PUPIL
RESEARCHER
INITIATIVE

Motoroptics

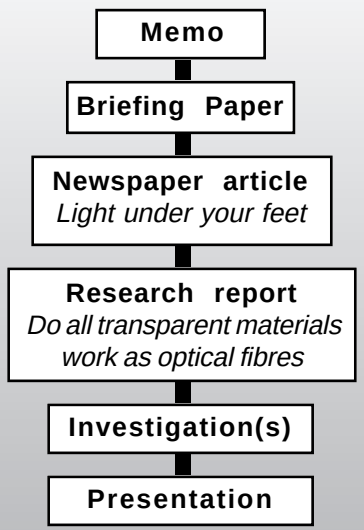
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject knowledge and understanding*

- ❑ 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



Introduction

In this Brief pupils take on the roles of researchers in a university department of Applied Physics. The department has been asked to investigate the possibility of using a cheap fibre optic system for lighting the dashboard of a low-cost car. The researchers have to carry out tests on a range of materials, following on from work which had taken place in the department earlier. They then plan a presentation to the car company, outlining their recommendations.

Experimental and investigative skills

- planning experimental procedures
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Before attempting this Brief pupils should have carried out work on refraction of light through glass or perspex blocks and be familiar with total internal reflection in semi-circular blocks.

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Running the Brief

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are :

Initial briefing	-	whole class; teacher briefly sets the context for the Brief and the tasks to be undertaken
Memo and briefing paper	-	individuals, pairs or small groups
Research report newspaper article	-	individuals, pairs or small groups
Investigation	-	pairs or small groups depending on how teacher allocates investigation tasks and the availability of equipment
Analysis of results	-	pairs or groups; individuals if work is to be assessed
Communication	-	compilation of reports (individual or groups) and presentation by groups to whole class for selection for 'dry run' presentation.

Timing

This Brief should take 3 to 4 hours of classroom time. The writing of the report could be set as a homework. It could take longer, if the 'dry run' of the presentation of the findings of the team to ADZ Cars' Technical Manager is carried out. The presenters would need to be chosen, visual aids prepared, as well as possible demonstrations, and the script for the presentation would need to be written and agreed upon by the whole class.

Activities

The teacher should issue the pupils with the **Study Guide** which provides them with a summary of what they should produce as they work through the Brief. It can also act as a checklist for pupils to monitor their own progress. The leader of the Optical Research team (the teacher) hands out copies of the **memo** and the **briefing paper**. The memo outlines the task to be undertaken : to investigate the possibility of using fibre optics to light up the dashboard of a new, low-cost car. The briefing paper gives guidance on making the presentation to the Technical Manager of the car company.

The first section of the presentation is an introduction to the use of optical fibres in everyday life, and this is followed by a second section providing a short explanation of how an optical fibre transmits light. A newspaper article, **"Light under your feet"** is included to help with this and provides background information on the uses of optical fibres and how they work.

The team leader may wish to get the team members to write their own versions of these two sections at this point - either individually, or as a joint effort between the members of each working group.

The team leader should now hand out copies of **Research report 22B.** This is a summary of previous research work on optical fibres carried out in the department. Team members need to read through this paper carefully, paying particular attention to the recommendations made at the end. Each working group should be allocated their task(s) by the team leader (the teacher). The tasks are:

1 to produce 'optical fibres' of the same thickness
2 to work out a way to measure (or compare) the amount of light emerging from the end of the fibre
3 to investigate the effect of covering the fibres, on their ability to transmit light
4 to investigate changing the angle at which the fibres are bent
5 to investigate the effect of varying the length of the fibre

Tasks 1 and 2 need to be carried out before 3, 4 and 5. Tasks 1 and 2 represent 'preliminary work'. Pupils will need to produce 'standardised samples' for the later investigations, and devise an appropriate method to obtain measurements or observations. Task 1 is to produce 'optical fibres' of the same thickness for testing later (tasks 3, 4 and 5). As a follow-up to this pupils can also produce data about the performance of each of the different materials they test during task 1, but they will need to do this after task 2, which involves them in working out how to measure the amount of light coming out of the end of the test fibres. This could be done using a light sensor, although pupils may devise a more subjective scale based on visual observation. The teacher may get all pupils to do tasks 1 and 2, and then just one of the remaining three investigations, depending on the time available.

Once the investigations have been carried out there needs to be a plenary session where the findings of each group are reported to the whole class. Notes need to be taken so that each pupil can write a full report on the activities together with a section

Teachers' Notes continued

making recommendations and pointing out the drawbacks of using optical fibres for the purpose. The 'dry run' requires pupils to be selected to make the presentation, but the whole class can be involved in selecting and making the visual aids, and in writing the script.

Investigation details

The test fibres need to be the same thickness, and this is likely to be governed by the thickness of the various materials, especially the glass available. Bundles of thin fibres could be used to make the thickness instead of using 1 thick piece. Pupils are required to examine the effect of length on the brightness of the transmitted light. Pre-cut lengths of glass should be made available for this investigation. Pupils can cut the other materials themselves.

Similarly, for the experiment to show what effect, if any, angle of bend has on brightness, some glass rods already bent should be made available, unless the teacher feels that the pupils can do this safely themselves. An effective teacher demonstration of the ability of light to travel along an angled glass fibre is to use a slide projector with a rubber bung in place of the focussing lens. The bung should have a hole bored through the middle and a glass rod carefully inserted. It is easily seen that light from the projector bulb is emitted from the far end of the glass rod by carrying out the demonstration in a darkened room. If the glass rod is bent through 90°, or a second pre-prepared bung is used, it can also be seen that light will emerge from the end.

Perspex and polycarbonate could be bent by pupils with gentle heating, but here there is the danger of the materials melting and catching fire. A light bulb of no more than 60 W is recommended for use in these experiments.

Pupils are also expected to investigate the effect of covering the fibres. The teacher may wish to offer pupils a limited range of materials for coverings.

Pupils should be reminded that placing polymers close to a hot light bulb for a prolonged period will cause them to soften and melt.

The activities of course will work best in a darkened laboratory.

Using IT. Light sensors may be used to measure the amount of light emitted by the various 'optical fibres'.

Technical details

Equipment needed will include :

- bench lamps (60 W max.) and power packs
- samples of each material (perspex, polycarbonate, PVC, polythene, soda glass, borosilicate glass and nylon)
- protractors
- metre rules
- light intensity meter or other means of measuring brightness, eg light sensor, interface box and computer
- instruments for cutting materials

Note : A simple light meter can be constructed using a circuit consisting of an LDR and a carbon resistor in series, connected to a 1.5 V cell. A voltmeter is connected across the resistor. The voltmeter reading provides a measure of light intensity.

Changing the value of the carbon resistor will alter the sensitivity of the device.

Safety issues

PLEASE NOTE: It is important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Cutting and abrading glass / plastics / perspex
Danger of cuts
Dust - irritant. Breathing affected; more serious for asthmatics.

If cut: cover cut and press firmly if no material in wound. Do not press if glass or other material in wound. Seek medical attention -- urgently if wound bleeding copiously.

If inhaled: Remove calmly to fresh air. Allow asthmatics to take medication. Seek medical attention.

Cutting and abrading by hand tools only under supervision.
Wear eye protection.
Keep area well ventilated; clear up broken materials and dust.

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Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales, Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

It is likely that the maximum marks pupils can achieve in all four Skill Areas will be in the low-to-middle range.

Scottish syllabus coverage

Standard Grade Physics - *Telecommunications*.

Further pupil research opportunities

A cardboard mock-up of a car dashboard could be made and the 'optical fibre' selected as the best could be fitted to illuminate the dials on the dashboard, using say, a 12 volt bulb as the source of light for the fibres. Pupils can readily see the problems involved in using optical fibres for this purpose and consequently be able to write a more complete report.