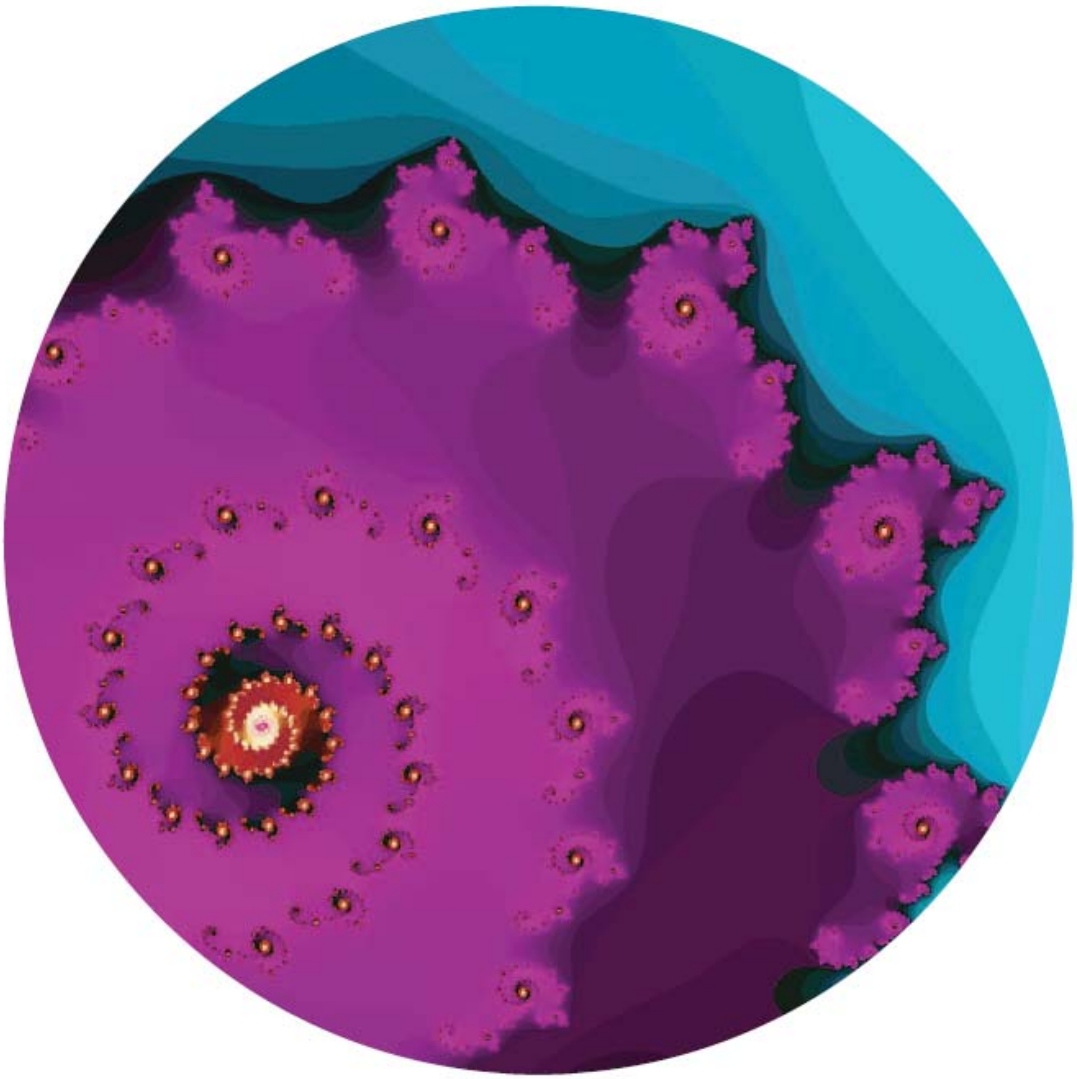
lab in a lorry
get connected to science

Data:

Transmission and Storage



see it!

Data

What's it all about then?

This experiment looks at how we manipulate data, or more specifically how we store it and transmit it from one place to another.

What you can explore through this experiment

- Visible light is a form of energy and is a small part of the "Electromagnetic spectrum"
- Wavelengths of light
- Lasers
- Sound and vibration
- How we use light and magnetism to store information

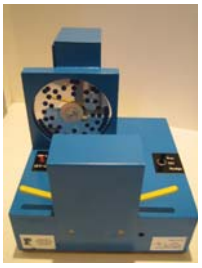
How to present this experiment:

This is a guide suggesting how to present the experiment to the students. You do not have to follow it exactly, as long as you allow the students to explore the concepts involved.

You can expand or shorten this experiment as necessary to fill the time allocated.

The kit:

- Small house with speaker inside and laser
- MP3 player
- Baggage cart
- Track for baggage cart
- Various types of storage media
- Laptop
- Light transmitters and receivers
- Walkie-talkies
- Microscope
- Microdots






Sample images of the equipment

Data

Introduction

Start the experiment by saying who you are and what you do for a living. Inform students that they are going to be taking on the role of secret agents, spying on the enemy and communicating their findings with some other agents. Relate it to James Bond or similar spy themed film/TV programme.

Part 1: Spying on the enemy

1.1 House and laser-microphone setup

Discuss with the students the nature of sound being vibrations. If they have done the resonance experiment they should already be familiar with this. Sound being vibration is the key to how the laser microphone works. The first task is to listen in to a conversation (music from MP3 player or phone) which is being played inside the house. To do this we need to shine a laser onto the window and move the receiver to pick-up the reflected ray. Ask a student to put on the headphones and turn the reciever until they can hear the sound coming from inside the house.

So how does it work?
The speaker vibrates to produce the sound. This in turn causes the air to vibrate and eventually the window. The laser produces a narrow focused beam of light which reflects off the window. As the window vibrates the laser light is reflected differently and this 'modulation' is picked up by the receiver. A digital (on or off) signal is produced which is then converted back into audio and played through the headphones.

Part 2 : Communicating the data

The students have seen how we can use a laser microphone to spy on the enemy and potentially listen in to a secret conversation. The next task is how to communicate this valuable intelligence to other agents. Discuss the methods we use to communicate or transport data, i.e. phone, DVDs, paper etc. Most of these involve storing the information in some form and passing it on. In our case we need to ensure the data is safe and undetectable by basic security techniques. Which is the best method of communicating the data?

2.1 Testing the different physical media

Setup the track with security station signs - see fig 1.
Place the cart onto the track and ask the students to pick a type of media to test. Fix it onto the cart and switch it on. The cart will move along and stop at each detector if the item is detected. Once the item is detected discuss why it was picked up and then look at the item in more detail - how does it work?
For each media type there is a hands on model to demonstrate how each works. For a detailed explanation of each type see GLOSSARY.

Data

Fig 1

2.2 Using the Electromagnetic Spectrum

By now the students should have investigated several types of storage media. They should realise that another way of communicating the data is by utilising one of the many parts of the electromagnetic spectrum. A typical example of this would be a mobile phone.

Show the students the picture of the EM spectrum and point out the different parts, i.e. X-rays, microwaves, infrared, visible light, radio. They should all be familiar with X-rays and radio waves. We will be investigating radio and visible light.
First of all take out the LED transmitters and receivers. They are colour coded for ease of use. On the back of the transmitter is a microphone. The students can speak into the mic and a second person can hear them through the headphones attached to the receiver. NOTE: for this to work the transmitter and receiver need to be in 'line of sight' and with no obstructions in the way.

LED Transmitters and Receivers

Place the transmitter and receiver at opposite ends of the track. The data will be transmitted and cannot be detected by any of the sensors. The problem with this setup is that it needs an unobstructed line of sight, which can be demonstrated by placing your hand infront of the beam, thereby stopping the signal.
The students can investigate a similar setup with different coloured LEDs, though with the same issues as before. There is also a white reciever which can detect information from all three coloured LEDs - and a white transmitter which can be detected by each of the coloured receivers - why?

To eliminate the 'line of sight' issue we need a technology which can penetrate through walls and transmit in all directions. Examples of this include microwaves or radiowaves.
To demonstrate this we have some two-way radios. Send a student outside with one of the radios. They should be able to talk to the remaining students by pressing and holding the talk button. There is a third radio which is tuned to the same frequency. This is to show that anyone on the same frequency can listen in - so information sent in this way isn't very secure. This could lead onto a discussion about data encryption. A typical example is when bank details are encrypted when you purchase things online.

Data

Glossary and 'Media specific' information

Optical Media - CD, DVD etc
The most common storage media today is optical media. This comes in the form of a disc and data is written and read from the disc using a laser. Most lasers are in the red part of the spectrum but newer Blu-Ray players make use of blue wavelengths. Since blue light has a shorter wavelength than red light more data can be stored on the same size disc as tracks can be thinner.
This type of media is good for storing all types of data. Modern dual layer DVDs or Blu-Ray discs can store large amounts of information; these are particularly useful for storing images or high definition video. For the experiment this is not a good choice! Optical media is not affected by magnetic fields, but it may be picked up by the metal detector, due to the silvering on the disc where the data is stored. Also it would be easy to identify on a person, either through a body search or x-ray machine.
The data is stored on the DVD as a series of pits, each pit is 0.16 micrometres deep and 0.3 micrometers wide. To demonstrate how this series of pits stores information we have a model consisting of a spinning disc and laser setup. The disc has a series of dark patches which do not reflect the light back to the reciever. The dark patches represent the pits on the disc. As the disc spins a kind of 'Morse Code' sound can be heard as the sound is turned on and off by the pattern of dots on the disc (above right).

Magnetic Tape Media - Audio / VHS cassette + Credit card etc.
The precursor to CDs and DVDs. It's possible that some students may never have seen an audio tape. Whilst VHS is slightly more common, it is rapidly being phased out for the newer and more versatile DVD. Unlike DVDs this technology uses magnetism to store information on a thin tape which passes between a series of heads. Some heads do the writing and some do the reading. The tape itself is produced from a ribbon of thin plastic, coated with metal oxide, typically iron or chromium. These particles are affected by variable magnetic fields in the heads.
Cassettes are usually large, easily detectable and can easily be wiped using high power magnets. Thus this media performs poorly in the security checks. Students can record something onto magnetic tape and then wipe it using a magnet. There is also an etch-a-sketch which works in a similar way.

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Solid state media - Flash Memory or Memory Stick - used in MP3 players, phones etc

Memory cards / sticks utilise a totally different technology to the above. A typical memory stick is made up of a network of paired transistors. Between each pair of transistors is a thin layer of metal oxide. When a current flows though one of the transistors electrons build up in the oxide layer, closing the connection between the paired transistors. Effectively this switches the pair of transistors `off'. The device is said to be `digital', as each pair of transistors has two states - on or off. Typically we call this 1 or 0, which can often be seen on the power switch of electrical appliances. 1 is on and 0 is off.

Typical flash memory chips contain billions of transistors.

This option is a good choice for this experiment as it can hold a large amount of data and is fairly small. However, it may be discovered during the simulated body search or by the metal detector (USB connector).

The students can investigate a model of a transistor pair (see below).

The 'transistor pair' model uses steel balls to represent electrons. Start with it in 'Normal' mode and drop the balls into the container at the top. They should flow freely through the transistor pair and out the bottom. This simulates electricity flowing through the memory card, perhaps to read it. There are also a series of LEDs which light up to show the direction of current flow. To store data on the card flick the switch to 'program' and repeat. This time the electrons (balls) will be stored inside the pairing. Once enough charge builds up (enough balls) the LEDs will go out representing a stop in the flow of current. At this point the LED labelled 1/0 will light up. This indicates that the transistor pair has been set to 1. As with all digital devices data is stored as a series of ones and zeros and this pairing would be replicated billions of times inside a typical memory device. Switch the device off and on to show that the state has been set to 1 permanently. This represents unplugging the memory device and shows that the data is stored, even when no power is present.

To store different information the pairing must be reset to zero, to do this select 'erase'. At this point the electrons will be released from the gate and current will continue to flow freely again.

Data

Magnetic Media - Computer Hard disk or Floppy disk

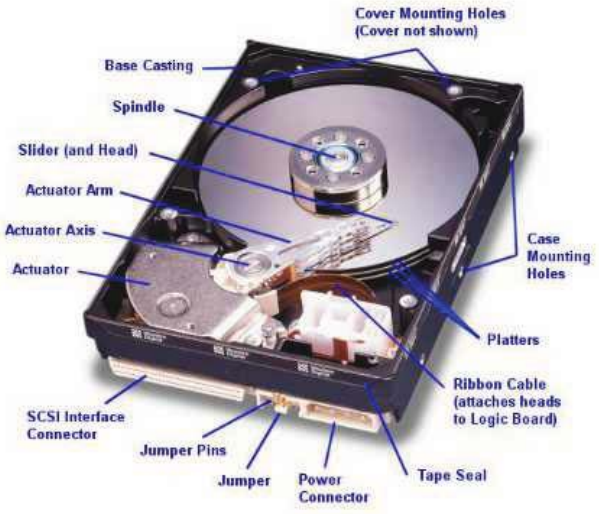
Whilst portable media is predominantly optical, desktop computers still rely on magnetism to store information. Hard disks and their less common floppy counterparts work in a similar way to the aforementioned audio and VHS cassettes. Magnetic media is necessary for computers due to its high read/ write capability. Although re-writable optical media exists it is much slower and the number of uses is limited. Modern computers are constantly reading and writing information to the hard disk - this would not be possible using optical storage.

A hard disk consists of a rotating disk of glass or aluminium, coated with magnetic material. There are usually several of these in a modern hard drive - increasing the overall capacity. The disks or `platters' spin very fast, typically 7,000 rpm which is about 150mph. An arm moves above the surface of the platter carrying a `head' which reads and writes the information. Unlike other magnetic storage the head itself doesn't come into contact with the surface.

A typical HD can store hundreds of Gigabytes of information. The current maximum capacity of a commercial HD is 2 terabytes. When compared with other media types hard disks are cheaper, providing more storage for your money. Unfortunately a hard disk would be easily detectable and easily wiped using magnets so a poor performer in the security checks.

The 2007 Nobel Prize in Physics was awarded to Albert Fert and Peter Grunberg for their discovery of Giant Magnetoresistance. This has revolutionised the way we retrieve and store information on hard disks.

Students can observe a working HD with Perspex lid - enabling them to see the head moving across the disk at very high speed. Magnetic viewing film when placed onto an HD will show where the magnetic field lines are.



Microdot

Microdots use photographic shrinking techniques to reduce the size of images and text. A typical microdot is a circular disk 1mm in diameter, similar in size to the 'full stop' at the end of this sentence - hence the name. Modern microdots are produced using lasers and can be used for security tagging purposes when coupled with glue which fluoresces under UV light. Microdots were used extensively during the Second World War to communicate with allies, due to their small and undetectable nature. The main problem is the small amount of data which can be stored. Students can use the ultraviolet torch to search for microdots on the case and laptop. They can also use the microscope to view some pre-prepared microdots.

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