The MODEL Project
Practical Physics at Work

What's in the file?

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- Student practicals
- Teacher and technician guide
- Worksheets and answers
- DVD ROM
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Introduction
About this resource

Physics is about how things work. It enables the development of new technologies which have profound effects on modern life. The skills and knowledge learned through using physics unlocks the doors to a wide range of jobs and careers.

Practical work engages students. *Practical Physics at Work* contains practical activities suitable for 14-16 year olds studying science in England, Northern Ireland, Scotland and Wales. These are supported by video sequences showing how some people use physics in the jobs they do.

The materials are arranged in topics. Each topic has:

- a number of student practicals, many of which contain more than one activity
- related video sequences, each with work-related on-screen questions.

The topics are given below (the summaries are taken from the opening screens of the DVD). The material is not presented as a teaching scheme. Components may be used individually or as relevant.

Harnessing energy

What will happen as we use up fossil fuels?
Are we facing an energy crisis?
Where will we get our energy from in the future?

Understanding the nature of energy, how it moves from one place to another and how it can be changed from one form to another will help us harness energy more effectively in the future. These practicals and videos help you to discover how energy works.

The practicals will help you to understand energy transfer and transformation and how we use energy in its various forms. The video shows a physicist working at the Centre for Alternative Technology. His job is to help people learn about conserving energy and using energy from the Sun, wind and water in place of fossil fuels.

**Video location:** Centre for Alternative Technology, Machynlleth, North Wales

Making a spectacle

Not everyone has good eyesight. Many of us need spectacles or contact lenses to improve our vision. A lot of science goes into making sure people get the right spectacles to suit their needs.

These practicals and videos will help you to discover the physics behind making good spectacles.

The practicals will help you understand the electromagnetic spectrum and about the kinds of materials that can be used in making spectacles. The video shows people working in an optician’s. They use physics to provide the correct lenses and frames their customers want.

**Video location:** RT Knight Opticians Limited, Bournemouth
Sounds good

Our modern society has more ways of making sounds than ever before. How can we control sound to get good quality when we want it and cut out the sounds we don't want to hear? These practicals and videos will help you to understand how science can improve sound quality.

The practicals will help you to understand the properties of sound. The video shows how the work of a university research scientist helps sound engineers control the quality of sound in a theatre. You too can use physics to get better sound reproduction at home.

**Video location:** Salford Acoustics, Audio and Video, Salford University and Milton Keynes Theatre

Cutting edge materials

What do materials scientists do?

They investigate the properties of materials. Sometimes they try to make a material for a purpose. Sometimes a material is discovered and they explore its potential uses. The properties of all materials must be rigorously assessed.

These practicals and videos will help you to find out more about how science is applied to using and testing new materials.

The practicals will help you to find out about an unusual material - nitinol (a smart metal alloy). You will also learn about making miniature electrical circuits. The video shows researchers working in the University of Liverpool doing world-beating research into advanced materials.

**Video location:** Department of Engineering, University of Liverpool

Bright sparks

We rely on electricity. It is a very versatile form of energy. But who installs electrical systems in our homes and workplaces? How can we be sure they will work correctly and safely once installed? Understanding the physics of electricity helps electricians do their work.

These practicals and videos will help you to find out and understand more about electricity and how we use it.

The practicals will help you to get an understanding of electricity. You will find out how it can be generated and used to power electric motors. The video shows electricians at work refurbishing an office complex in the City of London.

**Video location:** Electrical Contacts Limited working in Lime Street in the City of London

Physical health

Modern hospitals have changed enormously in your lifetime. Thanks to amazing technological advances, we can see what is happening inside the body in more and more detail. Much of this is because of the work of medical physicists.

These practicals and videos will help you to discover how physics can be used to check our health.

The practicals will help you to understand some of the physics used in medical analysis. The video shows medical scientists at work using a variety of sophisticated devices, which use physics’ principles to investigate what is happening inside the body.

**Video location:** King’s College Hospital, Camberwell, London
Using this resource

DVD

A topic is chosen via the Main Menu. There are then options to view the whole video or one of the sequences that make up the whole video. Whichever is chosen, a number of on-screen questions appear and there is always the opportunity to:

- access a printable version of the on-screen questions (Worksheet)
- view another sequence (View a sequence)
- look at a printable version of the notes for teachers and technicians (Teacher and technician guide)
- look at the student activities (Student practicals). A drop down menu allows you to select a practical and obtain a printable version.

One approach to using the video sequences and on-screen questions is to show the questions, hand out printed worksheets and explain to students what they should do. The video sequence could be shown full screen. Students might complete the worksheet individually, in pairs or in small groups and compare their answers.

There are many different approaches. Another is to show the on-screen questions and point out what students should be looking for, show the video sequence full screen and then use the questions as the basis of a whole class discussion. During this discussion the video might be playing on a small screen.

The variations are numerous but, whatever approach is used, it is essential to engage the students and be actively involved in watching the video.

The videos and questions may be used with whole classes, small groups or by individuals. On-screen navigation makes it easy for students to use the resources for themselves or to revisit sections or to catch up on what they may have missed.

File

The file contains photocopiable masters of:

- student practical activities
- notes for teachers and technicians
- worksheets for the on-screen questions, together with answers.

The student practicals

Each topic has a number of student practicals, many of which consist of more than one activity (see Student practicals: a synopsis, below). Some practicals relate directly to the video sequences while others extend student activity into associated areas.

Each student practical is stand alone. However, if you decide to try all practicals within a given topic, it may be a good idea to follow the sequence of student practicals shown in the contents list. The two exceptions are:

- **Making a spectacle** It would be sensible to do Correcting lenses immediately after Seeing the light.
- **Bright sparks** The preferred order might be Fuses fantastic; Electricity and heat; Shaking electricity; Electric shoes; Magnetism and electricity; Make a motor.
Student practicals: a synopsis

Harnessing energy

PV power
- Transforming energy Investigating electrical devices, identifying energy transformations, explaining usefulness of electrical energy and advantages and disadvantages of PVs.
- Extension: Day to day use of PVs Measuring PV output by charging and discharging a battery, calculating watt-hours, discussing use of PVs.

Solar powered vehicles
- How much power? Series and parallel connections of cells in PVs, calculating wattage for PV panels.
- Boat, car or plane? (non-practical) Explaining differences between power requirements of vehicles.
- Designing and making a solar powered boat Designing, building and testing a solar powered boat: use of practical skills including measuring accurately, recording and manipulating data, building electrical circuits, testing variables while keeping other variables controlled or constant.

Temperature and heat
- Calibration Measuring temperature using thermofilm, calibrating a thermometer.
- Heat energy flow Measuring temperature using different methods, recognition of temperature gradients and transfer of heat energy.
- Hot and cold Recognising direction of heat flow and relationship of hot/cold sensations to body temperature.
- Extension Relating heat energy transfer to temperature change.

Thermal insulation
- Feeling the film Using concepts of hot and cold, identifying heat transfer.
- Temperature Measuring temperature, calibrating thermofilm.
- Insulation Identifying heat transfer, measuring effectiveness and identifying properties of thermal conductors and insulators.
- Extension Observing and identifying transformation of mechanical energy to heat energy.

Solar house heating
- Thermofilm Measuring temperature, calibrating thermofilm.
- Using glass Investigating transfer of heat through glass, describing the physical changes taking place in the greenhouse effect.
- Transferring the heat Observing and describing convection of heat.

Absorbing solar energy
- Calibrating thermofilm Measuring temperature, calibrating thermofilm.
- Investigating heat absorption by metal sheets Investigating heat conductors and insulators, energy transfer and transformation, radiation, conduction, convection, measuring temperature, designing experiments, testing variables while keeping other
variables controlled or constant, checking reliability of results, identifying factors affecting rate of heat transfer.

- **Extension** Measuring heating effect over distance, recognising that available energy decreases with distance, demonstrating and understanding the inverse square law.

**Test a windmill**

- **Useful energy output of the windmill** Estimating energy output by measurement of distance moved and size of a load and calculation of useful mechanical work done in a measured period of time.
- **Wind speed and power** Constructing a device to measure airspeed, measuring airspeed, calculating power of the wind, calculating energy input, identifying sources of error, forming conclusions.
- **Efficiency of the windmill** Calculating efficiency from practical results.

**Make a windmill**

- **Making and testing your windmill** Designing and building a windmill, measuring variables accurately, designing experiments, testing variables while keeping other variables controlled or constant, checking reliability of results, testing performance.
- **What makes a good windmill?** (non-practical) Identifying factors affecting the performance of a machine (windmill).

**Making a spectacle**

**Spring surprise**

- **Smart materials** Identifying energy transformations.
- **Scientific ideas** Investigating action of smart metal alloys, using models to illustrate and explain scientific theories.
- **More evidence** Building electrical circuits, measuring distances, interpreting data, forming conclusions, evaluating evidence.

**Sudden changes**

- **Energy release** Investigating smart metal alloys, measuring temperature.
- **Resistance change** Building an electrical circuit, using voltmeters and ammeters to measure current and voltage, measuring temperature, graphing electrical resistance against temperature.
- **Extension** (non-practical) Relating structure to properties in smart metal alloys.

**Seeing the light**

- **Seeing better** Comparing behaviour of light using converging and diverging lenses, constructing ray diagrams, using callipers or micrometers to measure thicknesses, interpreting data, forming conclusions, understanding treatment of sight defects.
- **Extension** (non-practical) Calculating lens powers from focal lengths.

**Invisible waves**

- **The visible spectrum** Using an equilateral glass prism to obtain a white light spectrum.
- **Beyond the rainbow: Part 1** Using thermofilms to replicate Herschel's experiment to detect infrared radiation.
- **Beyond the rainbow: Part 2** Using light sensitive paper to replicate Ritter's experiment to detect ultraviolet radiation.
Ultra-violent light?

- **Cutting the glare** Investigating polarisation of light by viewing light reflected from metallic and non-metallic surfaces through a polarising filter.
- **Harmful rays** Using dispersed sunlight and light sensitive paper to investigate the filtering effect of sunglasses.

Correcting lenses

- **An artificial eye** Finding focal points of lenses, using a model eye.
- **Imitating short-sight and long-sight** Using a model eye to find lens powers needed to correct sight deficiencies, calculating lens powers, use of Gaussian form (real is positive) in lens formula.

Sounds good

Sound bites

- **Listening in** Using a balloon to intensify sound.
- **Speeding** (non-practical) Calculating times from distances and speeds.
- **The speed of sound** Comparing the speeds of light and sound, using a simple method to find the speed of sound, using and manipulating formulae.
- **The speed of sound using echoes ...** Using a simple method to find the speed of sound, using and manipulating formulae, comparing methods for finding the speed of sound.

Seeing sound

- **Bouncing rice** Using moving particles on a vibrating membrane to observe changes in frequency and amplitude.
- **Using light to see sound** Using a moving spot of light reflected from a vibrating membrane to observe changes in frequency and amplitude.
- **Sound solids** Using a tuning fork to observe transmission of sound through solids.
- **Dancing to the music** Making a loudspeaker.
- **Extension** Investigating factors affecting performance of loudspeakers, designing experiments, testing variables while keeping other variables controlled or constant, checking reliability of results, formulating conclusions.

Tubular sounds

- **Sounding off** Investigating factors affecting performance of musical instruments, designing experiments, testing variables while keeping other variables controlled or constant, checking reliability of results, formulating conclusions.

Sounds better

- **Sound and light** (non-practical) Predicting effects of objects on sound (reflection, absorption, diffusion).
- **Make your room sound like a concert hall** Investigating factors affecting quality of sound broadcast in a room.
- **Testing, testing** Investigating factors affecting quality of sound broadcast in a room.
- **Extension** (non-practical) Investigating factors affecting quality of sound in a concert hall or theatre.

Cutting edge materials

Work on a coil

- **Doing the work** Measuring distances, calculating work done.
• **Releasing the energy** Identifying energy transformations.
• **Extension** Identifying uses of memory metals.

Muscle metal
• **Relax, contract, relax** Building electrical circuits, identifying energy transformations, understanding work.
• **Heat or electricity?** Interpreting data to identify energy transformations.

Muscle wire
• **Muscles making you work** Building electrical circuits, calculating forces and work done, identifying energy transformations.
• **Two models** Comparing and testing theories, interpreting data, forming conclusions.

Muscle wire efficiency
• **How efficient?** Investigating a smart metal alloy, building electrical circuits, using ammeters and voltmeters, calculating efficiency.
• **Extension** Interpreting data.

Circuit training
• **Making a rain alarm** Etching printed circuit boards, interpreting circuit diagrams, building an electrical circuit using printed circuit boards, soldering electrical components.
• **Testing your rain alarm** Designing and using a testing regime for an electrical device, using electrical meters to make measurements.
• **Evaluation of your rain alarm** Using test data to evaluate performance of an electrical device.

High temperatures
• **Making a simple resistance thermometer** Building an electrical circuit.
• **Investigating a Bunsen burner flame** Using a liquid in glass thermometer and an ammeter to measure effect of temperature on resistance of a metal wire.
• **Calibrating the temperature probe** Constructing and using a calibration chart, using a resistance thermometer to measure high temperatures.
• **Extension: Measuring other temperatures** Using a resistance thermometer to measure high temperatures.

Bright sparks

Fuses fantastic
• **Hot wire** Building electrical circuits, using ammeters and voltmeters, recording and graphing voltage against changes in current.
• **Memory metal** Building electrical circuits to investigate the behaviour of smart metal alloys and circuit breaker design, using ammeters and voltmeters, recording voltage against changes in current, calculating power and graphing power against current.
• **Testing an idea** Measuring temperature, finding the temperature when a smart metal alloy reverts to its original shape, designing a simple investigation.
• **Extension** (non-practical) Comparing fuses and circuit breakers.
Electric shoes

- **Magnets maybe?** Using a voltmeter, generating electricity using a coil and magnet, investigating factors affecting generation of electricity, calculating electrical power and work.
- **Piezoelectrics perhaps?** Using a voltmeter, investigating factors affecting output of piezoelectric discs.
- **Charging batteries** Using a voltmeter, understanding circuit diagrams, using rectifiers, understanding piezoelectrics.

Shaking electricity

- **Shake-a-gen** Making a simple electrical generator.

Electricity and heat

- **Hot shadows** Observing and explaining convection currents and heating effect of electrical currents.
- **Hotting up** Using thermofilm to investigate heating in electrical appliances.
- **Blowing a fuse** (non-practical) Calculating fuse ratings.

Make a motor

- **Electric to kinetic** Build a simple electric motor, using voltmeters, ammeters, calculating power, understanding how electric motors work.

Magnetism and electricity

- **Poles apart** Using an electric current to move a wire in a magnetic field, applying the left hand rule.
- **Electromagnetism** Observing magnetic fields using magnetic viewing film and ferrofluid.
- **Extension ideas** (non-practical) Investigating factors affecting electromagnetism, designing and carrying out an investigation using scientific method, checking results for reliability, forming conclusions.

Physical health

Radiography

- **Casting a shadow** Investigating factors affecting image quality in radiography.
- **When soft tissues get older** Investigating factors affecting image quality in radiography applied to age changes in tissues.

Make and use a spectroscope

- **Making a spectroscope** Making spectrosopes, observing spectra, comparing CDs and DVDs.
- **Looking at absorption spectra** Comparing and contrasting absorption spectra.
- **Extension** Comparing emission spectra of different elements.

Colour analysis in medicine

- **How a pulse oximeter works** (non-practical) Describing pulse oximetry.
- **Making a colorimeter** Building an electrical circuit, using a LDR.
- **Testing the colorimeter** Investigating effect of concentration of a solution on output of light dependent resistors.

Activities also involve working safely, following instructions, working efficiently, working with others, using basic laboratory equipment safely and effectively, recording results accurately, using the correct units and meeting deadlines.