

Optoelectronics – the science and technology at the heart of 21st century telecommunications



Researching Physics

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Researching Physics Optoelectronics – the science and technology at the heart of 21st century telecommunications

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Overview of the unit and activities.

What is involved in the unit 'Researching Physics'?

Studying physics involves learning physics facts and concepts. It also involves developing particular skills. These include research skills, which may involve you in doing investigative experiments or researching information, perhaps from the internet. The aim of this unit is to help you develop these physics skills. You will learn some physics facts, probably in some depth, however it is the development of skills which is the focus of the unit.

What physics content will I be learning?

The context for your work is the application of optoelectronics devices in modern telecommunications. Telecommunications has been revolutionised in recent years due to developments in optoelectronics devices. The development and use of light emitting diodes (LED), laser diodes, photodiodes, optical fibres and liquid crystal displays (LCD) has led to the internet, mobile telephones and a whole range of handheld interactive devices and large flat screen displays.

Life as you know it would not exist if it were not for optoelectronics.

What activities will I be doing?

There are three types of activities in the unit.

Undertaking literature based research is a hugely important skill. In this unit, this is best carried out as web-based research. It is easy to simply look up a single fact on the internet, but undertaking a more structured project is more complex. Sifting through what is often a large amount of data is demanding. Keeping track of what you are trying to find out is one of the most difficult parts of this type of research, and summarising what you have found, without merely cutting and pasting someone else's work is also challenging. In this material, there is an activity which describes how best to carry out web-based research. There are also several research briefs which can be used in preparation for your investigation.

Investigative practical work can be fun and challenging. Planning and designing experiments is often the hardest part of this work. Actually carrying out the experiment may be straightforward. This material includes a number of activities which develop the skills required to do investigative practical work. There are also several investigation briefs which you can use to help you plan and carry out an investigation. The experiments you are likely to carry out in your investigation are not the kind where you can simply look up the results beforehand. There may be no right or wrong answers. What you find is what you find and your way of doing the experiment may not be similar to others in your class.

Scientific communication is hugely important. It does not matter how interesting or ground breaking your work is; if you cannot communicate your results then you have not completed your work. Information from your web research and data from your practical work will contribute to an assignment that you will complete under supervised conditions. This assignment is assessed externally by the SQA. You can pass this unit without completing the assignment, but you cannot get an overall course award in Higher Physics without doing so.

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Organising your work and carrying out the activities

How will I organise my work?



Some of the work you carry out in this unit will be in preparation for your research into one or more aspects of earthquakes. When you carry out the research activities themselves, it is likely that you will be responsible for organising your work.

You are required to produce a report on the results of a piece of web-based research, and you may produce a report of your practical investigation that you may submit as your assignment for SQA assessment. You are strongly advised not to produce these “as you go along”. Rather, it is very good practice to maintain a diary, or record of work. This should record all your experimental results, ideas, problems you met, references and all the other day to day observations and data that you want recorded. The record of work is your record and as such it should be in a format that suits you. However, experience shows that students who organise their work for ease of reference are likely to be able to extract the information more easily and the resulting reports are likely to be easier to produce.

Will I do the same work as everyone else in my class?

This material includes a number of web-based research and practical investigation briefs. It is likely that students within the same class will be allocated different activities, depending on resources available and other classroom management issues.

What about teamwork?

It is probable that you will undertake some of the work as part of a group. Sometimes, within your team, you will be undertaking the same task and other times you will each focus on a different part of the task. In either case, it is important that discussion takes place. Agree the part that each member of the team will play and ensure that there is time to share the results of the work.

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Assessment issues

What do I have to do to pass this unit?

As you work on this unit, you will carry out activities which develop your skills in undertaking research in physics. Two of the activities contribute to the unit assessment. To be awarded the unit, you need to demonstrate that your work is of at least the required standard in each of the two types of activity. The two types of activities are:

- Undertaking web based research
- Carrying out investigative practical work - you need to take an active part in planning and carrying out an investigation.

Do I need evidence?

For the web based research and scientific communication, you should ensure that you retain evidence that your work is of the required standard. Each year SQA will ask to see the evidence from a number of candidates. This process is easiest to manage if your evidence is stored in an e-portfolio. You can store text based work, together with pictures, web pages, and any other material which you wish to present as evidence. If you do not use an e-portfolio, you should ensure that your evidence can be easily accessed.

What about assessment in the Higher Physics exam?

The Higher unit - Researching Physics is available as a free standing unit. It is also a required unit for a course award in Higher Physics. There will not be any questions in the Higher Physics course assessment which specifically relate to the topic of this unit. However, there will be questions in the course assessment which relate to the skills that you have developed in the unit. The following are the skills which may be assessed in the course assessment:

- Selecting information from texts, tables, charts, graphs and diagrams,
- Presenting information in a variety of forms,
- Processing information,
- Planning and designing an experiment,
- Evaluating experimental procedures,
- Drawing conclusions and making predictions based on evidence provided.

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Initial Research Activity

Optoelectronics devices – what are they?

Research Brief

Using the internet requires technology that can send very large amounts of information in a short space of time. The internet developed from the need for the large number of research physicists working at CERN (the European Particle Physics Centre) in Geneva to share the large amounts of data generated in their experiments. This became possible when the use of optoelectronics devices and optical fibres replaced purely electronic devices and metal wires. In more recent years mobile telephone and laptop technology has evolved due to the availability of improved LCD screens enabling access to the internet and streamed video almost anywhere at anytime.

In this initial research activity you will find out some background information about optoelectronics devices.

In carrying out your research you should answer the following questions.

- Why are LEDs becoming more commonly used as light sources?
- What are the advantages of using optical fibres over other methods to communicate information?
- Why have flat panel display screen replaced other forms of displays such as cathode ray tubes in recent years?
- How can electromagnetic waves be polarised?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

You should spend approximately 2 hours on this activity.

If you work as part of a team which produces one report, you should include a short statement at the end of the report that indicates the part of the work for which you were responsible.

Research Brief

LEDs are increasingly used as light sources in a large range of applications. This includes lighting applications such as car brake lights and traffic lights as well as light sources used in telecommunications.

In carrying out your research you should answer the following questions.

- Why are LEDs increasingly replacing other types of light sources?
- What are the advantages of LEDs over other types of light sources?
- What are the present limitations of LEDs?
- What types of materials are used to make LEDs?
- What range of colours (frequency or wavelength) of LEDs are available?
- What sort of spectra do LEDs produce?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

You should spend approximately 2 hours on this activity.

If you work as part of a team which produces one report, you should include a short statement at the end of the report that indicates the part of the work for which you were responsible.

Research Brief

Optical fibres are used to transmit signals over large distances.

In carrying out your research you should answer the following questions.

- What are optical fibres made from?
- What sorts of signals are transmitted through optical fibres?
- How can optical fibres be used to transmit large amounts of data?
- How far can signals be transmitted through optical fibres?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

You should spend approximately 2 hours on this activity.

If you work as part of a team which produces one report, you should include a short statement at the end of the report that indicates the part of the work for which you were responsible.

Research Brief

LCDs are used in a variety of display devices from simple black and white digital watches and multimeters to colour mobile telephones, computer monitors and televisions.

In carrying out your research you should answer the following questions.

- Why are LCDs increasing replacing other types of displays?
- What are the advantages of LCDs over other types of displays?
- What are the present limitations of LCDs?
- How are different shades produced in a LCD?
- How are all the colours of the visible spectrum produced in a LCD?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

You should spend approximately 2 hours on this activity.

If you work as part of a team which produces one report, you should include a short statement at the end of the report that indicates the part of the work for which you were responsible.

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Practical Activity 1A

Investigating LEDs and Colour

Investigation Brief

LEDs come in a range of different colours and some produce electromagnetic radiation beyond the visible spectrum. LEDs are operated from a low voltage d.c. supply usually connected in series with a resistor which protects the LED from damage by having too much current in it.

The aim of this investigation is to compare the magnitude of the d.c. voltage required to light a range of different coloured LEDs to light.

Discuss how you will carry out the investigation.

Write your plan in your record of work.

You should also include a hypothesis in your record of work. What do you think is the relationship between the colour of light produced and the d.c. voltage required to light an LED?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory. You may have access to pre-prepared circuit boards with a number of suitable LEDs already mounted or may have to build the circuits from individual components.

Remember that LEDs only allow a current to flow through them in one direction.

It will be necessary to give some thought to how many LEDs should be investigated and how many times the experiment should be repeated to ensure you can draw an appropriate conclusion. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 to 2 hours on this activity.



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Practical Activity 1B

Investigating LEDs and Brightness

Investigation Brief

The brightness of an LED depends on the supply to which it is connected and hence the potential difference across it and the current in it.

The aim of this investigation is to measure the brightness of light emitted from an LED and compare how this varies with the magnitude of the d.c. voltage across it and the current in it.

Discuss how you will carry out the investigation.

Write your plan in your record of work.

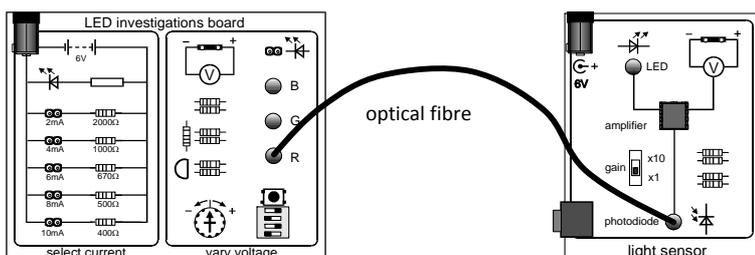
You should also include a hypothesis in your record of work. What do you think is the relationship between the brightness of light produced and either:

- the d.c. voltage across the LED or;
- the current in the LED?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory. You may have access to pre-prepared circuit boards with suitable LEDs already mounted or may have to build the circuits from individual components.

Remember that LEDs only allow a current to flow through them in one direction.



You will have to measure the brightness of the LED. There are light sensors based on photodiodes which can give a voltage which varies directly with the brightness of the light falling on the photodiode. An optical fibre may be used to direct the light from the LED on to the light sensor. It may be necessary to consider the effect of background lighting.

It will be necessary to give some thought to how many times the experiment should be repeated to ensure you can draw an appropriate conclusion. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 to 2 hours on this activity.

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Practical Activity 1C

Investigating the Spectra of LEDs

Investigation Brief

A spectrophotometer can be used to measure the intensity of light at different frequencies. The aim of this investigation is to use a spectrophotometer (or similar equipment) to investigate the spectra of a number of different LEDs.

Discuss how you will carry out the investigation. You will need to consult with your teacher on the following points:

What LEDs do you wish to investigate, and what is available?

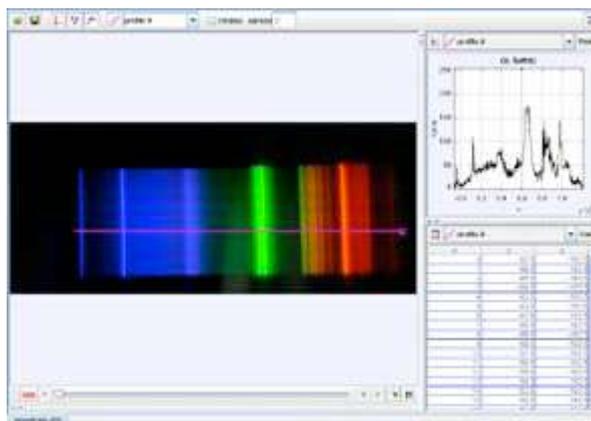
What kind of spectrophotometer is available?

Write your plan in your record of work.

Investigation Notes

Spectrophotometers can be very expensive items. However, it is possible to use a spectroscope to produce a spectrum. A digital camera can be used to capture the image and software is available which allows the spectrum to be analysed. Suitable software is available from <http://www.cabrillo.edu/~dbrown/tracker/>.

Including the planning stage, it is likely that this investigation will take up to 3 hours.



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Practical Activity 1D

Investigating the Energy Use of Light Sources

Investigation Brief

The aim of this investigation is to compare the energy use of different light sources, including LEDs.

Discuss how you will carry out the investigation. You will need to consult with your teacher on the following points:

What light sources do you wish to investigate, and what is available?

What methods of measuring the electrical energy supplied to a light source are available?

Write your plan in your record of work.

Investigation Notes

You should spend approximately 1 to 2 hours on this activity.



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Practical Activity 2A

Investigating Optical Fibres and Bending

Investigation Brief

Optical fibres are flexible. Light is transmitted through the optical fibre using the principle of total internal reflection. Total internal reflection depends on the angle of incidence that the light in the fibre makes with the surface of the optical fibre.

The aim of this investigation is to measure how the amount an optical fibre is bent affects the transmission of light through a fibre.

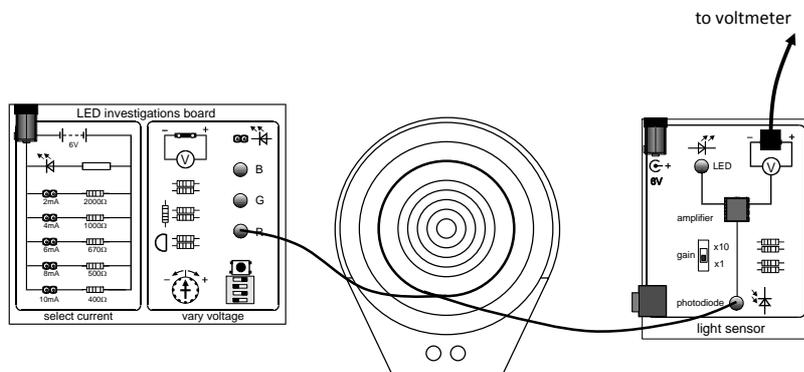
Discuss how you will carry out the investigation.

Write your plan in your record of work.

You should also include a hypothesis in your record of work. What do you think is the relationship between the amount of bending and the transmission of light?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory. You may have access to pre-prepared circuit boards with suitable LEDs already mounted or may have to build the circuits from individual components.



You will have to measure the brightness of the light transmitted through the optical fibre. There are light sensors based on photodiodes which can give a voltage which varies directly with the brightness of the light falling on the photodiode.

It will be necessary to give some thought to how many times the experiment should be repeated to ensure you can draw an appropriate conclusion. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 to 2 hours on this activity.

Investigation Brief

Light is transmitted through the optical fibre using the principle of total internal reflection. Total internal reflection depends on the angle of incidence that the light in the fibre makes with the surface of the optical fibre. Commercial, industrial standard optical fibres are made from very pure glass which does not absorb (attenuate) significant levels of the signals being transmitted. Cheaper, educational standard optical fibres are less pure and absorb more of the signals being transmitted.

The aim of this investigation is to measure how the amount of signal absorbed varies with the length of the optical fibre.

Discuss how you will carry out the investigation.

Write your plan in your record of work.

You should also include a hypothesis in your record of work. What do you think is the relationship between the length of optical fibre and the absorption of light?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory. Educational standard optical fibre is made of plastic and is relatively cheap to purchase and easy to cut into different lengths. You may have access to pre-prepared circuit boards with suitable LEDs already mounted or may have to build the circuits from individual components.



You will have to measure the brightness of the light transmitted through the optical fibre. There are light sensors based on photodiodes which can give a voltage which varies directly with the brightness of the light falling on the photodiode.

It will be necessary to give some thought to how many times the experiment should be repeated to ensure you can draw an appropriate conclusion. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 to 2 hours on this activity.

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Practical Activity 3A

Investigating Polarisation

Investigation Brief

Light and dark on a liquid crystal display is controlled by polarisation.

The aim of this investigation is to measure how the brightness of the light transmitted through a pair of Polaroid sheets is affected by the orientation of the Polaroid sheets.

Discuss how you will carry out the investigation.

Write your plan in your record of work.

You should also include a hypothesis in your record of work. What do you think is the relationship between the transmission of light and the orientation of the Polaroid sheets?

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory.



You will have to measure the brightness of the light transmitted through the Polaroid sheets. You may have to give consideration to the effect of background lighting.

It will be necessary to give some thought to how many times the experiment should be repeated to ensure you can draw an appropriate conclusion. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 to 2 hours on this activity.

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Practical Activity 3B

Investigating Polarisation using a Liquid Crystal Shutter

Investigation Brief

Light and dark on a liquid crystal display is controlled by polarisation.

The aim of this investigation is to measure how the brightness of the light transmitted through a panel of liquid crystal is affected by the voltage applied to the liquid crystal.

Discuss how you will carry out the investigation.

Write your plan in your record of work.

You should also include a hypothesis in your record of work. What do you think is the relationship between the transmission of light and the voltage applied to the liquid crystal?

Investigation Notes

A liquid crystal shutter apparatus allows a voltage to be applied to the panel of liquid crystal.



You will have to measure the brightness of the light transmitted through the liquid crystal shutter. You may have to consider the effect of background lighting.

It will be necessary to give some thought to how many times the experiment should be repeated to ensure you can draw an appropriate conclusion. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 to 2 hours on this activity.

Investigation Brief

A colour display screen needs to display all the colours of the visible spectrum. However, display screens are made up from only red, green and blue subpixels.

The aim of this investigation is to investigate how the colours in the spectrum can be produced from red, green and blue.

Discuss how you will carry out the investigation.

Write your plan in your record of work.

Investigation Notes

The equipment to carry out this investigation is normally readily available in a physics laboratory.

It will be necessary to give some thought to how you can determine the colour obtained. Also, you should give careful consideration to how you will analyse and present your results.

You should spend approximately 1 hour on this activity.



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Further Information

Further Information

The activities in this exemplar have evolved from the experiments, activities, equipment and continuing professional development produced by the Optoelectronics College. The Optoelectronics College was initially set up to develop materials, suitable for S1/2 pupils, both to enthuse and motivate pupils to study physics and to introduce the basic science behind modern optoelectronics devices. Three topics were developed: Solar Cells in Action, Illumination and Communication and Colour, Vision and Displays. Thanks to sponsorship from The Rank Prize Funds, Institute of Physics, Photonics Knowledge Transfer Network, MacRobert Trust and the Scottish Government free equipment kits for one or more of the topics have been supplied to over one third of Scottish secondary schools at workshops held as part of Association for Science Education, Institute of Physics and SSERC events since November 2008.

The practical activities in this exemplar were written with the use of some of the equipment from the Illumination and Communication and Colour, Vision and Displays topics in mind although other equipment could be used for many of the activities.

Teacher and technician guides and other supporting resources for all three of the S1/2 topics are available as downloads from the Optoelectronics College website www.opto.org.uk. Equipment for the Optoelectronics College topics was developed by or is available from:
www.mindsetonline.co.uk
www.fifex.co.uk
www.jjmelectronics.co.uk

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Stuart Farmer
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