PUPIL
RESEARCHER
INITIATIVE

Motoroptics

You work for a research department which has been asked to help a motor company to develop fibre optic lighting for car dashboards. You will carry out research into fibre optics and produce a report of your findings. You will use the report to help you plan a presentation to the motor company explaining how your research could help them develop their car designs.

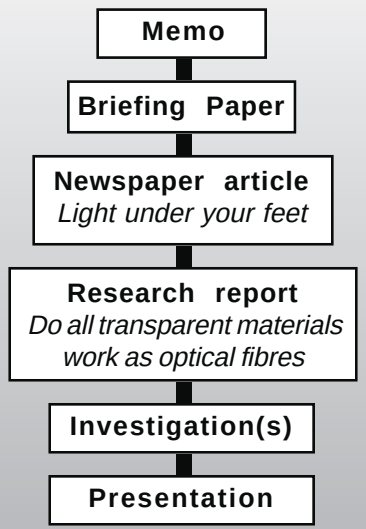
Pupil Research Brief

Study Guide

Syllabus Targets *Science you will learn about in this Brief*

- ❑ light can be sent down optical fibres
- ❑ this light can be used for seeing, or to carry messages in the form of pulses of light
- ❑ when light travels down an optical fibre, all the light may stay inside the fibre until it emerges from the other end
- ❑ this is because light travels down an optical fibre by repeated total internal reflection

Route through the Brief



Outcome Checklist

You will plan a presentation to a motor company about how your fibre optics research could help them develop designs for a car dashboard. The presentation will include a description of your investigations, as well as other information about the use of fibre optic technology in cars. You should make sure you produce the following items as you work through the Brief.

Briefing paper

- ❑ plan and notes for presenation to ADZ Motors
- ❑ ideas and notes for using fibre optic technology for a car interior lighting system
- ❑ advantages and disadvantages of using fibre optic technology in cars - for the manufacturer and for the motorist

Newspaper Article

- ❑ notes on fibre optics

Research Report 22B

- ❑ notes on current research carried out by the department into fibre optic materials

Memorandum

Department of Applied Physics

From: Professor Mundella

To: Senior Investigators, Optics Research Group

Subject: Collaboration with ADZ Motors

Date:

At a recent trade conference I had a meeting with Sarita Nessim, Technical Manager for ADZ Motors, a company specialising in making cars and vans at the cheaper end of the market. They want to develop a new, robust, reliable 4-wheel drive vehicle for both off-road and general road use. It will not be as sophisticated as existing off-road vehicles, and it will need to be much cheaper to be attractive to a different sector of the market than the usual 4-wheel drive car buyers.

The car needs to have the minimum number of components to help to keep the cost down, and so that there is as little as possible that can go wrong. Ms Nessim suggested that we act as lighting consultants, carrying out research to help ADZ develop ideas for a cheap and reliable interior lighting system for the car.

As a result of our meeting, we have been asked to make a short presentation to the ADZ Technical Manager and her team next week, outlining the way we might go about the research.

She asked us to start by looking at the lighting of the dashboard. In existing ADZ cars, this is normally done with several light bulbs, wired in parallel. This is expensive because of the cost of wiring, and bulbs are likely to fail (particularly if the car is driven over rough ground). I suggested fibre optics as an alternative, and explained the benefits to Ms Nessim, who seemed quite keen on the idea. However, this would be a new approach for ADZ, and she suggested that we would need to 'sell' the idea to her team during the presentation.

I am handing this project over to the Optics Research Group. I have attached some useful papers, beginning with a *Briefing pape*r, to help you get started. Let me know how you get on. I would like to see a 'dry run' of the presentation before you go to ADZ.

Department of Applied Physics

Briefing Paper

ADZ Project

These notes are to help you plan the ADZ presentation.

I suggest the presentation has the following parts.

1. Introduction to the Department of Applied Physics (I will do this, so don't spend any time preparing this section).

2. Fibre optics technology

    - What is fibre optics? (I enclose a recent article from the local paper which gives some good examples of where fibre optic technology is used in everyday life. You could use this to provide background information to the ADZ team).

    - How does an optical fibre work? (You will need to explain about total internal reflection - don't go into too much detail - just enough to explain how light travels down the fibre without getting out).

    - Current research carried out by the department into fibre optics. This is the tricky bit. Read Research report 22B - *Do all transparent materials work as optical fibres*? This describes some work carried out to find an alternative to expensive, high purity optical fibres. The results and conclusions in the report are insufficient for use in the presentation. The research team which produced the report some time ago did make several recommendations for further work. I suggest that you follow up some of their ideas. Use the findings from your own investigations in the presentation. This will show ADZ the kind of work we are doing, and how it is relevant to their needs.

3. Ideas for using fibre optic technology in cars. We will need to offer them some suggestions about where fibre optics can be used. Remember ADZ are looking for a cheap and reliable design for their car's interior lighting system. Use simple diagrams, each with a brief description, for this section.

4. Advantages and disadvantages of using fibre optic technology in cars - both for the manufacturer and the motorist.

Light under your feet

What's going on down your street? Many Exton streets have been receiving the attentions of digging crews from the cable TV company OptiCo. Our reporter ***Tina Kelly*** *investigated.*

Cables not wires

OptiCo's Kay Bell took me to see the work being done to bring cable TV to the homes of Exton. Thick black wires were being laid in a channel dug along the pavement. Were these the cables which will bring TV programmes to our homes? Kay explained:

"In fact, these cables are not wires. They contain optical fibres, which are glass fibres capable of carrying dozens of TV channels at the same time. They have light rather than electricity travelling along them.

"The great advantage is that the householder doesn't experience the same problems you get with reception using an aerial, and they can receive many more channels."

So, the TV pictures are being beamed along these glass fibres?

"Not exactly," explained Kay. "The cables carry a light signal with the TV programmes in digital code. The light flashes on and off at high speed, a bit like a modern version of Morse Code. Then the decoder box changes the flashing light signal into the usual electrical signal which your TV set needs to make it work."

Travelling light

So now you know. Under your feet as you walk the streets of Exton, television programmes are travelling along at the speed of light. To find out more about optical fibres, I went to see Professor Harriet Matthews at Exton University."There's nothing very new about optical fibres. BT sends most of our long-distance telephone calls along 'light pipes' these days. They are the same fibres used by surgeons to look inside the human body when they use an endoscope."

So how does an optical fibre work?

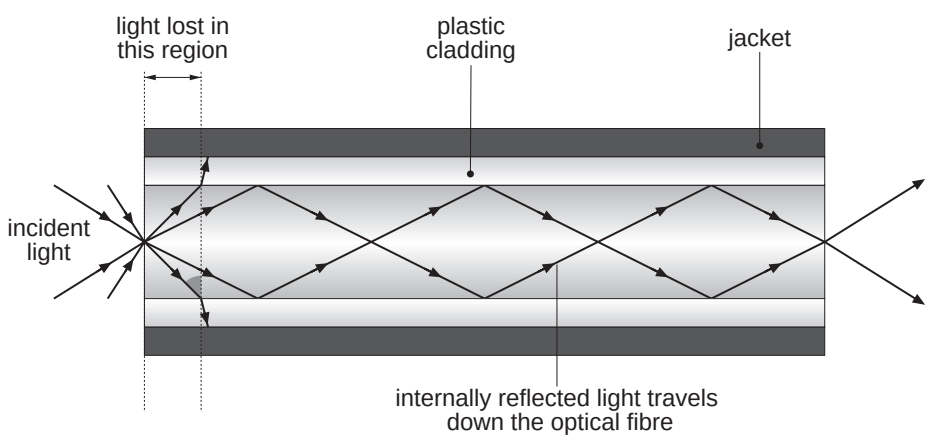
"It's a clever idea, but very simple. You shine light in at one end of a long glass thread, and it comes out at the other. It follows the curves of the fibre, bouncing along inside. Provided there aren't any sharp bends, all of the light which you put in at one end comes out at the other.

"The important thing is that the glass must be very pure, because the light may have to travel a hundred kilometres or more. If the glass wasn't perfectly clear, the light would never make it to the other end."

The future?

So how does Professor Matthews see this field developing?

"Optical fibres work by something called total internal reflection. The same principle is used in binoculars, and even in the reflectors on the back of a bicycle. It's an excellent way of getting light from one place to another. We're always on the lookout for new ways of using total internal reflection."



Research Report 22B

Department of Applied Physics

Do all transparent materials work as optical fibres?

Aim

To find out which transparent materials can transmit light by total internal reflection and would be suitable as inexpensive alternatives to higher purity optical fibre glass, for use in car internal lighting systems.

Background

Light can travel along a fibre optic cable by reflecting off the inner surfaces. To transmit light over long distances the cable must be made of expensive, pure glass. To send light over a distance of a metre or so it should not be necessary to use such expensive materials.

We decided to investigate some everyday materials to find a cheaper alternative.

Materials used

- lengths of Perspex rod and tube
- polycarbonate strip (similar to the material used in lemonade bottles)
- PVC tubing
- polythene rod
- soda glass rod
- borosilicate glass (Pyrex)
- nylon cord (similar to the material used in garden strimmers)

Method

Our first trial was to see if we could get some light out of the end of the samples. We set up the equipment as shown below. We put one end of each sample in turn right up to the lamp, and bent them so that we could see if any light was coming from the end. If in doubt, we pointed the end of the sample at a piece of white paper.

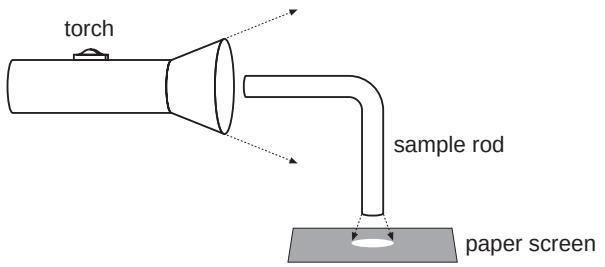


Fig. 1 Method for testing materials to see if they will transmit light

Results

All materials were transparent (clear).

Material	Light out of end?
Perspex	yes
polycarbonate	yes (pink colour)
PVC	no
polythene	no
soda glass	yes
borosilicate glass	yes
nylon	no

Research Report 22B

continued

Conclusions

Not all materials tested seemed to behave like fibre optic cable. Perhaps this was because they were impure, or something else was stopping the light getting through. Polycarbonate changed the colour of the light.

Further work

We feel that there were several ways in which these preliminary tests could be improved.

1. We did not use the same shape or thickness for all materials, so this was not a fair test.

2. We did not measure the brightness of the light coming from the samples.

3. Optical fibres usually have a material covering the outside. We did not try this.

4. Does the angle at which the cable is bent affect the brightness of the light?

5. Does the distance light travels down the cable make any difference to its brightness?

We feel that these factors should be investigated, with a view to selecting the most appropriate material for use in car lighting systems.

You could try passing light through several thicknesses of the same material and measure the amount of light transmitted. Then compare it to other materials - this should give you information about which material is best at transmitting light. This method means you do not have to produce 'optical fibres' from material like polycarbonate (the material used to make many soft drink bottles) - flat strips which could be laid on top of each other would do, for the purposes of this test.

When you have tested fibres with and without covering, try an uncovered fibre, but where the outer surface has been abraded with a file.

We did not try the use of hollow, flexible tubing filled with liquid or gel - you could have a go at this.