

Subject: **Physics**

Topic: **Light waves**

Application: **Remote sensing in dangerous environments**



## Using the worksheet and podcast resources

This worksheet is based on the [Inventive podcast](#).

It supports Gatsby Benchmark 4: Careers in the curriculum by introducing a career and role model. The worksheets are based on topics in the KS3 curriculum.

The short audio clips can be used to provide context to the worksheet and could be played during a lesson.

A QR code on the student sheet links directly to the podcast.

## KS3 National Curriculum statements

### Physics

- speed of light;
- the transmission of light through materials: absorption, diffuse scattering and specular reflection at a surface;
- use of ray model to explain imaging in mirrors.

## Audio clips from Inventive podcast.

- **Jack Clip 1:** Jack's work and route into his current job
- **Jack Clip 2:** How robots are used in extreme environments
- **Jack Clip 3:** What Jack thinks about working in teams with different people.

## Finding out more about the robots

[Mirrax](#)

[Carma](#)

## Other resources

[Jack's career poster](#)

[More information about Jack](#)

## Meet the engineer



**Jack Haworth**

**Electrical engineer**

Jack Haworth is an electrical engineer working at Sellafield, a site that stores and processes nuclear materials. Jack works on small robots that monitor the condition of nuclear waste. He uses two robots, CARMA and MIRRAX, to produce images from places that are too dangerous for humans to approach.

## Scan the QR code



to access all the resources and the full podcast from:  
[nustem.uk/inventive/#jack](http://nustem.uk/inventive/#jack)

## Know

1a. Ray is absorbed, reflected or changes direction.

1b.

- i) opaque e.g. brick, book;
- ii) transparent e.g. water or glass;
- iii) translucent e.g. frosted glass, tracing paper.

2a. The angle of incidence should be shown as the angle between the incident ray and the normal. The angle of reflection as the angle between the reflected ray and the normal.

2b. 30°

2c. 45°

2d. It scatters in different directions.

## Apply

3. MIRRAX uses a laser to send out pulses of *light*, and a sensor to detect reflected *light*.

The time taken to detect the return signal depends on the *speed* of light and the *distance* that the light has travelled. Light scattering from a surface close to MIRRAX is detected before light scattering from a surface further away.

4. The second container is twice as far away as the first. The time is proportional to distance, so if the time doubles, that means that the distance was doubled.

## Extend

5. Many correct answers - some suggestions to start students off:

Possible uses:

Inaccessible or dangerous places e.g. underwater, in space, underground, mine-fields

Extending the skill of human operator: medical uses (remote or augmented surgery)

Used for repetitive but skilled work: car manufacturing

Advantages: easier to replace robots; smaller and lighter than humans; can be programmed to do certain jobs; collect lots of data

Disadvantages: may only be useful for a single job (especially in manufacturing), need to be programmed, expensive to design and build, human operation still required in some cases.

These links include more information and short videos about Carma and Mirrax

<https://uomrobotics.com/robots/carma-2.html>

<https://uomrobotics.com/robots/mirrax.html>

## Light and Remote sensing

Light travels in lines called rays. Smooth surfaces reflect light in one direction, and rough surfaces scatter light in different directions. Light passes through transparent materials and is absorbed by opaque materials. Translucent materials transmit some light and absorb the rest.

Ray diagrams show the path of rays and can be used to show how images form.

Lasers produce intense light rays of a single colour. If a light ray reflects from a mirror, the angle of incidence equals the angle of reflection.

Remote sensing is when we inspect and collect information from places that we can't reach or go into.

Jack Haworth uses laser light to explore buildings that are not safe for people to go into.

The MIRRAX robot is a remote inspection robot that uses lasers to scan nuclear storage bunkers.

## Meet the engineer



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## Link to Jack's story



## Know

**1a.** State three things that could happen when rays travel through different materials.

**1b.** Give an example of an object that is:

- i) opaque
- ii) transparent
- iii) translucent

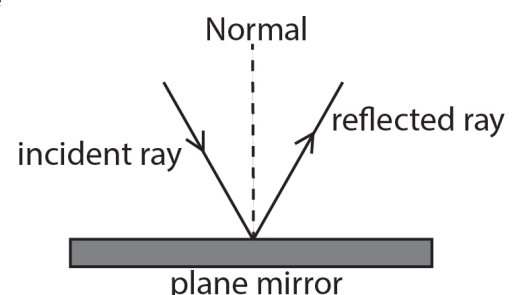
**2.** A student shines a ray of light at a mirror and draws the ray diagram shown.

**2a.** Label the diagram to show the angle of incidence and the angle of reflection.

**2b.** The angle of incidence is  $30^\circ$ . State the angle of reflection.

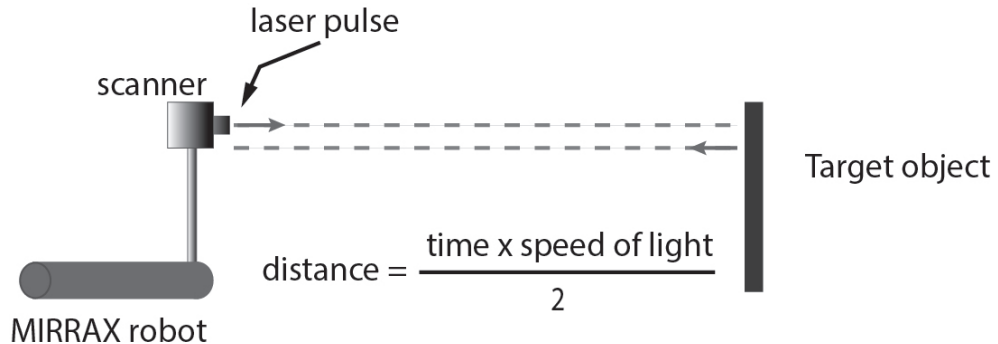
**2c.** The student increases the angle of incidence to  $45^\circ$ . Write down the new angle of reflection.

**2d.** The mirror is smooth and reflects light in one direction. What happens to light reflecting off a rough surface?



## Apply

3. The diagram shows how the MIRRAX robot uses lasers to scan the walls of nuclear storage bunkers.



Use the diagram to help you complete the following sentences.

MIRRAX uses a laser to send out pulses of \_\_\_\_\_. It has a sensor which detects \_\_\_\_\_ reflected from the target object. The time to detect the return signal depends on \_\_\_\_\_ of light and \_\_\_\_\_ the light has travelled. Light scattering from a surface close to Mirrax is detected before light scattering from a surface further away.

4. MIRRAX is scanning two storage containers in a bunker.

The signal from the first container takes 2 milliseconds to be received.

The signal from the second container takes 4 milliseconds to be received.

How much further away from MIRRAX is the second container compared to the first one?

Explain your answer using information from the diagram in Q3.

## Extend

5 Jack uses robots to go into places that are too dangerous for humans to go.

This is one advantage of using robots.

Research two other uses of robots.

Describe what the robots are used for, and suggest advantages and disadvantages of robots for each use.