IOP Institute of Physics

Using Ultraviolet

Experiment 1

UV light will make tonic water fluoresce bright blue but doesn't affect tap water. Ultraviolet light is invisible to humans but you can see its effects.

How it works

A component of tonic water (quinine) absorbs the ultraviolet light, which is invisible to humans eye, thereby exciting its electrons. This is an unstable state, so the electrons emit energy as photons of light in the blue region of the visible spectrum.

What next?

Look at a passport/drivers' licence/bank note under ultraviolet light. Washing powder contains chemicals that fluoresce when they absorb U-V rays. Dried urine and some make-ups fluoresce too.

Experiment 2

Hold the legs of the UV LED either side of a 3V button battery and shine the light onto the glow-in-the-dark film and on to the UV-sensitive beads. The paper will glow and the beads change colour.

How it works

The UV light causes a chemical in the glow-in-the-dark film to fluoresce. The beads contain a amount of photochromic pigment that responds to UV light.

Experiment 3

Put tonic water into three beakers. Smear suncream on clear plastic lids, and place these over the top of each beaker, face down. Use different factors or thicknesses of UV. Place the UV lamp onto of each lid and compare how far the tonic water fluoresces. Compare with normal face cream.

How it works

Tonic water fluoresces when it absorbs UV. The suncream absorbs UV so the high factor sun cream should reduce the fluorescent effect more than low factor sun creams.

Safety notes: UV radiation can cause damage to the skin and eyes. A hot UV lamp can cause burns.

Visible light: A simple spectroscope

What to do

Make a simple spectroscope using card and a template e.g. from
http://www.thesolarspark.co.uk/teachers/downloads/SpectrometerTemplate.pdf
Put a CD in the spectroscope and point the small slit towards a light source. View the CD through the viewing aperture to see the spectrum from light sources e.g. different bulbs, fluorescent bulbs, burning salts (flame tests)

How it works

The regular fine grooves on the CD act as a diffraction grating splitting the light into a spectrum. Hint - you may need to use an angle of 60^{o} for DVDs = and an angle of 45^{o} for CDs (grooves are spaced differently as different amounts of information are stored on different disks)

Analyse images using Cabrillo Tracker and/or imagej software

Tracker and imagej are two free apps for pcs and macs. Import a picture (e.g. of a spectrum), drag the cursor over the image and the software analyses the frequencies present. More detailed instructions are available online or from me

Visible light: optic fibres

What to do

Connect an LED to one end of the optic fibre and watch the other end as the LED turns on and off. Switch on the optic fibre torch, and see which colours of light travels up which fibre

How it works

Light travels through the optic fibre by total internal reflection so no light escapes through the sides. The signal travels long distances as it is not absorbed well by the glass.

Looking beyond visible light (Herschels experiment)

What to do

Use an open cardboard box; cutting a small section to fit a prism in the top edge. Put the box in strong sunlight; tilt it so the base is in shadow and a spectrum is seen in the shadow region. Mark the position of the spectrum. Place a strip of thermofilm slightly longer than the spectrum across these pencil marks. Look carefully at the red end of the spectrum. Repeat using glow-in-the-dark paper. Look carefully at the violet end of the spectrum.
http://www.ipac.caltech.edu/outreach/Edu/Herschel/backyard.html has images of a setup using thermometers - substitute thermofilm/glow-in-the-dark paper

How it works

The thermofilm should detect infrared just beyond the red light. The paper should glow just beyond the violet end of the spectrum, detecting ultraviolet light.

Simulating x-rays

Demonstrate how a shadow picture is formed using glow-in-the-dark paper, exposed to UV/visible light. The object absorbs the light so its shape is displayed as the shadow region. When an x-ray image is taken, bones absorb x-rays but they penetrate other tissues.

Beyond the visible - Infra-red

Experiment 1 ***short wavelength IR***

Hold the legs of the IR LED either side of a button battery and point it towards your mobile phone camera lens. The IR LED shows up as a bright spot on the photo.

Experiment 2 *short wavelength IR*

Point the remote control towards the camera and press the controls.
The mobile phone camera shows bright pulses coming from the controller (infrared signals)

Experiment 3 *short wavelength IR*

Shine the light from the light source through a prism and turn the prim till you see a spectrum. View the spectrum through the mobile phone camera. Some mobile phone cameras are sensitive to IR light and show IR just beyond the red end of the spectrum

Other infrared detectors *long wavelength IR*

- Infrared thermometer - try measuring the temperature of clouds and the clear sky.
- Thermofilm - pupils can calibrate this as part of their HSW preparation.

Detecting radio waves

What to do

Tune the radio to an MW radio station, Use the wire to short-circuit the battery. You will hear interference (crackling) when the battery is connected.

How it works

The circuit generates a radio signal that the AM radio detects. AM radios receive analogue signals and cannot distinguish between noise (unwanted signals) and the broadcast signal so both signals are amplified.

What next?

Investigate if there is interference from LW/FM/DAB radios, and other electrical equipment

Safety note

Don't keep the wire connected, or it will overheat.

Measuring the speed of light - Microwaves

What to do

Remove the turntable from the microwave oven. Place a plate covered evenly with grated cheese or chocolate buttons in the oven and turn it on. Stop the oven as soon as you can see food melting in spots. Measure the distance between the hotspots

What happens?

Microwaves reflect off the inside walls of the oven and produce standing waves. If the turntable does not rotate the food, hot spots develop at the nodes, melting the food
The distance between hotspots is half a wavelength. The frequency of commercial microwaves is usually 2450 MHz. Multiply the wavelength by the frequency to calculate the speed of light. You should get a value of 3×10^8 m/s

What next?

Investigate standing waves, the wave equation, or uses of the electromagnetic spectrum.

A mobile phone detector

What to do

Ring or text a mobile phone leaving a mobile phone flasher (from Mindsets) nearby. The flasher detects the signal and flashes red just before the phone rings. Repeat the experiment wrapping the detector in a foil, or putting it in water (wrapped in polythene)

How it works

Mobile phones produce microwave signals which the mobile phone flasher detects. It also detects the signal just before the phone rings because the phones communicate while they establish a connection. Water absorbs microwaves so the detector cannot detect. Foil reflects microwaves so these cannot be detected. This does not work with smart phones