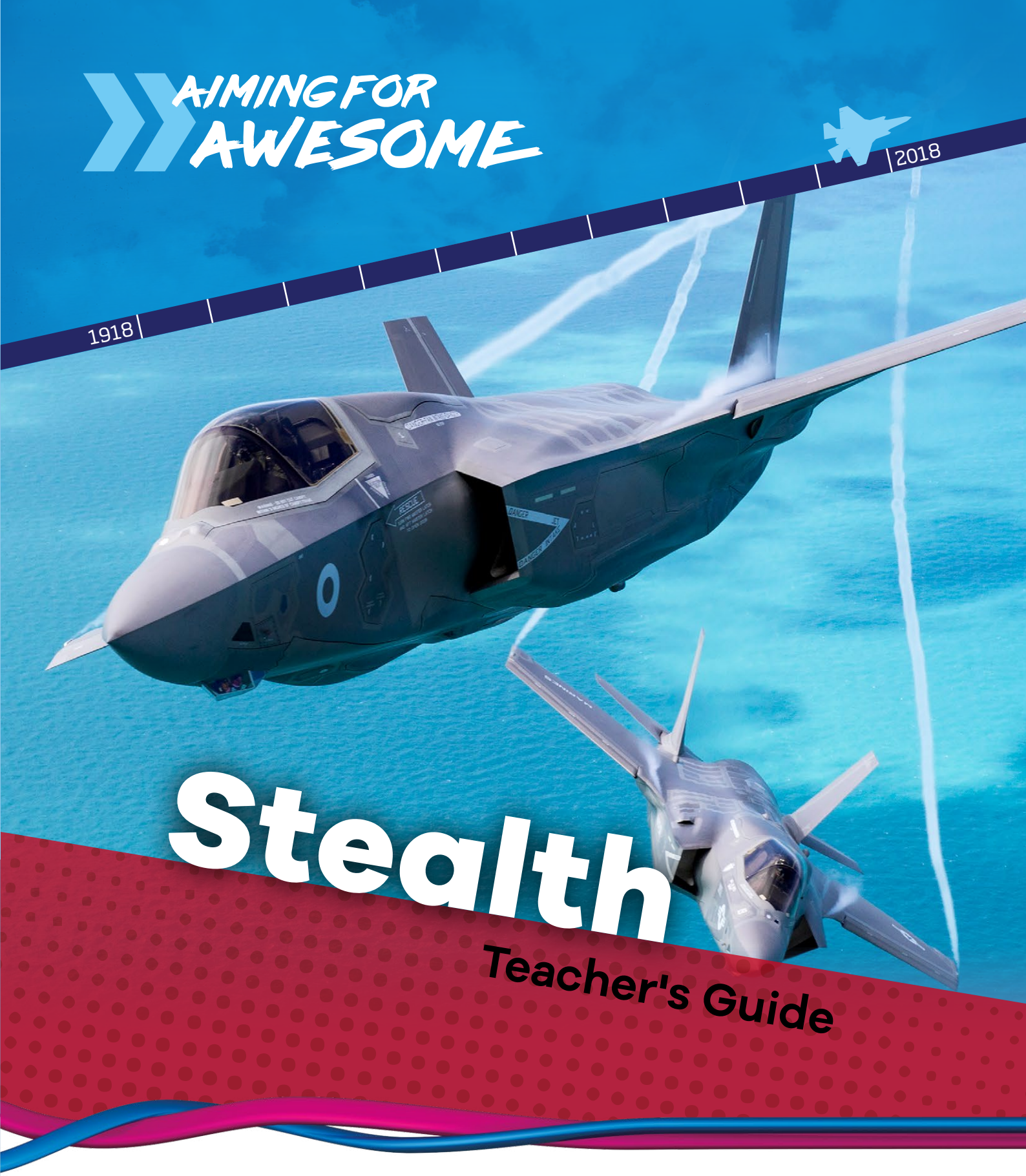
AIMING FOR AWESOME

1918 2018



# Stealth

## Teacher's Guide

ROYAL ACADEMY OF ENGINEERING

RAF 100

The aim of this resource is to give students the opportunity to investigate the impact of science, technology, engineering and mathematics (STEM) on making stealth vehicles.


# Curriculum links

## England

| Activity | Key Stage | Subject | National Curriculum |
|---|---|---|---|
| **Time to investigate one** | KS2 | *Science* | **Light:** use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into the eye. |
| **Time to investigate two** | KS2 | *Science* | **Light:** use the idea that light travels in straight lines to explain why shadows have the same shape as the objects that cast them. |
| **Time to think** | KS2 | *Science* | **Light:** use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into the eye. |
| **Time to investigate one** | KS3 | *Science* | **Light waves:** colours and the different frequencies of light, white light and prisms. |
| **Time to investigate two** | KS3 | *Science* | **Experimental skills and investigations.** |
| **Time to think** | KS3 | *Science* | **Light waves:** the transmission of light through materials: absorption, diffuse scattering and specular reflection at a surface. |

## Scotland

| Activity | Subject | Topic | Experiences and outcomes |
|---|---|---|---|
| **Time to investigate one** | *Sciences* | Vibration and waves | SCN 2-11b |
| **Time to investigate two** | *Sciences* | Vibration and waves | SCN 2-11b |
| **Time to think** | *Sciences* | Vibration and waves | SCN 2-11b |

## Wales

| Activity | Key Stage | Subject | National Curriculum |
|---|---|---|---|
| **Time to investigate one** | KS2 | *Science* | **How things work:** how light travels and how it can be used. |
| **Time to investigate two** | KS2 | *Science* | **How things work:** how light travels and how it can be used.<br>**Skills:** communication.<br>**Skills:** enquiry. |
| **Time to think** | KS2 | *Science* | **How things work:** how light travels and how it can be used. |
| **Time to investigate two** | KS3 | *Science* | **Skills:** communication.<br>**Skills:** enquiry. |

## Northern Ireland

| Activity | Key Stage | Subject | National Curriculum |
|---|---|---|---|
| **Time to investigate one** | KS2 | *The world around us* | **Strand 2:** Movement and energy: the causes and effect of energy, forces and movement. |
| **Time to investigate two** | KS2 | *The world around us* | **Strand 2:** Movement and energy: the causes and effect of energy, forces and movement. |
| **Time to think** | KS2 | *The world around us* | **Strand 2:** Movement and energy: the causes and effect of energy, forces and movement. |

## Preparation

- Ensure all materials and equipment needed are available well in advance of the session. See the resource list below for essential materials and components.
- A full risk assessment should be conducted prior to the session.
- This session is expected to last 60 minutes.
- Ensure technology is available to project the relevant video materials.

This resource has been linked to the Engineering Habits of Mind (EHoM). For more information about the EHoM please see the information sheet provided or www.raeng.org.uk/ltbae.


## Resource list

**For this activity, you will need the following per student:**

- Coloured filters
- Torch
- Aircraft cut outs
- Squared or graph paper



# Lightning

**Stealth is the ability to evade detection by radar, infrared sensors or emission interception.**

Stealth provides greater survivability, and makes it easier for aircraft to operate in contested areas without being detected.

The Lightning aircraft was designed to be hard to detect.

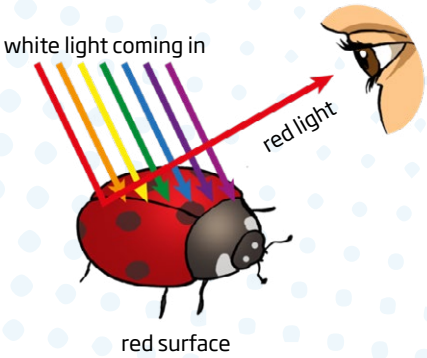
Engineers used a combination of the aircraft's shape and stealthy, radar-absorbent materials to make it a very-low-observable aircraft.

The Lightning is a single-seat, single-engine supersonic jet and has the most advanced computers and networking abilities of any aircraft so far.

The F-35B has short take-off and vertical landing (STOVL) capabilities, meaning it can hover.

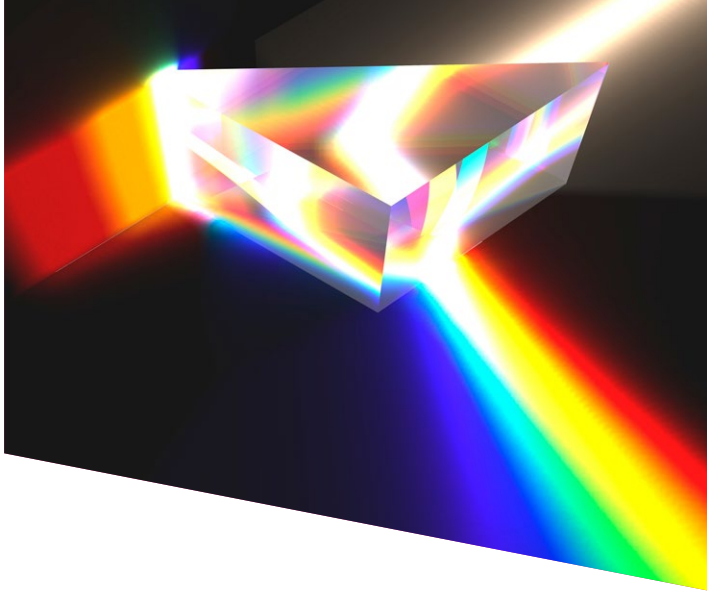
# Camouflage

**Objects reflect different colours of light. The colours that are not reflected are absorbed. This ladybird is red, because it reflects red light.**




Some animals can use this to camouflage themselves. Most chameleons change colour as social signalling or a reaction to external temperatures. However, some chameleons can change their colour to camouflage themselves.

Aircraft can also be coloured to camouflage. For example, until 1941, the top of Royal Air Force (RAF) fighter aircraft were painted in dark green and brown to blend in with the ground, and sky colours underneath to avoid being seen from the ground. However, aircraft were lost and pilots reported that the colours used made their fighters conspicuously darker than the sky.



## TIME TO INVESTIGATE – 1

# How are different colours made?

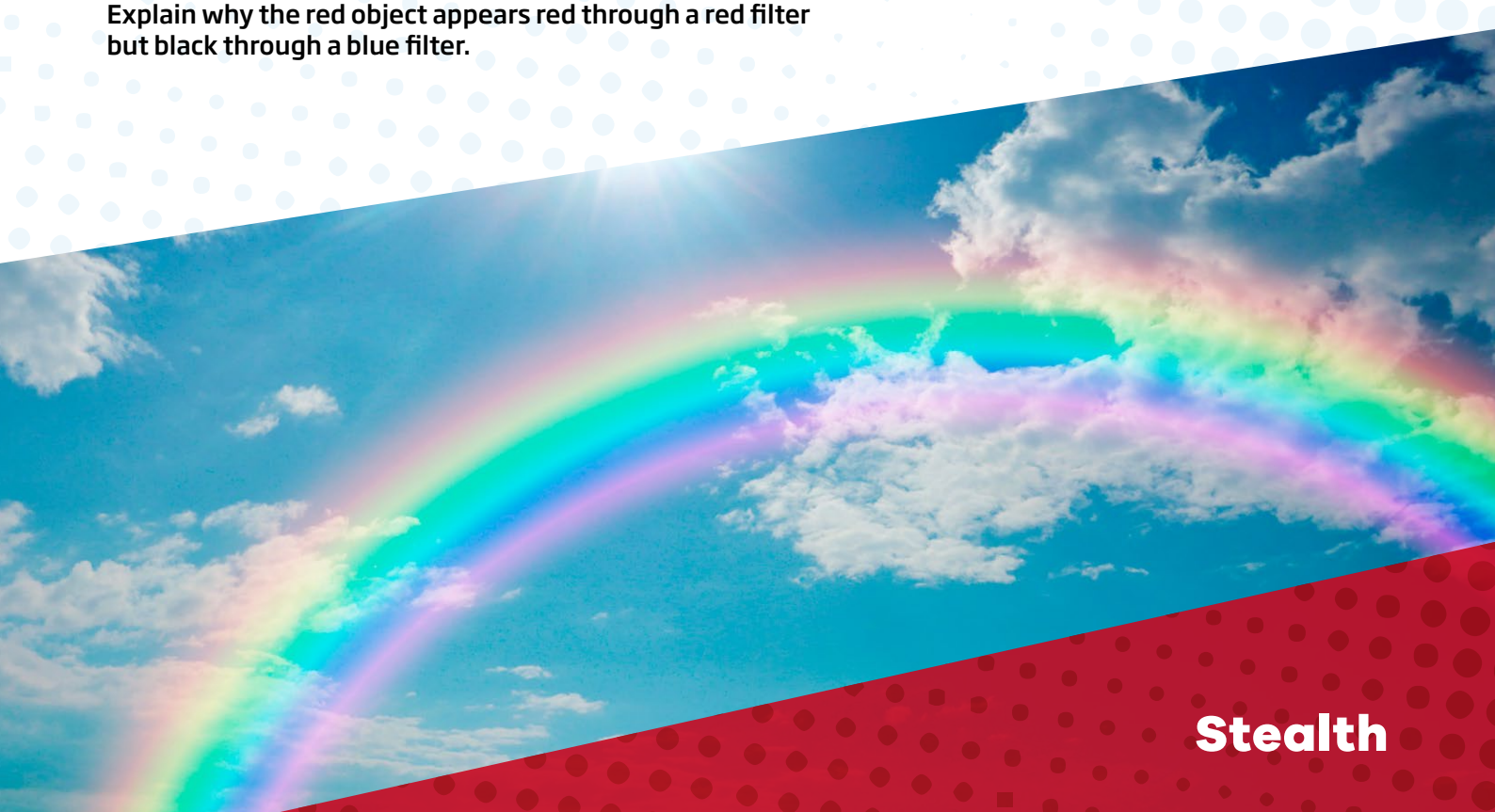
**White light is made up from the colours of the rainbow.**

A coloured filter allows some colours to pass through and absorbs the others. For example, a red filter transmits red light only and absorbs all the others, whereas a blue filter will absorb all colours except blue.

The primary colours of light are red, green and blue. View a red, green and blue coloured object through the different filters.

| Object colour | Filter colour | Observation |
|---|---|---|
| **Red** | Red | |
| | Green | |
| | Blue | |
| **Green** | Red | |
| | Green | |
| | Blue | |
| **Blue** | Red | |
| | Green | |
| | Blue | |

**Explain why the red object appears red through a red filter but black through a blue filter.**




## STRETCH AND CHALLENGE

**Use the filters to work out how to make the secondary colours of light.**

| Object colour | Filter colour | Observation |
|---|---|---|
| **Yellow** | Red | |
| | Green | |
| | Blue | |
| **Cyan** | Red | |
| | Green | |
| | Blue | |
| **Magenta** | Red | |
| | Green | |
| | Blue | |

**Yellow is made of red and green light.**

**Cyan is made of green and blue light.**

**Magenta is made of red and blue light.**

### Guidance provided to STEM activity leader

Before the students conduct this activity, you could demonstrate dispersion, or splitting white light into the constituent colours.

Use a ray box to shine a single beam of white light into a triangular prism. The prism will split the light into the spectrum of colours. The prism does this because the different colours of light have different wavelengths, which means they are refracted by different amounts. This is how a rainbow is made. Droplets of rain act as a prism and refract the light from the Sun.



# Radar detection

**Radar can also be used to detect aircraft.**

A bistatic radar system has a transmitter and receiver separated by a distance, whereas a monostatic radar has the transmitter and receiver in the same place.

There are many different methods to detect aircraft using bistatic radar, one of which is forward scatter radar. The forward scatter radar technique uses bistatic radars to emit a radar that hits the object and is blocked from the receiver, much like how a shadow is formed. Forward scatter radar is useful because it is not effected by stealth coatings.

## TIME TO INVESTIGATE – 2

**The size and shape of an aircraft is also important to consider to avoid it being detected.**

Shine a torch on the cut-outs of the RAF aircraft through the ages. What do you notice about the area of the shadows?

Write a method to investigate how the shadow changes for each of the cut-outs.

To make sure the experiment is reproducible you need to control all the variables, except the independent and dependant variable. The independent variable is what you change each time, in this case the aircraft shape, and the dependent variable is what you measure, in this case the area of the shadow.

What variables are you keeping the same each time?

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Use the table below to record your results.

| Aircraft | Area of shadow cm² |
|---|---|
| | |
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| | |
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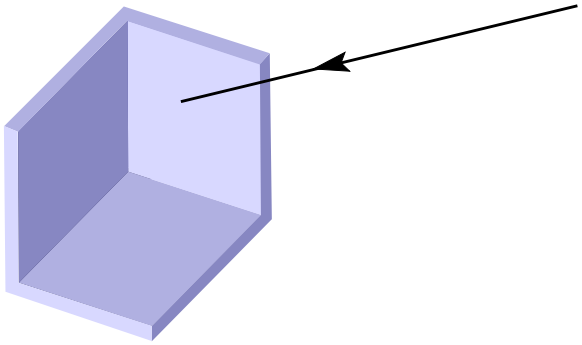
| | |

Which aircraft is the best for avoiding forward scatter radar detection?

The backscatter technique uses the reflection of radar to detect and aircraft.



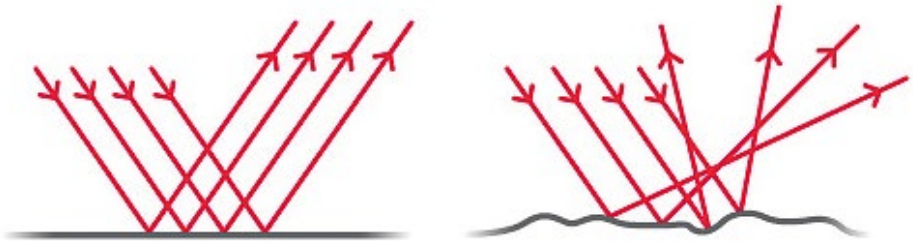
## TIME TO THINK

**What do you think you will see if you look into the corner cube, or retroreflector?**

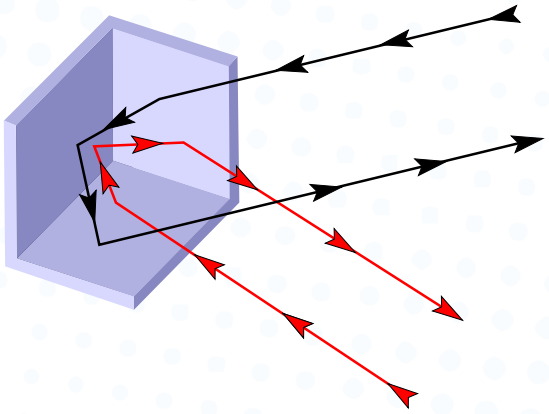
**Do you think it will be different if you look at the vertex from the other side?**

## TIME TO DEMONSTRATE

Explain that light travels in straight lines and is reflected by shiny surfaces. We can see objects because light is reflected off them and into the eye. When light is reflected by a smooth shiny surface, the light is all reflected in one direction and we see a normal image, just like a mirror. When light is reflected by a rough surface, the light is reflected in all directions; this is called diffuse scattering. It explains why you can see a clear image of yourself in a shiny flat mirror, but not in a dull rough wall.



With the retroreflector cube, no matter which angle the light hits the mirror, it is always reflected off each side and directly back to the source.



With the introduction of new detection technologies, aircraft skin is now designed to scatter light and radar to stop aircraft being detected in this way.

# Stealth

ROYAL ACADEMY OF ENGINEERING

## Royal Academy of Engineering

As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering.

## We have four strategic challenges:

### Make the UK the leading nation for engineering innovation

Supporting the development of successful engineering innovation and businesses in the UK in order to create wealth, employment and benefit for the nation.

### Address the engineering skills crisis

Meeting the UK's needs by inspiring a generation of young people from all backgrounds and equipping them with the high quality skills they need for a rewarding career in engineering.

### Position engineering at the heart of society

Improving public awareness and recognition of the crucial role of engineers everywhere.

### Lead the profession

Harnessing the expertise, energy and capacity of the profession to provide strategic direction for engineering and collaborate on solutions to engineering grand challenges.

RAF 100

The RAF 100 Youth & STEM programme has been designed to engage and inspire young people by building their interest in engineering and technical career pathways.

From cyber specialists to aerospace, aviation, electronics and mechanical disciplines, the RAF is committed to using our centenary celebrations to extend opportunity to all and to encourage greater diversity in this critical area of national skills shortages.

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