PIADS-CDT x GSF

Science At Home Workbook

EPSRC and SFI Centre for Doctoral Training in PHOTONIC INTEGRATION AND ADVANCED DATA STORAGE

GLASGOW SCIENCE FESTIVAL

Who are PIADS-CDT?

The Centre for Doctoral Training (CDT) in Photonic Integration and Advanced Data Storage (PIADS).

We are a PhD programme partnership between the Queen's University Belfast, University of Glasgow and the SFI Centre for Photonics IPIC, Cork which aims to tackle some of the challenges created by the increasing quantities of data generated by today's society.

What is Photonics?

Photonics is the science and technology of generating, controlling and detecting light.

Meet the Scientists!

Hello there! My name is Nicholas Stephen and I'm part of the Photonics Integration and Advanced Data Storage Centre for Doctoral Training. I am originally from Scotland and currently based at Queen's University Belfast.

My research involves investigating metamorphic laser samples by electron microscopy techniques. Metamorphic lasers are new type of laser which can be used in various technologies including telecommunications, medical and environmental sensing. My work involves looking at samples the nanometer scale (very very small!) and examining surface features like defects and strain. A typical day work involve can involve preparing samples, conducting experiments, writing reporting, coding and helping with demonstrating in undergraduate teaching laboratories.

Outside my research, I am keen fan of watching sports with Rugby Union and Ice Hockey being favourites. I also enjoy doing jigsaw puzzles and computer gaming.

Hi There, My name is Nidhya Mathew , PhD student in MCCI, Tyndall National Institute, Cork, Ireland and my studentship is funded by Science Foundation Ireland (SFI) under the Centre for Doctoral Training (CDT) in Photonic Integration and Advanced Data Storage (PIADS).

My project is titled as "Compact Multi-Spectral Imaging for surgical guidance and diagnostics", and my research is in power converter circuits to driven a micro camera. I am currently investigating on resonance based switched capacitor converters to come up with a excellent solution in terms of area, power and performance.

Outside my research, I would like to travel, specially to hilly areas. I also love to do cooking, gardening and reading fictional novels

Meet the Scientists!

Hi my name is Zeki Shaw, and I am a CDT PIADS student and part of the University of Glasgow's Integrated Photonics group.

My work involves using computer simulations to study light-matter interactions in hybrid plasmonic-photonic devices. My focus is to look at how the interaction between light and matter can be enhanced and used in various areas, such as solar cell harvesting and focusing light to enhance data storage capabilities.

In my spare time, I like to go out for walks in the countryside, play video games, and have an ever expanding collection of houseplants.

Hi my name is Nicola Parry and I'm in my second year with PIADS. I completed my undergraduate degree in Physics at Royal Holloway, University of London.

Currently I'm working on developing passive waveguides for blue laser diodes supervised by Prof. Anthony Kelly at the University of Glasgow in collaboration with Kelvin Nanotechnology.

Outside of my PhD, I enjoy live music and knitting, not necessarily at the same time!

LAB REPORT

Suitable for 5+

SWITCHING ARROWS

DATE:

Background

Images that we see are made up of many rays of light, like pieces of a puzzle, that our eyes pick up and put them together into a picture. Light can bounce off an object and travel directly back to your eyes. This is called reflection. Sometimes light meets another object and bounces in a different direction. This is called refraction.

Question/Problem

Can we make an arrow change direction using just a glass of water?

Did you know?

We have different layers in our atmosphere. Some of the air is thick and some air is thinner. We see stars twinkling at night because light is refracting through the different layers of our atmosphere.

What you need

- Clear Glass
- Jug/bottle of Water
- Picture of arrow (with pen and paper or a picture on your phone)

What you need to do

Step 1: Place the picture of the arrow a short distance behind the clear glass, you could hold it with your hands or rest it against something so that it stands up.

Step 2: Look through the empty glass and note the direction of the arrow.

Step 3: Now fill the clear glass with water.

Step 4: Look through the glass again and see what happens!

What did you see?

Draw or write what you see! Why do you think this happens?

Why not try using a different type of liquid or different size/shape of glass and see what happens?

Conclusion

When viewing from a filled glass, the arrow switches direction. This happens because of a physical phenomenon called refraction. When a wave (in this case light) travels from one transparent (clear) medium to another, there is a change in speed of the light wave, which causes bending (refraction) of the wave. The light bends when it enters the water and then bends again when it leaves the water, which is why the image ends up looking flipped!

LAB REPORT

Suitable for 15+

LASER JELLY

DATE:

Background

This experiment is designed to show how light can be transmitted and absorbed in media.

Question/Problem

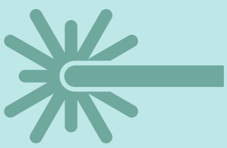
What happens when we shine a laser through different coloured jelly?

Did you know?

LASER is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

What you need

- A red laser pointer (be careful never to shine the beam directly into your eyes or anyone else's!)
- Red and green jelly
- A container for the jelly (such as a glass bowl or Tupperware)



What you need to do

Step 1: Prepare the jelly according to packet instructions in a suitable container.

Step 2: Hold the laser against the table and shine the light through the side of the green jelly container. Does the laser light shine through?

Step 3: Now shine the laser through the red jelly. What do you see?

What did you see?

Draw or write what you see! Why do you think this happens?

Why not try the experiment again with a green laser or different colours of jelly and see what happens!?

Conclusion

When light interacts with a substance it is either reflected, transmitted or absorbed. Here we see the red laser light is transmitted by the red jelly and absorbed by the green jelly. Jelly is made of Gelatin which has large molecules which are spread throughout the jelly. The red jelly does not absorb red light it transmits it, therefore we can see the beam clearly in the jelly and exiting on the other side. The green jelly absorbs the red light and the beam immediately gets dimmer as it enters the jelly and we are unable to see it exiting on the other side.

LAB REPORT

Suitable for 5+

TYNDALL EFFECT

DATE:

Background

White light is made up of all of the colours of the rainbow – red, orange, yellow, green, blue and indigo. When white light bounces off an object it can break up into the different colours. As light from the sun goes through the atmosphere it is scattered around. Blue light is scattered more than other colours and is bounced back to our eyes, which is why the sky is blue. John Tyndall thought that the light bounced off dust or water vapour in the air. This idea is known as the 'Tyndall Effect'.

Question/Problem

How does light travel through different liquids?

Did you know?

The light from the sun scatters off of the air itself and the molecules in the air, for example nitrogen (N2), oxygen (O2) and carbon dioxide (CO2). This is known as 'Rayleigh Scattering'.

What you need

- 2 clean glass jars or 2 glasses, straight-sided
- Water
- Milk
- Small torch
- Teaspoon

What you need to do

Step 1: Fill both jars with water and let it settle, so the air bubbles disappear.

Step 2: Add half a teaspoon of milk to one of the jars and stir, so it's just uniformly cloudy.

Step 3: Darken the room.

Step 4: Put the torch next to each of the jars and look from the side to see how the light travels though the liquid.

What did you see?

Draw or write what you see! Why do you think this happens?

Why not try adding more milk to the jar or watching from the other side of the jar?

Conclusion

The beam path of the light should not be visible inside the jar with clear water – light travels though water freely. Inside the jar with milky water, the milk particles suspended in the water scatter the light and you can see the beam now! The white light of the torch is made of multiple colours which combined, appear white.

Placing the torch in front of the jar with milky water shows slightly blue colour of the jar contents – the blue light is scattered more than the red. The red passes through and blue is bounced back. Watching from the other side of the jar you can see the warm light that passes through, while the blue is scattered. Similar thing happens during the sunset – light from the Sun goes through denser parts of the atmosphere so the blue is scattered even more, and red goes through.

LAB REPORT

Suitable for 8+

FIBRE OPTICS AT HOME

DATE:

Background

We can use refraction to send information from one place to another. John Tyndall is known as the grandfather of fibre optics. John Tyndall's Light Pipe experiment showed that light will travel along a path of a stream of water. This is because the light will bounce from one side of the stream to another until it reaches the end of the water. This is called Total Internal Refraction. Fibre optic cables are long tubes of glass which allow light to bounce down the tube, transferring the light from one end to another.

Did you know?

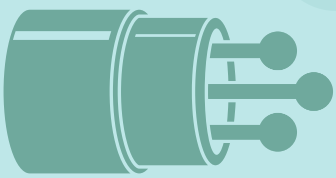
There are over 420 under water fibre optic cables in the world stretching 700,000 miles or 1.1 million kilometres.

Question/Problem

Can light bend around corners?

What you need

- Scissors
- Tape
- A4 white paper
- Card/thick paper
- Tin foil
- Torch



What you need to do

To make your "cable"
Step 1: Roll the A4 paper lengthways (long-side) to a tube with a diameter of approximately 4cm-5cm. Tape to secure.
Step 2: Cut on end of the paper tubes at a 45° angle
Step 3: Tape the cut ends together to form a 'L' shape

To make your "mirror"
Step 4: Cut the thick card into a rectangle measuring 9cm long and 5cm wide
Step 5: Cover the thick card with tin foil. Make sure you smooth the foil. Tape to secure.

And finally...
Step 6: Cut a slot across the join of the 'L' shape tube
Step 7: Place the "mirror" into the slot
Step 8: Use the torch to shine a light from one end of the tube.

What did you see?

Draw or write what you see! Why do you think this happens?

Why not try using different coloured lights? Or add a glass of milk at the start of the cable?

Conclusion

Light doesn’t bend on its own. When the mirror is removed you won’t see the light. When you add the mirror the light bounces off the mirror and changes direction. This allows light to travel around corners.

Fibre optic cables use a "transmitter" to send out a light signal. The light bounces against the inside of the cable allowing it to travel along the cable. This light signal is boosted across the fiber by an "optical regenerator". At the other end an "optical receiver" detects the light signal and decodes it. This can transmit information across vast distances and very quickly as light travels faster than sound.

Send messages through your cable!

Morse code is a way of communicating. It uses a series of dots and dashes to indicate specific letters. These letters can be combined to create sentences. The most common use of Morse code was the telegraph.

A • —
B — • • •
C — • — •
D — • •
E •
F • • — •
G — — •
H • • • •
I • •
J • — — —
K — • —
L • — • •
M — —
N — •
O — — —
P • — — •
Q — — • —
R • — •
S • • •
T —

U • • —
V • • • —
W • — —
X — • • —
Y — • — —
Z — — • •

1 • — — — —
2 • • — — —
3 • • • — —
4 • • • • —
5 • • • • •
6 — • • • •
7 — — • • •
8 — — — • •
9 — — — — •
0 — — — — —

What message do you want to send?

To find out more you can visit us at

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