# REMOTE SURGERY

## LESSON AIM

To familiarise students with the role that communications technology plays in modern healthcare and to give students the opportunity to build their own laser communication device.

## LESSON OBJECTIVES

Students will be expected to:

- Work in pairs to build an electronic device.
- Plan and carry out an investigation into the performance of the device and use evidence from this investigation to decide on its suitability for a particular function.
- Make suggestions about how the device might be improved.

## LESSON OUTCOMES

By the end of this lesson:

- **All students must be able to** understand how modulation can allow one wave form to 'carry' another. They should also understand that combining different existing technologies can lead to entirely new fields of engineering.
- **Most students should be able to** understand the role of the audio transformer in the device that they will build. They should also be able to understand how time delay can limit the potential uses of a communication system.
- **Some students may be able to** make calculated estimates regarding the possible range of their communications device and suggest improvements. They may also be able to explain how the use of fibre optic cables and a digital signal could increase performance.

### Time Required

Approximately three hours. Ideally students should complete the construction phase in one lesson and the testing and presentation in a subsequent lesson or lessons. This will allow time for students to come back with their own ideas for evaluating and testing the device and time for the technician to assemble any required equipment/apparatus.

## Specification links

| Board | Unit | Spec. |
|---|---|---|
| AQA Physics A | 1 | 3.1.3 (a.c. current and the use of an oscilloscope to display waveforms) |
| | 3 | Investigative and practical skills |
| | 4 | 3.4.4 (capacitance)<br>3.4.5 (transformers) |
| | 6 | Investigative and practical skills |
| AQA Physics B | 1 | 3.1.1 (analogue and digital signals; data transmission) |
| | 3 | Investigative and practical skills |
| | 6 | Investigative and practical skills |
| Edexcel (concept approach) | 2 | 2.3 (e.m. spectrum, wave equation and wave propagation) |
| | 3 | Exploring physics |
| | 4 | 4.4 (capacitance) |
| | 6 | Experimental physics |
| Edexcel (context approach) | 3 | Exploring physics |
| | 4 | 10.4 (fibre optics and attenuation) |
| | 6 | Experimental physics |
| OCR Physics A | G482 | 2.4.1 (wave equation)<br>2.4.2 (e.m. radiation) |
| | G483 | Practical skills in physics |
| | G485 | 5.1.3 (transformers)<br>5.2.1 (capacitors) |
| | G486 | Practical skills in physics |
| OCR Physics B (Advancing Physics) | G491 | PA 1.1 (signalling and analogue/digital communication) |
| | G492 | UP 1 (wave equation and e.m. radiation) |
| | G493 | Physics in practice |
| | G494 | RF 1.1 (capacitors) |
| | G495 | FP 1.1 (transformers) |
| | G496 | Researching physics |

## MATERIALS AND EQUIPMENT REQUIRED

### Per student

- *Resource Sheet 3.1 – What is Remote Surgery?*

### Per pair of students

- Soldering iron and stand suitable for soldering small electronic components
- Lead free solder
- Soldering/heat proof mat
- Small side cutting pliers
- Needle nose pliers
- Cable stripper
- Phillips/posidrive and flat bit electricians' screwdrivers
- 1 laser communicator kit (see Technician Notes)
- Electrical tape
- *Resource Sheet 3.2 – Remote Surgery Laser Communications Device*
- *Resource Sheet 3.3 – Testing the Remote Surgery Laser Communications Device*

**Note:** All electronic components used in this activity are readily available. Specific suppliers and part numbers are given in the Technician Notes at the end of this lesson plan.

## PRIOR KNOWLEDGE REQUIRED

Students should be aware that laser beams can be used for communication and are particularly effective in this context when used in conjunction with fibre optic cables. It will be useful for students to also be familiar with the concept of modulation and the operation of capacitors.

## LESSON STRUCTURE

**Intro activity:**

**15 mins approx**

- Ask students to spend one minute in pairs thinking about what is meant by the term *remote surgery*. Get each pair to offer a definition. The definition of remote surgery should be something along the lines of

  *the ability for a surgeon to perform a surgical procedure on a patient even though they are not physically in the same location.*

- Discuss the key points of remote surgery. *Resource Sheet 3.1 – What is Remote Surgery?* can be used here, either to guide the discussion or as teacher reference material for reading prior to the lesson.
- The key points that students will need to consider are:
  - What technologies make remote surgery possible?
  - What are the governing factors that might decide which communications technologies should be used?
  - What are the limitations of this technology?
  - What might be the social implications of widespread use of this technology?

**Practical:**

**90 mins approx**

- In this practical, students will build a laser communications device and carry out a number of tests on it to determine whether it would be suitable for incorporation into a new remote surgery system.
- The practical is designed to deliver a set of specific subject related learning outcomes and to also demonstrate the application of physics in a real-world context, allowing students to learn about some aspects of the role of clinical engineers in the NHS.
- Explain that in real life a clinical engineer might be asked to evaluate new equipment but it is unlikely that they would actually be asked to evaluate equipment at such an early stage in the design process. This would be done by engineers employed by the company developing the machine. These engineers would certainly include trained clinical engineers. Students can find out more about the role of clinical engineers in the NHS at www.nhscareers.nhs.uk

**SAFETY**

- It is crucial to stress to students that they will be using low power laser modules and that on no account should they look directly into the beam or point it in such a way that it might shine into the eyes of anyone else. In order to prevent students from accidentally energising their lasers, batteries should not be inserted into the device until it is complete and in a position to be safely tested.
- As an additional safety precaution students should be instructed to keep a piece of electrical tape stuck over the laser aperture until their device is ready for use in a carefully controlled manner. The tape will prevent accidental discharge of a laser beam during the construction process.
- While working on the laser devices suitable warning signs should be placed on doors leading into the lab to inform visitors of possible risks.
- It is important that this activity is properly risk assessed for the lab/work space it will be carried out in.

- Issue the students with the following resource sheets:
  - *Resource Sheet 3.2 – Remote Surgery Laser Communications Device*
  - *Resource Sheet 3.3 – Testing the Remote Surgery Laser Communications Device*
- Before commencing the activity ensure that students are fully aware of the necessary safety precautions for this activity.
- Once students have built their devices they will carry out a number of tests on them. They will use the results of the tests to make their assessments and suggestions for improvements. One of the suggestions they have been asked to make will involve replacing the bi-colour LED with a cheaper component. The main purpose of the LED is to protect the laser module from voltage spikes so it could be replaced with a capacitor. To understand why this is possible, students will need to have at least an outline understanding of how capacitors work.
- Students will need to think about how different operating conditions such as fog, rain etc will affect the performance of their device. These could be simulated with a smoke machine borrowed from the Drama Department or possibly a hand operated gardener's water spray (safety considerations allowing).
- *Resource Sheet 3.3 – Testing the Remote Surgery Laser Communications Device* contains a large number of suggestions for tests that students could conduct on their device. If you would prefer them to come up with their own ideas you may want to only provide them with the front page of this resource sheet.
- Obvious improvements that students should suggest would include the use of fibre optic cables for transmitting the laser beam and using a digital signal instead of the analogue signal used in the prototype.
- At the end of the testing process students can present their assessments and recommendations back to the rest of the group.

**Plenary activity: 50 mins approx**

- Students will need to refer back to *Resource Sheet 3.1 – What is Remote Surgery?* in order to appreciate the importance of effective and reliable communications in remote surgical procedures.
- Presentations should be no more than 5 minutes in length and should show clearly how the data collected from testing of the devices supports any conclusion.

## EXTENSION/HOMEWORK

- Students can be asked to consider how they might improve their communications system to make it more reliable and give it a greater range. When estimating the range they should use the maximum permissible time delay as 200 milliseconds.
- Students can be asked to consider what the long term future for remote surgery is. In particular they could be asked to consider whether remote surgery is just a step on the way to fully autonomous robotic surgery. An interesting reference for this work can be found at http://docinthemachine.com/2007/08/08/traumapod/. This article discusses the development by the US military of a fully autonomous *Trauma Pod* for use in battlefield emergencies.
- As an interesting exercise to explore modulation the laser module can be replaced in the circuit with a normal 2.5 volt incandescent light bulb. This creates a 'talking' light bulb which can be received, as in the original exercise, with a solar cell and amplifier. As the light bulb is a much less concentrated energy source the solar cell has to be very close and this experiment needs to be done in a dark room.

## RISK ASSESSMENT

It is the responsibility of the supervising teacher to carry out all risk assessments with regard to this activity and to make sure that any such risk assessment complies with the requirements of the particular institution in which it is being conducted.

## MATERIALS AND EQUIPMENT REQUIRED

### Per student

- *Resource Sheet 3.1 – What is Remote Surgery?*

### Per pair of students

- Soldering iron and stand suitable for soldering small electronic components
- Lead free solder
- Soldering/heat proof mat
- Small side cutting pliers
- Needle nose pliers
- Cable stripper
- Phillips/posidrive and flat bit electricians' screwdrivers
- 1 laser communicator kit (see Technician Notes)
- Electrical tape
- *Resource Sheet 3.2 – Remote Surgery Laser Communications Device*
- *Resource Sheet 3.3 – Testing the Remote Surgery Laser Communications Device*

**Note:** All electronic components used in this activity are readily available. Specific suppliers and part numbers are given in the Technician Notes at the end of this lesson plan.

## PRIOR KNOWLEDGE REQUIRED

Students should be aware that laser beams can be used for communication and are particularly effective in this context when used in conjunction with fibre optic cables. It will be useful for students to also be familiar with the concept of modulation and the operation of capacitors.

## Tools

The construction of each device will require the following tools:

- Small soldering iron
- Side cutting pliers
- Wire stripper
- Needle nose pliers
- Access to a hot glue gun
- Access to a lighter or other heat source suitable for use with the heat shrink sleeving
- Small Phillips screwdriver
- Small slotted head screwdriver
- Two retort stands
- Two bosses and clamp arms

## Sourcing the Parts

All of the parts for the laser communicator are readily available from electronic components suppliers. For convenience, the table below gives part numbers for Maplin Electronics, T2 Online and Middlesex University Teaching Resources (MUTR). It is possible to source the same or equivalent components from other suppliers.

| Component | Supplier | Supplier website | Part No. | Amount required per device |
|---|---|---|---|---|
| Laser module | Maplin Electronics | www.maplin.co.uk | LE07H | 1 (or laser pointer) |
| Laser pointer | Maplin Electronics | www.maplin.co.uk | L99AC | 1 (or laser module) |
| Bi-colour LED | Maplin Electronics | www.maplin.co.uk | QY83E | 2 |
| LT 700 Audio transformer | Maplin Electronics | www.maplin.co.uk | LB14Q | 1 |
| 3 x AA battery pack | Maplin Electronics | www.maplin.co.uk | YR61R | 1 |
| PP3 battery clip | Maplin Electronics | www.maplin.co.uk | HF28F | 1 |
| Project box (118 x 98 x 45 mm) | Maplin Electronics | www.maplin.co.uk | LH22Y | 2 |
| Amplifier/speaker | T2 Online | www.t2retail.co.uk | 2771008 | 2 |
| Multimedia type microphone with 3.5 mm jack plug connection | Maplin electronics | www.maplin.co.uk | HW71N | 1 |
| Headphones with 3.5 mm jack plug (these are optional) | Maplin Electronics | www.maplin.co.uk | A38AH | 1 |
| Switch | Maplin Electronics | www.maplin.co.uk | FH97F | 1 |
| Stripboard | Maplin Electronics | www.maplin.co.uk | FL17T (213 x 38 mm section - enough for approximately 7 devices) | 1 off 4cm x 3cm section |
| 3.5 mm jack plugs | Maplin Electronics | www.maplin.co.uk | HF80 | 2 |
| Speaker cable | Maplin Electronics | www.maplin.co.uk | XS47B | 1.5 to 2.0 metres |
| 7/0.2 Equipment wire | Maplin Electronics | www.maplin.co.uk | BL00A | 0.50 metres |
| Lead free solder | Maplin Electronics | www.maplin.co.uk | N34BJ | 1 unit |
| 2.5mm heat shrink sleeving | Maplin Electronics | www.maplin.co.uk | BF87U (1 metre lengths) PB22Y (5 metre lengths) | 15 cm |
| 4.5V 100mA solar cell | MUTR | www.mutr.co.uk | EL1 006 | 1 |

## Testing the Device

Once constructed, students will need to test their devices. The exact methods employed in this testing will be down to the students to decide. *Resource Sheet 3.3 – Testing the Remote Surgery Laser Communications Device* provides some ideas.

It will therefore be useful to have the following equipment to hand:

- Garden water mist sprayers (plus mop and bucket)
- A smoke machine (if your drama department has one they will lend you)
- Croc clip patch leads
- Long tape measures (up to 10 m ideal)
- Metre rules