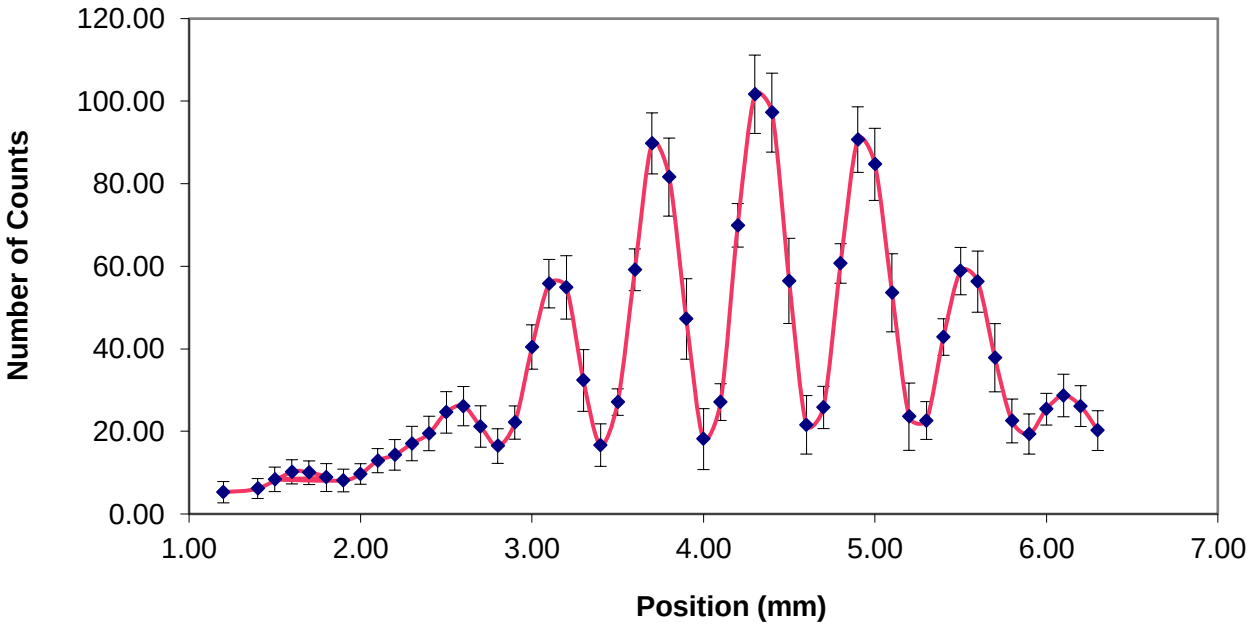
Draw a schematic diagram of the experiment.

Sketch the results of the experiment.

Particle nature

What pattern would you expect for particles?

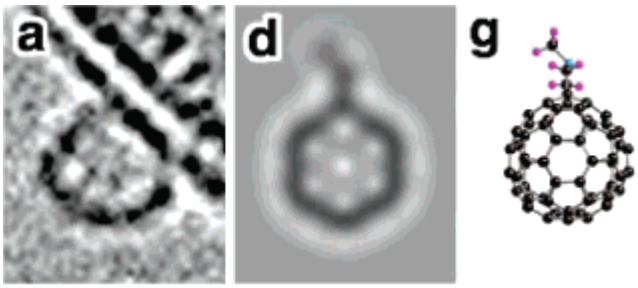
Light can also be considered as a stream of particles called photons. I performed the double slit experiment at university. I sent one photon through the slits at a time. These were my results:



What would this pattern look like on the screen?

But each particle goes through by itself, so what is happening?

In 1999, this experiment was done with a type of particle called Buckyballs, made of 60 carbon atoms. Here is an image of them:



Here are their results:

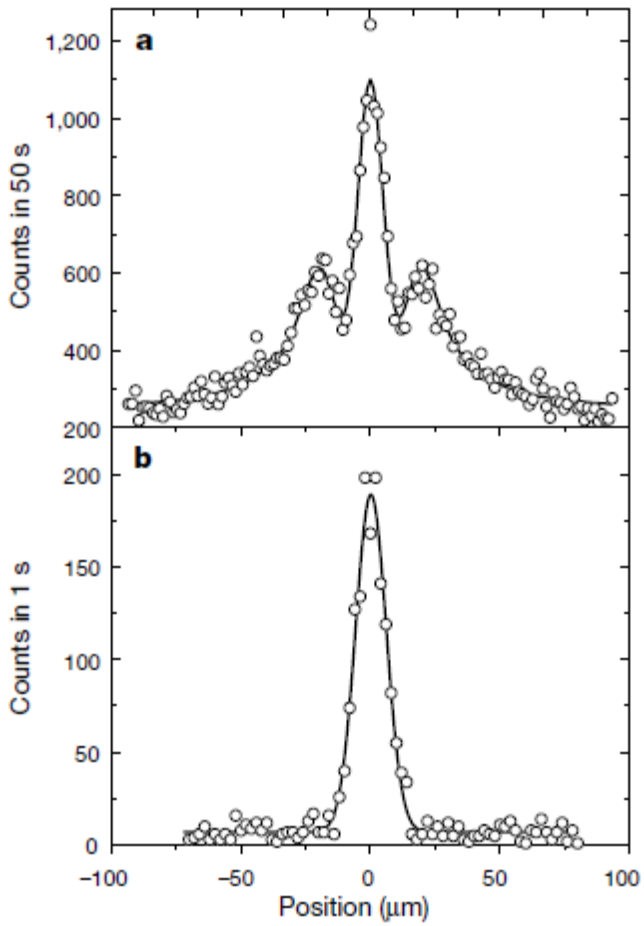


Figure 2 Interference pattern produced by C_{60} molecules. **a**, Experimental recording (open circles) and fit using Kirchhoff diffraction theory (continuous line). The expected zeroth and first-order maxima can be clearly seen. Details of the theory are discussed in the text. **b**, The molecular beam profile without the grating in the path of the molecules.

This is not particle-like behaviour.

These particles are displaying wave-like behaviour. Their position is not well-defined as they pass through the slits.

Particles can behave like waves. And waves can behave like particles. Welcome to the crazy world of quantum mechanics!

Homework: Write a scientific report about the practical

Use 2 pages to report on the practical we did. Use the following sections:

- Introduction
  What were we investigating?
- Methods
  What did we do? Include the schematic diagram.
- Results
  What did we find out?
- Conclusions
  What conclusions did we draw?

Tutorial 2 – Manipulating light

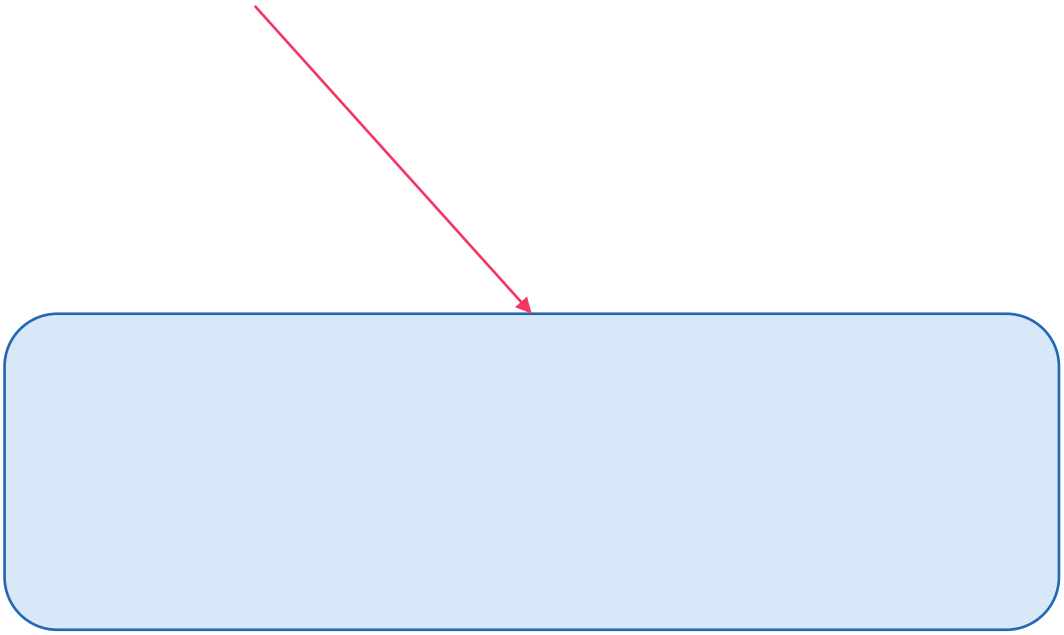
What is the Purpose of Tutorial 2?

In Tutorial 1, we were trying to understand more deeply the nature of light. In this tutorial, we consider how light can be manipulated to image objects.

- To review the concept of refraction
- Be introduced to the theory of lenses, including the lens equation
- To take measurements of an optical system
- To understand a camera as an optical instrument

Reflection and Refraction

The diagram below shows a light ray hitting water. Complete the diagram to show the reflected and refracted rays.



Experiment: Measuring the focal length of a lens

Sketch a schematic diagram of the practical.

Note down your observations from the practical.

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The power of a lens, *P*, is the reciprocal of its focal length, *f*,

$$P = \frac{1}{f}$$

The distance from the centre of the lens to the image is denoted *v*, and to the object, *u*. Mark *v* and *u* on your sketch above. These distances are related to the focal length by the lens equation,

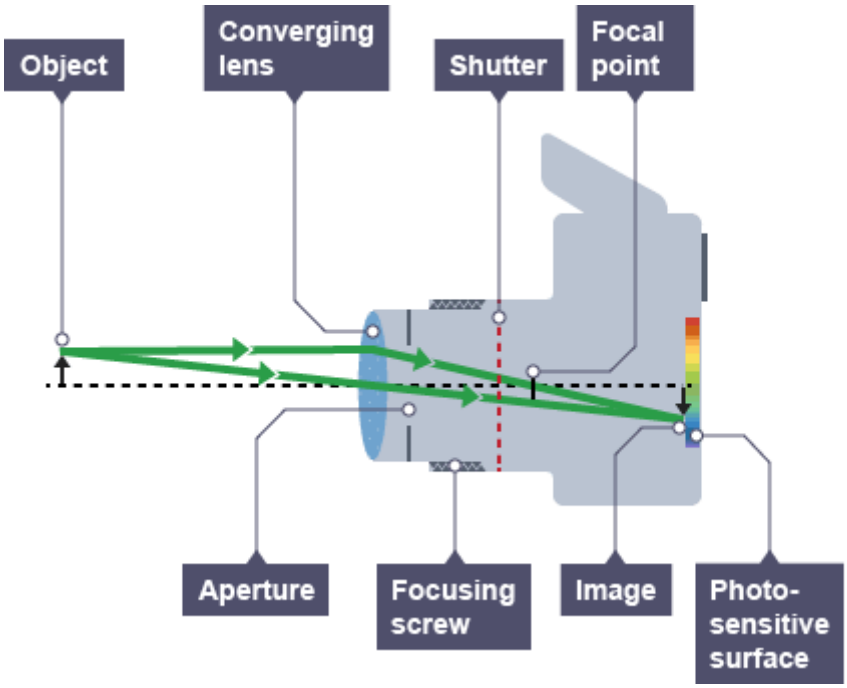
$$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$$

Fill in the results of the lens experiment. Use the lens equation to calculate the focal length.

u	v	1/u	1/v	1/f	f

Camera

Here is a sketch of the major components of a camera:



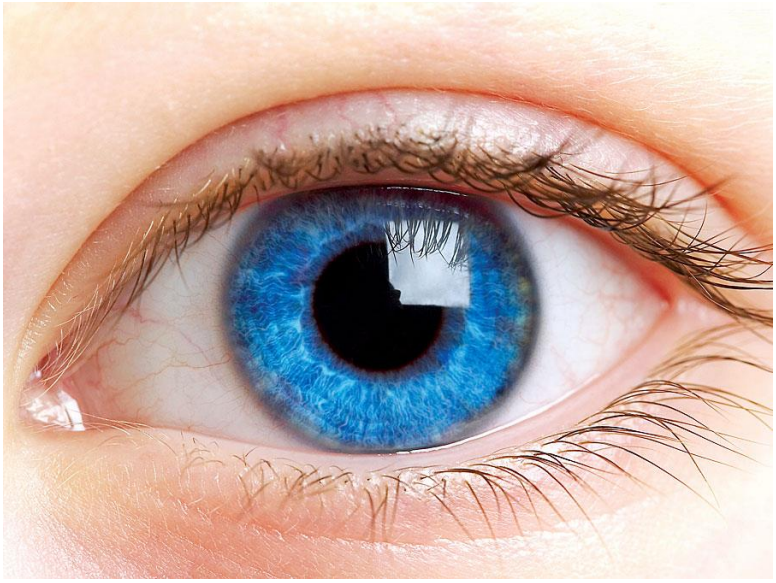
What are the functions of each part of the camera?

Camera part	Function
Lens	
Focusing screw	
Aperture	
Shutter	
Photosensitive surface	

Homework: Visual impairments

Research one kind of visual impairment, for example, age-related macular degeneration or glaucoma or retinitis pigmentosa. Prepare a 3 minute description of your findings to share with the group next week.

Tutorial 3 – How we see



What is the Purpose of Tutorial 3?

- To describe the visual impairment you have researched.
- To be able to explain how we see things
- Know the basic structure of the eye

How do we see things?

What did Plato and Pythagoras think?

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What did Alhazen discover?

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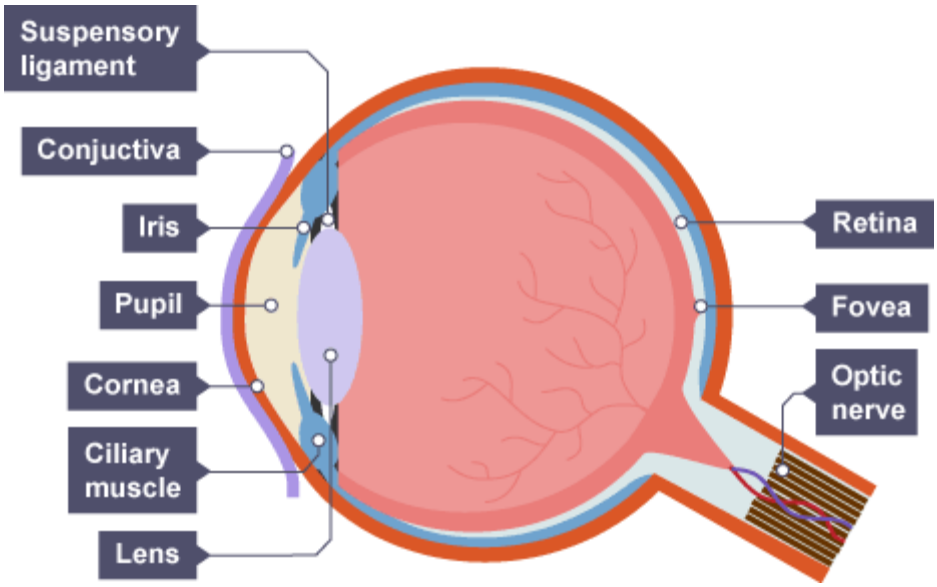
The eye as an optical instrument

Here is a sketch of the major components of the eye:

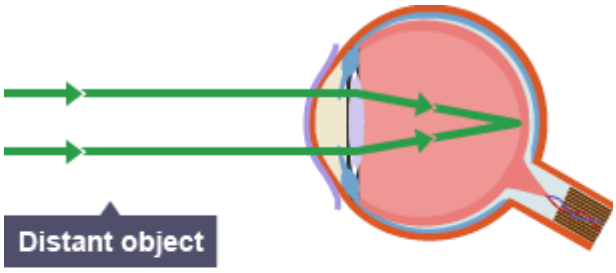


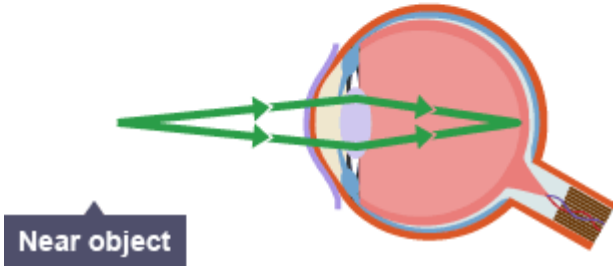
Look at the diagram of the structure of the eye above. What is the function of the following components of the eye? And how do they compare to the parts of a camera?

Eye component	*Function*	*Comparison to camera*
Cornea		
Lens		
Ciliary muscles		
Iris		
Retina		
Optic nerve		

Optical paths

The green rays demonstrate the optical paths that light takes as it passes through the eye.

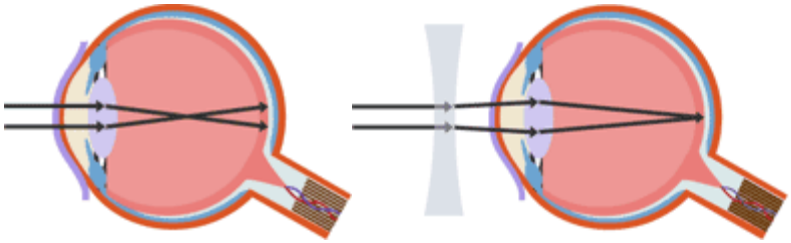




Edit the following table based on the above diagram:

Object	Ciliary muscles	Suspensory ligaments	Muscle tension on the lens	Lens shape
Near	Contracted/Relaxed	Slackened/Stretched	High/Low	Fat/Thin
Distant	Contracted/Relaxed	Slackened/Stretched	High/Low	Fat/Thin

Short sightedness:



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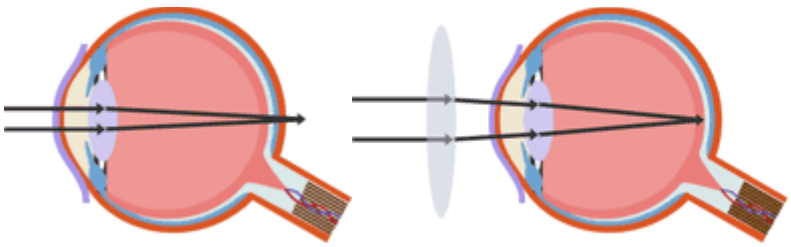
Long sightedness:



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Practical

Draw a schematic diagram of the practical.

Note down your observations from the practical.

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The psychology of vision

There is a lot more to the human visual system than the eye. In fact, it is possible for the eye to be healthy and yet be blind through it. This is true in amblyopia (commonly known as lazy eye): The eye is healthy but the neural pathway to the brain was not developed in childhood, leaving no vision through that eye.

Another illustration of this comes from optical illusions. Can you see the 2 characters in this image? The light arriving through the eyes does not change as you look at it, but our perception changes. So seeing happens in the brain.

W.E. Hill, 1915 (earliest known form from an anonymous 1888 postcard)

Homework: Optical illusions

Look up other optical illusions. What do they tell us about vision? Write your notes below.

Tutorial 4 – Eye vs camera: Designing the experiment

What is the Purpose of Tutorial 4?

- Know the optical properties of resolution and field of view
- Design an experiment to compare the optical properties of a camera and an eye
- Understand the difference between objectivity and subjectivity
- Begin to carry out the experiment

Resolution

Look at your outstretched hand. What can you see? Now bring your hand in close. What extra detail can you see? You would say, "I can **resolve** my fingerprint at a close distance". At about what distance can you resolve your fingerprint? What things effect the resolution?

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The letter chart eye test at the optician measures visual acuity, a measurement of resolution. How does this test measure visual acuity?

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How will you design an experiment to compare the resolution of the eye to the resolution of a camera? Describe your methodology and draw a schematic diagram.

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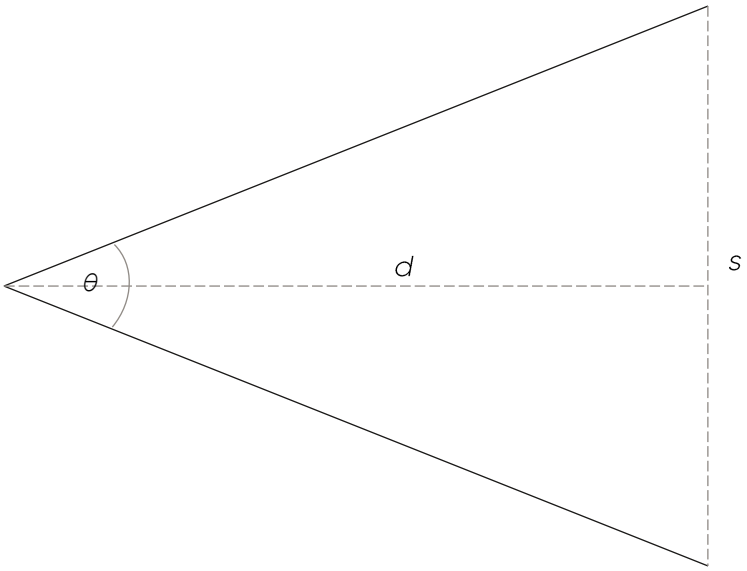
What will be the control variables?

Field of view

The field of view is the angle at which objects can be seen. Use trigonometry to work out a formula for the field of view, θ, of two objects separated by a distance of s at a distance of d, as shown below.



What is the approximate field of view of one eye (monocular) and both eyes together (binocular)?

How will you design an experiment to compare the field of view of the eye to the field of view of a camera? Describe your methodology and draw a schematic diagram.

Objective vs subjective

An objective statement is something that can be verified by someone else. For example, "There is a 1m high chair in the corner of this room." A subjective statement depends on the individual making the statement, for example, "Fish tastes better than chips." Scientific language seeks to maintain a high degree of objectivity.

This means we want to take objective measurements where possible. This is easy when taking measurements for the camera, but more difficult when taking measurements of the eye. Are there any changes you would make to your methodology to make your measurements more objective?

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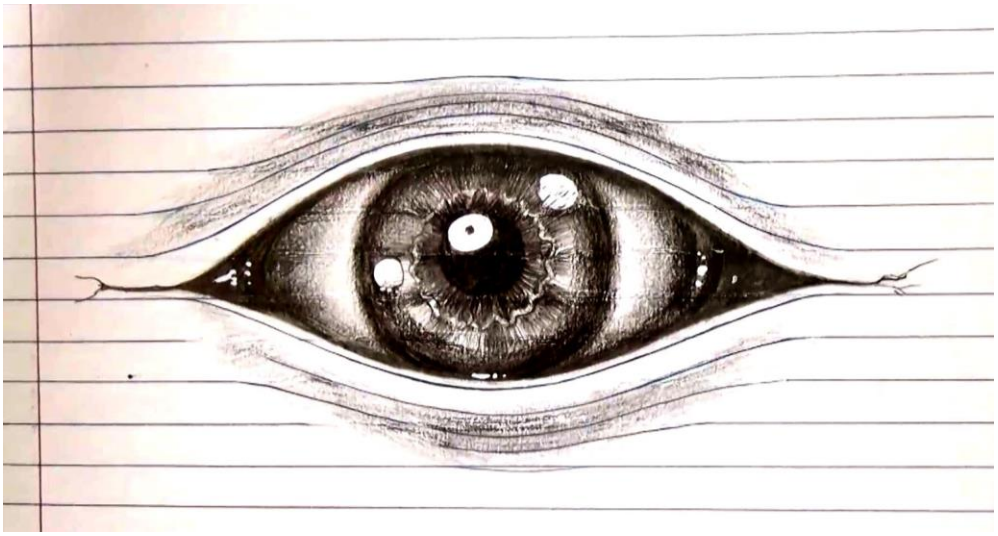
Homework: Beginning experimental write-up

Write the introduction to the scientific report of your experiment.

Tutorial 5 – Eye vs camera: Carrying out the experiment



What is the Purpose of Tutorial 5?

- Finish carrying out the experiment
- Know the structure of a scientific report

Writing a scientific report

A scientific report aims to communicate what you were aiming to discover, how you went about discovering it, what you found, and what you think this means. Therefore, a scientific report has the following sections:

Section	Purpose of section
Title	A descriptive statement of your experiment
Abstract	A short summary of the report: Your aim, method, results and conclusion
Introduction	What was your purpose? What was the theory you were using?
Method	A description of the procedure of your experiment, detailed enough for someone else to perform the experiment
Results	A statement of the results of your experiment
Discussion	What do your results mean? What would you do differently next time?
Conclusion	A summary of the paper
References	A list of the sources referred to in the paper

Homework: Complete experimental write-up

The length of the report should be 3 to 4 pages.

Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on final assignments.
- To share examples of best practice with the other pupils in your group.
- To write targets for improvement in school lessons.
- To reflect on the programme including what was enjoyed and what was challenging.

Final assignment feedback

What I did well…	What I could have improved on…
•	•
•	•
•	•

My target for future work is…

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.
    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].
    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].
    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.
    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.
    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.
    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Appendix 2 – Using the VLE

VLE username	
VLE password	

Please remember the following key details…

- You are able log into the VLE either through the link on our website (www.thebrilliantclub.org) or going directly to the VLE site at (https://portal.thebrilliantclub.org/sign-in).
- Please update your profile with your full name and email address- this will allow you to retrieve forgotten passwords or usernames
- If you forget your log-in details you can request them to be emailed to you by clicking the link on the VLE home page. (If you are still having problems you can email: schools@thebrilliantclub.org)

What is the VLE?

The VLE is a virtual learning environment for all pupils on Uni Pathways it is used for:

- messaging your tutor
- submitting homework
- submitting your final assignment
- accessing resources for your tutorials
- finding out more information about university and careers

How should I use the VLE?

The VLE is a professional academic environment in which pupils are able to message their PhD Tutor. Here are a few things to consider:

- Ensure you keep a professional tone in the messages you send to your tutors.
- Ensure you always reply to your tutors in a timely manner.
- Thank your tutor for the effort they are putting in to give you your feedback etc.
- Submit all homework to your tutor on time.

IMPORTANT: Final assignment

- When you submit your final assignment, please remember that you need to do so through the 'My Activities' tab and not as an attachment to a message.

Notes

Notes

Notes

Light: Man vs Machine

Key Stage 4 Programme

researchersinschools.org