THE VIRTUAL PHYSICAL LABORATORY

BACKGROUND

I had the privilege of teaching physics at Hebron School in Ooty in South India between August 2000 and June 2003. I consider it a privilege because I was accepted even though I have no formal teaching qualifications! My training at Imperial College in London was in physics, and my career was as a research scientist at the National Physical Laboratory.

During my brief years as a teacher, I became convinced of the value of interactive simulations as an aid to teaching physics. The 'experiments' can be set up instantly, they work first time, they cannot be 'broken' and they can be duplicated to match the number of pupils without any difficulty! This is particularly easy if you have networked computers connected to a server.

INTRODUCTION

I wrote this package primarily to meet my own needs as a teacher and those of my pupils. It has become somewhat of an obsession, and I have spent thousands of hours over a five year period developing them further! These simulations are not intended to replace practical work in a school laboratory, nor are they meant to displace the use of text books (or teachers!). This software library serves to illustrate and animate most of the topics taught in a modern physics curriculum. Some of the animations and virtual experiments go beyond what is required at school, but are included to stretch the more able pupils.

The Virtual Physical Laboratory has been used successfully in a broad range of curricula in the United Kingdom, Canada, Australia, India, Pakistan and Sri Lanka, and is endorsed by The National Physical Laboratory, The Institute of Physics and Cambridge International Examinations. The Virtual Physical Laboratory software library is the copyright of www.vplab.co.uk. For any enquiries please email vpl.admin@vplab.co.uk.

ACKNOWLEDGMENTS

Firstly I would like to thank my wife Carolyn for her patience with me as I spent so many late nights working on this; many more than I intended! I am also grateful to National Instruments for granting me permission to use their LabVIEW software to write all these simulations (LabVIEW is fantastic, I thoroughly recommend it!).

I am also grateful to my fellow teachers at Hebron School as well as to my pupils for their encouragement. I am also appreciative to Cambridge International Examinations for listing the Virtual Physical Laboratory as one of their recommended resources in their syllabus. This boosted my confidence in further developing this resource.

Finally I would like to thank the Institute of Physics (UK) and the National Physical Laboratory (my present employer) for their interest in promoting my work. Thanks to their comments and suggestions the software progressed from version 4 to version 5.

Thank you. Dr John Nunn 11th February 2006

TOPICS

Any ordering of the simulation titles will be somewhat arbitrary. I have arranged the simulations firstly in alphabetic order of topic, and then in alphabetic order of simulation. Some simulations appear in two different topics. Where this happens, I have not incremented the number the second time a particular simulation is listed.

I have given an indication of the level for which each simulation has been written, however this is merely indicative. Some have been designated as ‘A level’ simulations because of their quantitative complexity, but could equally well be used qualitatively for GCSE instruction. I am also aware that some areas of physics have dropped out from the A level syllabus completely (e.g. reactance and inductance); they are still included here as a means to stretch and stimulate the more able pupils.

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CHARGED PARTICLES

1 Inside a CRO GCSE/A level

This simulation shows the internal workings of a cathode ray oscilloscope, including the cathode, anode, X and Y deflection plates and the time-base.

2 Mass Spectrometer A level

This simulation shows the workings of a mass spectrometer, where the mass of the ions and the magnetic field strength can be varied, thus producing circular paths of different radius.

3 Oscilloscope GCSE/A level

This simulation combines a signal generator and an oscilloscope, with variable gain and time-base so that it can be used to measure the amplitude and frequency of the signal.

4 Velocity Selector A level

This simulation shows how crossed electric and magnetic fields can be used to select a charged particle with a particular velocity and exclude all other velocities.

COMMUNICATIONS

5 Digitising A level

This simulation shows what digitisation is, and how it affects a signal, a colour level, and a sound signal. The number of bits can be varied by the user.

6 Fourier Components A level

This simulation shows how sinusoidal signals with different amplitudes, frequencies and phases can be used to make any arbitrary signal shape.

7 Signal Modulation A level

This simulation shows the difference between amplitude modulation (AM) and frequency modulation (FM). The modulation frequencies can be changed by the user.

8 Sampling Rate A level

This simulation shows the effect that the sampling frequency has upon the reconstructed signal. It also shows how insufficient sampling can lead to aliasing.

DYNAMICS

9 Bullet Speed A level

In this simulation a bullet is fired at a suspended sand box, causing it to swing away. From the maximum angle of swing it is possible to determine the speed of the bullet that struck it. It is a study on conservation of momentum (at the collision) and conservation of energy (during the swing).

10 Loop the Loop A level

In this simulation a variable Loop the Loop ride is being tried out. The shuttle runs down a slope powered only by gravity. Get a wrong combination for height and radius and the trolley falls off the rails killing the occupants!

11 Momentum A level

In this simulation trolleys of variable mass are made to collide with each other. Investigate elastic and inelastic collisions. Predict the final velocities of the trolleys and see if you get them right!

12 Orbits A level

This simulation maps out orbits of satellites in the Earth's gravitational field. The initial conditions may be varied in order to achieve bound orbits or give the satellite sufficient energy so that it can escape! The potential and kinetic energies are calculated at each stage of the trajectory.

13 Roller Coaster A level

This simulation shows how the potential and kinetic energies vary along a Roller Coaster. If insufficient starting kinetic energy is given, the trolley cannot make it to the other side!

14 2D Collisions A level

This simulation shows how momentum is conserved in two dimensional collisions. It will appeal to pool or billiards players!

ELECTRICITY AC

15 AC Generator GCSE/A level

This simulation shows how alternating currents are induced in a rotating coil. The coil parameters can be varied in order to investigate the effect. The phase relationship between the coil orientation and the incuced emf are also shown.

16 AC Power A Level

This simulation shows how the average power coming from AC is equal to the Root Mean Square (RMS), and how the RMS is related to the peak value

17 AC Rectification A Level

This simulation shows how AC currents can be rectified with diodes. Half and full wave rectification are shown, together with the effect of a smoothing capacitor. It also shows how the size of the electrical load affects the amount of ripple in the output.

18 Capacitive Reactance A Level

This simulation shows the reactive behaviour that a capacitor presents to alternating currents at different frequencies. It includes phase relationships, using phasor diagrams, and leads on to the concept of impedance.

19 Inductive reactance A Level

This simulation shows the reactive behaviour that an inductor presents to alternating currents at different frequencies. It includes phase relationships using phasor diagrams, and leads on to the concept of impedance.

20 LCR reactance A Level

This simulation demonstrates the behaviour of a capacitor in series with an inductor (and a resistor). It illustrates how this circuit can be tuned to oscillate at a particular frequency. The phasor diagram shows how the voltages across the capacitor and the inductor can be much larger than the driving voltage!

21 Power Distribution A Level

This simulation illustrates why it is necessary to distribute electrical power at high voltage. Power losses are shown and current limits due to the cable diameter are imposed.

22 Transformer A Level

This simulation illustrates a simple transformer where the number of turns in the primary and secondary may be adjusted independently. Graphs show the input and output AC voltages, and dials monitor (Vin, Iin) and (Vout Iout) showing power is conserved.

ELECTRICITY DC

23 Circuits GCSE/A level

This simulation shows how voltages and currents behave in series and parallel circuits where one of the resistors is variable. It ends by testing the student on series and parallel circuits.

24 Electrolysis Gas GCSE

This simulation shows how water is decomposed into oxygen and hydrogen when an electric current is passed through it.

25 Electrolysis Liquid GCSE

This simulation shows how an electrolyte is decomposed such that ions are deposited on the electrodes. The deposition rate and polarity and the electrolyte concentration may be adjusted.

26 Explaining electricity GCSE

This visualisation program shows Coulombs of charge travelling round a circuit. They receive Joules of energy at the battery and dissipate them in the resistor. They finally return empty back to the battery to be re-filled.

27 I V Characteristics GCSE

This simulation allows the student to investigate the relationship between the current and the voltage for several components: the Ohmic resistor, a metallic resistor, a thermistor and a diode.

28 Potentiometer A level

This program simulates a slide-wire potentiometer which is used to measure the emf of an unloaded battery and also its p.d. when it is loaded with a known resistor. From these measurements the internal resistance of the battery may be calculated.

29 Resistivity GCSE/A level

This simulation illustrates how the resistance of a conductor is affected by length and diameter of the conductor, as well as the number of charge carriers in the material. This leads to the concept of Resistivity.

ELECTROMAGNETISM

rpt AC Generator GCSE/A level

This simulation shows how alternating currents are induced in a rotating coil. The coil parameters can be varied in order to investigate the effect. The phase relationship between the coil orientation and the induced emf are also shown.

30 Bell GCSE

This simulation shows the energising and de-energising of the electromagnet that operates an electric bell. Fast and slow motion are included.

31 Current Balance A level

This simulation explains how a current balance works. In this example it is used to measure the strength of the magnetic field in which the wire moves.

32 DC Motor & Generator A level

This simulation shows how a DC Motor and Generator are essentially the same thing which differs depending on whether current or motion are supplied to it.

33 Hall Probe A level

This simulation aims to show what is going on inside a Hall probe. It illustrates clearly how the electrostatic and magnetic forces balance. The current and the magnetic field strength can be adjusted

34 Moving Coil A level

This simulation shows the internal workings of a moving coil galvanometer. This is the basis of every analogue electrical meter.

rpt Transformer GCSE/A level

This simulation illustrates a simple transformer where the number of turns in the primary and secondary may be adjusted independently. Graphs show the input and output AC voltages, and dials monitor (Vin, Iin) and (Vout Iout) showing power is conserved.

ELECTRONICS

35 Capacitor A Level

This simulation shows the charging and discharging of a capacitor through variable resistors. The size of the capacitor can also be varied. V and I graphs are plotted against time.

36 Light Dependent Resistor GCSE/A level

This simulation illustrates the principle and the use of a light dependent resistor. See how its resistance is affected by light intensity, and then connect it into a real circuit to operate an automatic lighting circuit where the switching threshold can be adjusted by means of a variable resistor

37-46 Logic Gates A Level

This simulation illustrates the principles of logic gates. Learn how the different types operate, and then take a test!

47 Oscillator A Level

This simulates an oscillating circuit using two resistors, a capacitor and a relay. The resistances can be altered in order to vary the 'on' and 'off' times.

48 Operational Amplifiers A Level

This comprehensive simulation shows nine different ways in which operational amplifiers may be used in order to achieve different functions. It starts with the simplest comparator and goes right up to the integrator.

49 Thermistor GCSE/A level

This simulation shows the principle of a thermistor, and also shows how a thermistor may be used in a practical circuit to control the temperature of water.

50-54 Transistor A Level

This programme shows the principle and characteristics of the common npn transistor. It contains 4 sub programs illustrating the input characteristics, the output characteristics, the transfer characteristics, and a simple circuit showing an AC coupled audio amplifier.

ELECTROSTATICS

55 Electrometer GCSE/A level

This simulation shows the workings of an electrometer, and how it can be used to detect the presence of electric charge on a body.

56 Electrostatic Induction GCSE/A level

This simulation shows two different ways of electrostatic charging by induction. The first uses two spheres, the second a single sphere and an earthed wire.

ENERGY

57 Geothermal Energy GCSE/A level

This simulation shows the principle of harnessing geothermal energy by converting water into steam that drives a turbine. Eventually the earth crust cools down and the scheme loses its viability, making it necessary to relocate!

58 Hydroelectricity GCSE/A level

An artificial lake in the hills stores water. You have control over the sluice to adjust the amount of water you flow past the turbine. Manage the plant to try to ensure a relatively constant power output even through the weather is changeable!

59 Nuclear Energy GCSE/A level

You are the new manager of Nuclear Power station! You can choose between water cooled or gas cooled reactors! Adjust the control rods and the pressure valve to the turbines in order to run the plant efficiently. If you allow it to overheat, safety procedures are imposed and you are fired!

60 Solar Energy GCSE/A level

Investigate how the power collected by solar cells changes throughout the day. Test the difference between fixed cells and auto-tracking solar cells can make. Notice the effect of cloud cover

61 Tidal Barrage GCSE/A level

Manage a Tidal Barrage to try to get the maximum overall energy from the tide. You will notice that however hard you try, there will always be two 'dead-times' in a complete tidal cycle. Since the tides are not synchronised with the day/night, these dead-times will come at different times of the day or night!

62 Wind Energy GCSE/A level

Check the wind indicator to see where the wind is coming from. Adjust your wind turbine to face the wind. Investigate the effect of the size and number of the blades. Store your results and plot graphs. (In this simulation, you can even control the wind speed!)

FORCES

63 Balance GCSE

In this program the pupil will learn to apply the principle of moments to find the mass of an unknown weight by using known weights and adjusting the length of a graduated arm. The program also checks the answers arrived at by the pupil.

64 Force and Acceleration GCSE/A level

In this simulation a trolley is caused to accelerate along a track by means of weights attached to a pulley. The acceleration is measured using two light gates. (Calculations need to be carried out). A graph can be plotted in order to investigate the relationship between Force and Acceleration.

65 Friction GCSE/A level

This simulation illustrates the effect of friction with a block on an inclined plane. The forces can be hidden or displayed and the angle table can be adjusted until the block just starts to slide. Calculations are also included.

66 Hookes Law GCSE

This simulation allows the pupil to measure and plot the extension of several springs as they are loaded by with a calibrated set of masses. From the graphs the pupils are able to determine the spring constant and ask the computer to check their answers.

67 Pulleys GCSE

This simulation allows the pupil to investigate the effect of using different numbers of pulleys in order to lift a given weight. A distinction is made between useful pulleys and pulleys which simply change the direction of the effort. The simulation shows how total energy is conserved.

GASES

68 4 Stroke Engine A level

See how a 4 Stroke Engine works in slow motion. Adjust the throttle to see how this affects the intake and so the power and velocity of the engine.

69 Absolute Scale A level

Cool a gas down until the pressure drops to exactly zero. You will notice that the pressure reaches zero at the same temperature regardless of the initial volume or quantity of gas used!

70 Boyles Charles A level

Investigate Boyles Law and Charles Law on a gas inside a closed container. Adjust the parameter and watch the isothermal or isobaric change being plotted on a graph. Chose what you want to plot along the X and Y axes, and reach your own conclusions!

71 Heat Pump A level

Investigate how a heat pump works inside the refrigerator. See how compression leads to heating (which is wasted out the back) and expansion leads to cooling (the purpose of the machine). The pump works in both manual mode and automatic mode (where a thermostat is used to control the operation.

72 Isothermal Adiabatic A level

Investigate Isothermal and Adiabatic changes and see the curve that gets plotted as you vary the volume. If you artificially inject some heat (as in the internal combustion engine) you can see how the curve jumps to another locus.

73 Pressure from Molecules A level

This simulation helps to visualise how pressure is exerted by molecules striking the walls of the container which encloses them. It helps in understanding the effect of temperature on pressure.

74 Steam Engine A level

This modelled Steam Engine illustrates how heated water becomes high pressure steam which can be used to drive a reciprocating piston. When the piston is connected to a wheel, it can be used to drive any number of mechanical devices.

HEAT

75 Conduction GCSE/A level

Visualise how heat gets conducted along a solid rod. Alter the conductivity and see what difference it makes. Investigate the effect of insulation.

76 Constant Flow GCSE/A level

Carry out a virtual experiment to determine the specific heat capacity of water using the constant flow Constant Flow method. Change the flow rate and repeat experiment at the same temperature to cancel errors due to heat losses.

77 Convection GCSE/A level

Heat one side or other of a closed rectangular pipe and watch the convection currents that are formed with the aid of a die that slowly dissolves into the liquid.

78 Gas Expansion GCSE/A level

Watch how rapidly a gas expands even with a very small increase in temperature. Estimate what temperature increase is required to produce a 1% increase in volume.

79 Heat & Area GCSE/A level

This simulation shows how the shape of an object determines the rate at which its centre cools down. The user can change the conductivity of the material and the temperature of the surroundings.

86 Heat Capacity GCSE/A level

Determine the Specific Heat Capacity of a solid block of material. Heat it with an electric heater for a short time. Allow the temperature to stabilise and record it. Repeat the heating and stabilising steps until a graph is formed. Use it to calculate the result.

80 Latent Heats GCSE/A level

This simulation shows what happens at the molecular level as a solid is given more and more energy. It goes through the 3 phases of matter, plotting the temperature against the energy input, with the temperature lingering at each phase change.

81 Liquid Expansion GCSE/A level

Heat a liquid inside a large spherical vessel and watch the liquid level rise inside the tube. From the rise in liquid level and the measured temperature rise, calculate the volume expansion coefficient.

82 Melting GCSE/A level

Melt some ice with the help of an electrical heater, and collect the water over a measured length of time. Calculate the power input from the voltage and current and so calculate the latent heat of fusion. Repeat the experiment at a different power rate to cancel out errors due to heat absorbed from the surroundings.

83 Method of Mixtures GCSE/A level

Heat a block of unknown material in boiling water. Transfer it to a calorimeter which contains water at room temperature. Note the rise in temperature, wait for temperatures to stabilise, and calculate the specific heat capacity of the block!

84 Radiation GCSE/A level

Notice the perceived colour change as a hot plate warms up. Visualise the shortening of the wavelength as well as the increase in intensity. See an introduction to Wien's displacement law.

85 Solid Expansion GCSE/A level

Heat a metal rod with the aid of Bunsen burners, note the rise in temperature and also the expansion as magnified by a simple dial gauge. Calculate the linear expansion coefficient for several different materials.

86 Vapourisation GCSE/A level

Vapourise water with an electric heater, condense the steam and measure the rate at which the water is being condensed. Use this information to calculate the latent heat of vapourisation. Change the power supply to the electric heater and repeat in order to cancel out errors due to heat losses.

87 Weather GCSE/A level

This program simulates a weather system driven by convection currents due to the differential heating of land and water. It is set in South India, where the 'Monsoon' winds dominate the weather system.

KINEMATICS

88 Bounce meter A level

This interesting experiment can calculate the height from which you drop a ball! The only requirement is that the ball bounces several times. A microphone is required to listen for the times at which the ball hits the table or floor.

89 Bouncing graphs A level

This simulation shows a ball bouncing and plots the displacement, velocity and acceleration graphs so that the users can see the relationship between them clearly. It is designed to help the user to interpret the three types of graph.

90 Graphs GCSE/A level

Learn to read information from distance-time and velocity-time graphs. Check your interpretations against the computer.

91 Gravity A level

Measure gravity with the aid of a free-fall experiment using light gates. Drop the ball from different heights and obtain a graph from which g can be calculated. (Slow motion can be selected)

92 Projectiles A level

Fire a projectile from the side of a cliff and adjust the initial velocity and angle in order to investigate the effect on the range. Visualise the constant horizontal component to the velocity and the accelerated vertical component. See how air resistance affects projectiles

93 Terminal Velocity GCSE/A level

See how the terminal velocity of a parcel is affected by the size of parachute attached to it. (Choose when to open the parachute, but don't leave it too late!). Graphs of velocity and acceleration are plotted as the parcel falls. Experiment with different size parachutes!

MATHEMATICS

94 A sin Bx GCSE/A level

Plot an equation of the form A sinBx. Visualise what A and B do to the shape of the locus

95 Instant equation plotter GCSE/A level

Type the equation in the box, select the X max and X min limits and the graph will be plotted. This enables students to visualise what shape any given equation will produce.

96 Interactive polynomial plotter GCSE/A level

This program allows the student to get immediate feedback on the effect of coefficients in a normal polynomial. The values of the coefficients can be controlled using sliders.

97 Matrices A Level

This program shows one use of matrices in transforming the coordinates of a polygon in the Cartesian space. Several transformations are given, including a user definable one.

98 Numerical integration GCSE/A level

This program carries out Numerical Integration under the curve of any equation given. The effect of step size can be studied, and integrations under standard functions can be compared.

99 Polar Coordinates A Level

This program illustrates the use of polar coordinates (as compared with Cartesian coordinates). It shows why they are useful and gives some typical applications.

100 Sin Cos Tan GCSE/A level

This simple program shows how Sin, Cos, and Tan derive from a vector on Cartesian axes.

101 Trigonometry to Waves GCSE/A level

This program shows how Sin, Cos and Tan can be plotted as waves on a graph.

102 Vectors GCSE/A level

This program shows how two vectors can be combined in order to obtain a resultant.

MATTER

103 Alpha Scattering A Level

This simulation shows how Alpha particles can be scattered from a gold foil. Zooming in to the gold foil reveals the presence of atoms within it. Zooming further in begins to reveal the presence of the nucleus. Investigate the effect of the initial speed of the Alpha particles.

104 Atomic Density GCSE/A level

This simple simulation shows how density can be affected by the mass of the atoms making up the solid and interatomic spacing.

105 Density GCSE

This simple simulation prompts the student to calculate the density of a block of material by making use of Archimedes' Principle. The simulation allows the pupil to weigh an object in air and also when submerged in water. From the up thrust due to the water, the pupil should be able to calculate the density of the object and get the computer to check his answer.

106 Elastic Plastic A Level

This is simulation allows the pupil to investigate the different stress/strain relationships of 4 different materials. The concepts of ductile and brittle, breaking stress and breaking strain are shown clearly. Graphs are produced from which pupils should be able to read information to be tested by the computer

107 Floating GCSE

This simulation prompts the student to calculate the density of a block of material which floats. This is achieved by measuring what proportion of the block lays under-water.

108 Molecular Model A Level

This simulation allows the student to visualise the motion of molecules as the phase changes from solid to liquid and then to a gas, going through the melting point and the boiling point.

109 Young’s Modulus A Level

This is a fairly sophisticated simulation which mimics a travelling microscope looking at the extension of wires of different material and diameter as they are loaded. Measurements are recorded, a graph is plotted and from that the Young’s Modulus can be calculated and compared with the values stored in the computer.

MEASUREMENTS

110 Acceleration Measurements GCSE

This simple simulation tests the pupil's ability to calculate the acceleration of a trolley that goes past two light gates connected to three clocks. The pupils calculated answers can be checked against the computer calculated value.

111 Micrometer GCSE

This simulation illustrates the operation of a Micrometer. It runs in two modes: learning and practicing. The pupil can compare his reading with that of the computer in order to check that he has read it correctly.

112 Reflex time GCSE

This program offers the user the opportunity to test his reflex time 10 times. It plots out the response times and calculates the average. It tells the user how far his car would have travelled on the motorway before he even reacted!

113 Velocity Measurements GCSE

This simple simulation tests the pupil's ability to calculate the velocity of a trolley that goes past two light gates connected to a clock. The calculated result can be checked against the computer calculated value.

114 Vernier Callipers GCSE

This simulation illustrates the operation of a Vernier Calliper. It runs in two modes: learning and practicing. The pupil can compare his reading with that of the computer in order to check that he has read it correctly.

OPTICS

115 Colour Filters A Level

This simulation shows how colour filters may be used to study and measure the scattering and transmission of coloured light from various compounds. The scattering is a measure of the concentration of the compounds.

116 Colour Match GCSE

This simulation shows how Red, Green and Blue (RGB) combine to form all the colours possible on a monitor. If a good magnifying glass is used, the colour pixels on the monitor can be seen, otherwise select 'show detail' to see an enlarged part of the screen.

117 Dispersion GCSE

This simulation shows how lights of different colours are refracted by different amounts when they encounter a refractive index boundary, giving rise to Dispersion.

118 Eye GCSE

In this simulation, several patients with different eye conditions come to you to have their vision checked and, if necessary, corrected. You must diagnose the problem, chose the right type of lens, and adjust the power of the lens for perfect focussing on the retina.

119 Imaging GCSE

This simulation shows how and where images form when the position of the object or power of the lens is varied. Real and virtual images are formed and the magnification is shown.

120 Lenses GCSE

This is a virtual lens testing machine. The effect of surface curvatures on the focal length can be seen in real time, and if the lenses are significantly curved, spherical aberration begins to present itself. Chromatic aberration can also be noted if the colour of the rays is changed. Converging and diverging lenses can be modelled.

121 Mirrors GCSE

Parabolic mirrors are tested with this simulation, showing how the curvature affects the focal length. If the shape is changed from being parabolic (i.e. not an x^2 function) bad aberrations ensue.

122 Polarisation A level

In this simulation a polarizer can be rotated in front of polarised light and a detector measures the intensity of the transmitted light. If sufficient data is obtained a graph showing the Cos^2 relationship is obtained.

123 Prisms GCSE

In this simulation, a ray of light of variable colour is made to shine onto a face of a Prism of variable angle and refractive index. The refraction at each of the faces is shown and the overall deviation is noted. If white light is selected, the typical prismatic dispersion of colours is shown.

124 Refraction GCSE

This simulation shows how Refraction at a refractive index boundary comes as a consequence of the slowing down of the light as it enters the medium. The refractive index of both media can be adjusted, such that even total internal reflection is possible.

125 Speed of light A level

This virtual experiment allows the student to measure the speed of light using the rotating mirror method. A laser beam is reflected back and made to shine upon a microscope slide where the position of the reflection can be measured.

PRESSURE

126 Hydraulic Jack GCSE

The Hydraulic Jack simulation shows how when the piston of the master cylinder is pumped, oil flows past non-return valves and pushes the piston of the slave cylinder up. Pressure gauges show how the pressures in both cylinders are the same, and yet the force multiplication is achieved.

127 Manometer GCSE

A simple U tube manometer is simulated to show how increased or reduced pressure in one side causes the levels to rise or fall relative to each other. The density of the liquid in the tube can also be changed.

128 Mercury Barometer GCSE

This simple simulation shows how a Mercury Barometer is made. It illustrates how the atmospheric pressure on the surface of the free mercury supports the weight of the mercury column.

129 Pressure from Molecules A level

This simulation helps to visualise how pressure is exerted by molecules striking the walls of the container which encloses them. It helps in understanding the effect of temperature on pressure.

QUANTUM

130 Absorption Spectrometer A level

A continuous spectrum source is made to shine through glass cells containing different gases. Then the spectrum is studied through a diffraction grating and a microscope, particular lines are found to be missing from the spectrum. The gas can be changed giving rise to different dark lines.

131 Emission Spectrometer A level

Gases in glass discharge tubes are excited when connected to high voltages. The light emitted from the discharge is studied with a microscope after it is diffracted through a grating. The spectrum reveals certain coloured lines. The number and colour of the lines is unique to the gas used.

132 Energy Levels A level

This simple simulation illustrates the following quantum phenomena: Light absorption and re-emission, phosphorescence, Fluorescence, Laser, and Ionisation

133 Millikan's Experiment A level

This simulation follows Millikan's oil drop experiment. Oil droplets are injected between two flat electrodes and are viewed through a microscope. The potential difference across the electrodes is adjusted until any particular droplet ceases to fall under gravity. The voltage is recorded and a radioactive source is used to re-ionise the droplet. The balancing voltages are recorded, building up evidence for the quantisation of charge.

134 Photoelectric Effect A level

Different colour filters are used to change the wavelength of the light shining on a metallic surface. A reverse voltage is applied to an electrode in order to just cut the photoelectric current to zero. The voltage and wavelength are plotted and from the graph, a value for Plank's constant is obtained. Two materials with different work-functions are available.

135 Wave or Particle A level

This simulation illustrates how the wave model of light could not explain the instantaneous ejection of electrons from metal surfaces. Switching over to the quantum or particular model of light illustrates how there is sufficient energy to cause the immediate ejection of electrons.

<u>RADIOACTIVITY</u>

136 Beta Penetration GCSE/A level

This simulation is designed to show how sheets of aluminium absorb beta particles, preventing them from reaching the Geiger-Muller tube. Time the number of counts for a few minutes, change the number of aluminium sheets, and store the data so that it can be displayed on a graph.

137 Cloud Chamber A level

This simulation shows the workings of a cloud chamber, and the typical tracks produced by the three different types of particle. It also invites the user to deduce for himself the types of radiation coming from different sources.

138 Geiger Muller Tube GCSE/A level

This simulation shows the internal structure and workings of a Geiger Muller tube. The voltage between the anode and cathode may be adjusted to see what effect it has on the sparks produced (and counted) by box attached to it.

139 Half Life GCSE/A level

The ionisation current in a chamber containing radon gas is measured as time progresses. The student can record the value of the current at various time intervals. When enough data has been gathered, the graph will enable the student to determine the half life of the radioactive decay. The student can then compare the value he obtained with that known by the computer.

140 Inverse Square Law A level

This simulation enables the student to measure the activity of a radioactive source at different distances from it. As the graph is plotted, the student then has the option of plotting the count rate against various different quantities on the X axis, in order to investigate the inverse square relationship.

141 Nuclear Reactions A level

This simulation shows how nuclear fusion and fission take place. It shows the graph of the binding energy per nucleon and how when nuclear reactions take place, there is a change in total binding energy. The energy released is calculated and displayed.

142 Nuclear Stability A level

This simulation shows the graph of the 'stability line' for all the elements in the periodic table. It shows how Alpha and Beta decays can move a nucleus closer (natural) or further away (artificial) from this line of stability.

143 Random Decay GCSE/A level

This simple simulation is designed to show that radioactive decay is a random process, and whilst the overall behaviour of a large number of atoms can be predicted reasonably well, it is impossible to predict when any particular atom will decay.

SIMPLE HARMONIC MOTION

144 Damping A level

This simulation allows the student to investigate the effect of damping on a simple oscillating system. The concept of critical damping is also introduced.

145 Phases A level

This simulation shows the phase relationships between the displacement and the velocity, acceleration, kinetic energy, and potential energy in Simple Harmonic Motion. Showing how the velocity and displacement are in phase quadrature, and the KE and PE are in antiphase with each-other and at twice the frequency.

146 Resonance A level

A resonating system is driven by an oscillator whose frequency can be controlled precisely. The student will notice how as the driver frequency approaches the natural frequency of the system; the amplitude of the oscillation will increase dramatically. The amplitudes can be stored at different frequencies until a resonance curve is obtained. The effect of damping on the quality of the oscillator can also be studied

147 SHM A level

The effect of length, mass and amplitude on the frequency of a simple pendulum can be investigated as well as the effect of the spring constant and mass on the frequency of mass on a spring.

SOUND

148 Beating A level

The effect of two sound waves of similar frequency interfering with each-other can be heard through the computer speakers (if fitted) and seen on the screen. It will be noted that as the difference between the frequencies increases, the frequency of the beat also increases.

149 Doppler A level

The effect of movement on a source of sound is investigated in this simulation. Sound waves get 'bunched up' or 'spread out' depending on the direction of the movement. The simulation is visual as well as audio. The simulation also explains the bang heard when travelling at the speed of sound!

150 Impulse Excitation A Level

This experiment allows the user to obtain a fairly accurate measurement of the Young's Modulus of elasticity of a metal rod. The method consists in measuring the frequency of the ringing made when the rod is struck. It ties together the chapters of materials, waves and sound!

151 Pipes A level

Sound waves in open and closed pipes can be investigated both audibly and visually. The position of nodes and antinodes will be noted as the fundamental and overtones are played. The longitudinal waves as well as the transverse representation may be displayed.

152 Sound Generator GCSE/A level

A simple sound generator is displayed where the amplitude and frequency can be adjusted. The simulation shows the inverse relationship between frequency and wavelength. It also allows the student to see and hear the difference between sinusoidal, triangular, saw tooth and square waves. The simulation also introduces 'white noise'.

153 Sound Level GCSE

This program simply records the sound level (volume) and displays it in arbitrary adjustable units in a variety of ways. It can be used as a means to investigate the inverse square relationship of sound intensity with distance in a real experiment. (Microphone required)

154 Spectrum Analyser A Level

This program records a sound signal obtained from a microphone, and analyses the spectrum and displays a graph. It can be used to measure the frequency of sound signals originating from plucked strings, resonating columns of air, tuning forks, etc.

155 String A level

This simulation allow the student to investigate the relationship between the frequency of oscillation of a stretched string and its tension, length and thickness (strictly- its mass per unit length).

TEMPERATURE

rpt Absolute Scale A level

Cool a gas down until the pressure drops to exactly zero. You will notice that the pressure reaches zero at the same temperature regardless of the initial volume or quantity of gas used!

rpt Thermistor GCSE/A level

This simulation shows the principle of a thermistor, and also shows how a thermistor may be used in a practical circuit to control the temperature of water.

156 Thermocouple A level

This program shows the calibration procedure for a thermocouple for the range between 0 and 100C. The non-linearities are apparent, and serve to illustrate the limitations on accuracy.

157 Thermometer GCSE/A level

This program shows the calibration procedure for a mercury in glass thermometer, using the ice point and the steam point, and interpolating the range in between.

WAVES

158 Diffraction A level

This simulation shows the relationship between the angular diffraction of a laser beam as it hits a diffraction grating and the wavelength and period of the grating

159 Huygens Wavelets A level

This simulation shows how sources that are significantly closer together than the wavelength begin to look like a single source. The position of 6 spatially separate but coherent sources can be changed to see how it affects the overall interference pattern.

160 Lissajou A level

This simulation shows Lissajou figures which are commonly used in visualising two sinusoidal signals with a phase difference between them. They can also be used to visualise the relationship between a signal and one of its harmonics.

161 Longitudinal Transverse GCSE/A level

This simulation helps to visualise Longitudinal and Transverse waves, and makes clear that it is the disturbance that propagates, and not the actual particles, which execute simple harmonic motion about a fixed locus.

162 Microwaves Standing A level

This simulation allows the user to locate nodes and nodes in a standing wave pattern of invisible microwaves by moving the dipole antenna back and forth. The wavelength of the microwaves may then be calculated and checked against the computer.

163 Microwaves Young’s Slits A level

This simulation allows the user to map out the pattern of microwaves after they have diffracted and interfered in a Young's Slits arrangement. After locating and marking the positions of nodes and antinodes, the pattern should gradually emerge.

164 Ripple Tank GCSE/A level

Two point or bar sources oscillating in phase can be moved about the surface of a tank. The pattern of nodes and antinodes is clearly visible. A vertical profile across the tank can be selected and displayed.

165 Stationary Wave A level

This simulation shows clearly how two coherent waves travelling in opposite directions interfere with each other and produce a 'standing' or stationary wave with nodes and antinodes ant set positions.

166 Water Diffraction A level

This simulation shows how water ripples diffract when they go through a gap. Both the wavelength and the gap can be varied.

167 Wave Interference A level

This simulation shows the principle of superposition of waves clearly. Constructive and destructive interference can be seen clearly.

168 Young’s Slits A level

This simulation shows clearly how slit separation and wavelength combine to determine the angle of the diffracted orders. Both the slit separation and the wavelength can be varied by the user.