AH Physics Project Advice for Staff (20th January 2017)

Reference Books:

• Physics - A Textbook for Advanced Level Students (2nd or later Edition)		Tom Duncan
• A Level Physics (Third or later Edition)		Roger Muncaster
• Understanding Physics *for Advance Level* (Fourth or later Edition)		Jim Breithaupt
• A Laboratory Manual of Physics	(Any edition if you can get your hands on one)	F. Tyler
• Advanced Practical Physics	(Ancient but good)	Leslie Beckett
• Practical Physics in SI	(As good as Tyler)	E. Armitage
• Project and Investigations for Advanced Physics	(Old but good)	Jim Breithaupt
• Physics Through Investigation	(2000ish - good)	Green Ireson
• Physics by Experiment	(A level old but good)	J R L Hartley & D L Moselle
• A Level Practical Work for Physics	(2015)	
(Great wee book on techniques - graphs, measurement etc rather than procedures)		Chris Mee & Mike Crundell.
• Practical Physics	As above but older and more detail.	G L Squires.
• CFE AH Physics	Bright Red	A. McGuigan

Teaching Advanced Physics – IOP - http://tap.iop.org/ loads of good teaching ideas for coursework and experiments.

Apparatus Suppliers

DJB	http://www.djb.co.uk/	
Scichem Pasco	http://education.scichem.com/Catalogue/Search	
Timstar	http://www.timstar.co.uk/	
Philip Harris	http://www.philipharris.co.uk/	
Lambda Scientific	http://lambdasys.com/downloads	American, expensive but downloads have useful ideas?
Mindsets	http://mindsetsonline.co.uk/Site/Home	
3bScientific	https://www.3bscientific.co.uk/physics,pg_83.html	

General Comments

- A good grasp of uncertainty treatment is a requirement of the course.
- At this level candidates should be confident in the use of Excel or an equivalent spreadsheet package in relation to calculations and graphical presentation.
- They should also have a clear idea of how to use LINEST or equivalent to find the gradient and uncertainty in a line. Some schools treat the time just after the change of timetable to introduce Excel.

Uncertainties

http://www.sserc.org.uk/index.php/physics-home/advanced-higher/3358-data-handling

Education Scotland Resource
N Fancey , G Millar - Book on Uncertainties? Not available on Education Scotland website – seems the HSDU materials have been "streamlined by educational experts" ???
This and other support can be accessed through
http://www.mrsphysics.co.uk/advanced/category/backgrounddocuments/upsnanduncertainties/

(Thank you Jennie)

https://education.gov.scot/nationalqualifications/resources/physics

(I cannot access these at present so don't really know what is there that might be worthwhile).

Check Guzled for other support

'*An Introduction to Error Analysis - A Study of Uncertainties in Physical Measurements*' by John R. Taylor.
(recommended by Peter Law) – available on Amazon.

AH Physics Project Advice for Staff

Title	Apparatus List / Supplier if possible	Support notes / tips /safety issues
Finding g		
Compound pendulum	Metre stick drilled with holes 10 cm apart. Thin needle to suspend pendulum by fitting through holes. Retort stand Timer. Details from SSERC to follow.	Standard experiment available in most reference books. Ask Technician or CDT department to drill the holes along the centre of the metre stick
Simple pendulum	Long piece of string Bob or mass to be suspended. Fit string into a slit made in a rubber bung to allow ease of adjustment of the length of string. The bung can be held in place using a retort stand. Retort stand, G clamp to secure set up. Scales to weigh mass, callipers to find midpoint.	Use a retractable measuring tape or equivalent to measure different lengths – useful for lengths greater then 1m. Be aware of toppling retort stand, if not secured properly. Analysis – graphical approach essential.
Kater's Pendulum	Haven't seen a home made version – maybe a possibility. Might be able to borrow one from a University?	Use graphical analysis.
Bifilar Pendulum	Long Metal rod. Means of suspending the rod horizontally. Two retort stands Timer	Vary the distance, d, of separation of suspension and measure the period T. Graphical analysis possible
Ball Bearing on Concave Mirror	Spherometer Curved concave mirror. Ball bearing. Timer	Fairly simple measurements, theory a bit tricky.

Oscillating Spring	Long spring (30cm), retort stand, G clamp, masses, stop clock. Alternative method for timing: Motion sensor connected to laptop a possibility – PASCO or alternative.	G clamp to secure the retort stand for safety. Motion sensor pointing upwards below the mass. Ensure the motion sensor is at least 25 cm from the mass.
Water stream	Measure diameter of a vertical stream of water at various points	http://www.sserc.org.uk/images/Physics/g_by_flow_rate.doc
Sphere rolling down a slope	Sloped track , sphere (large marble or ball bearing). Micrometer or vernier callipers. Timer (light gates) metre stick. Scales	Use the conservation of energy, the formula for I to find g.

Title	Apparatus List / supplier	Support notes / tips /safety issues
Waves in Strings (Related to Melde's Experiment)	Sonometer Different thicknesses of wires at least 5. (Can use guitar strings if they can be attached) Pair of pliers. Safety specs. A means of increasing the tension in the wire. SSERC have a relatively cheap, home made version, using Westimster kit magnets. Can easily set up make school. Details from SSERC to follow. Frequency can be measured: • using a horse shoe magnet across the wire and a signal generator, looking for the point of resonance. • Lissajou figures (CRO required) • Audacity or frequency spectrum analyser app	**Must have eye protection when dealing with stretched wires.** **Find relationships between length of wire, tension, mass per unit length and frequency.** **The wire can get hot if using the signal generator method.**
Standing Waves	White elastic thread. (Most Scientific suppliers ok with this) Signal generator and frequency meter required. Again, frequency spectrum analyser app could be used. Pulley wheel	Use elastic thread connected to a vibration generator. Connect the other end over a pulley to masses. Impressive standing waves can be produced. Relationship between frequency and number of nodes? etc

Title	Apparatus List / supplier	Support notes / tips /safety issues
Refractive Index Apparent Depth	Travelling Microscope Beaker Fine powder (Lycopodium powder ok)	Lycopodium powder okay to use – not banned as originally thought.
Triangular Prism	Use of spectrometer with collimated light source. Solid – find n for material. Hollow – find n for different liquids, concentrations, temperature, etc	
	It is possible to use a laser to find the angle of deviation for different liquids in a hollow prism. An adjustable platform for the prism or laser can make things easier. Increasing the projection distance is advantageous. Can be done in the school hall provided laser precautions are taken.	Normal safety procedures with a laser. (SSERC link on safety to follow) http://www.sserc.org.uk/health-safety/health-a-safety-home136/optical-radiation-safe-use81 (requires log in)
Gases Michelson Interferometer	Michelson Interferometer Vacuum pump Use of gas cell	Introduce carbon dioxide or helium into the gas cell from vacuum and measure the movement of fringes. Leakage can be a frustrating problem. Use the Helium from “party” balloons – otherwise can be expensive.
Air cell	Details from SSERC to follow.	Nice cheap version – pupils could even construct this.
Lenses	Lens holders, metre stick Various convex lenses - focal length ranging from 20 – 80 cm. Optical bench nice if you have one. Bright source for object.	Lens formula. Focal length of lenses

Title	Apparatus List / supplier	Support notes / tips /safety issues
Refractive Index		
Liquids	Curved mirror Retort stand Cork and pin as object Metre stick	
Liquids	Diffraction grating 300 linesmm^{-1} Laser Screen Transparent container Details from SSERC to follow.	Measurement of the separation of fringes in air and liquid allows the calculation of the refractive index of the liquid.

Title	Apparatus List / supplier	Support notes / tips /safety issues
Moment of Inertia Disc	Use Pasco rotating platform to find I of disc Compare experimental value with using data to calculate $I = ½ mr^2$ more directly.	See Pacso worksheets for info. Use $T = I\alpha$
Disc	Conservation of angular momentum Pasco rotating platform and Inertia	See Pacso worksheets for info.
Cylinder	Conservation of energy (runway light gates). Use rotating cylinders down a slope. Compare experimental value with using data to calculate $I = ½ mr^2$ more directly. Repeat with a sphere – less friction See: http://www.sserc.org.uk/images/AH_Physics/Advanced_Higher_Physics_experiments.doc page 11	Can be difficult to get any reasonable results but good for uncertainty calculations.
Rod	Bifilar suspension rod. Timer Relatively easy set up.	
Bicycle Wheel (Through centre)	Straight forward set up, if you have a bicycle wheel. Remove tyre, mount wheel vertically, apply force to rim. See also “Tobermory method” using a rotating air puck and Tracker www.sserc.org.uk/images/H_Physics/Motion_Analysis_using_tracker/Tracker_guide.pdf (page 6)	Reference: Apply torque, calculate angular acceleration by timing angular displacement. Account for friction?

Bicycle Wheel (Suspended, oscillating)	Straight forward set up, if you have a bicycle wheel. Support stand. String. Timer.	Reference : Suspend the wheel and find the period of oscillation.
Wheel and Axle	Some schools might still have one of these. String. Masses Timer.	Apply torque, measure angular acceleration, estimate frictional torque – find I. Compare with "geometrical estimate"
Investigate I using a cardboard disc and coins	Details from SSERC to follow.	
Friction	Wooden blocks of the same mass but different cross sectional area. String Track (Bench) Pulley, masses, string, plastic bottle. Tilted wooden surface. Protractor Possibility of using different methods of measuring force. (Force sensor – Pasco) Variable speed rotating turntable plus block on surface. Method of timing.	Different methods of measuring coefficient of static and kinetic friction. Horizontal / tilted track. http://www.philipharris.co.uk/products/physics/forces-energy/motion-acceleration/b8h25109_inclined-plane-and-friction-board Add water to the bottle until the block just moves etc. Compare surfaces. Independence of surface area? Relatively easy investigation to carry out – not over demanding. Increase speed of turntable until the block is just held in place. Central force provides frictional force . Find μ. Vary the area of the block.

Title	Apparatus List / supplier	Support notes / tips /safety issues
Lasers	**Suitable lasers for project work will be Class 2 (and not Class 2A, "C or 2M).** **These might be:** **A helium neon laser** **A semiconductor laser** **A laser diode module.** **All should be bought from reputable suppliers. Laser pointers and devices such as laser spirit levels should not be used as the classification cannot be trusted.**	**Safety: LASERS - SSERC – log in required. www.sserc.org.uk/health-safety/health-a-safety-home136/optical-radiation-safe-use81/school-sources78**
Intensity profile across the beam	Compare properties of different lasers. Lasers plus suitable light sensor (Photo diode plus meter)	Quite difficult to set up. Attach a light sensor to a micrometer. Move the screw to move the sensor across the beam Or photograph and use Tracker Plot I vs d
Intensity variation with distance	Laser, metal adjustable ruler, light sensor	
Wavelength using diffraction grating	Laser 300mm^{-1} grating (600 mm^{-1} does not give enough values of θ) Screen Metre Stick / metal ruler to measure grating distance to screen) Graph paper for screen to mark the pattern. **DO NOT USE A LASER WITH AN OPTICAL SPECTROMETER**	$d\sin\theta = m\lambda$ Possible to use graphical approach to find λ. Plot $\sin\theta$ against m (Tan θ should not be used as an approximation for sin θ. This is not Young's Slits)
Diffraction pattern around a hair.	Screen, hair, some device to hold the hair in place. Screen plus paper Travelling microscope.	Attach the hair to a suitable holder to enable the projection of beam onto screen. Gives better control.
Spiral separation of CD, DVD	CD, DVD, blue ray disc plus screen with a hole in the centre to enable beam to be directed onto the disc. Disc position vertically on its end.	Nice practical with reasonable results. Should attain a difference in the spiral separation. Blue ray carries more information.
Metal Rule Interference	Laser Metal rule with fine graduations. Screen	Ensure screen is (2 – 3)m from ruler http://www.sserc.org.uk/images/Bulletins/191/Bulletin_191%20(2).pdf

Title	Apparatus List / supplier	Support notes / tips / safety issues
Single Slit Diffraction	Single slit – commercial. Screen +paper to record position of fringes. Metre stick , measuring tape? Travelling microscope	
Young's Slits	Laser Double slit Screen +paper to record position of fringes. Metre stick , measuring tape? Travelling microscope	Although in syllabus, an addition might be considered where Dx against D is plotted, using the gradient to find the wavelength. Better to use a slit of known separation – difficult to measure directly using a travelling microscope - gives high uncertainty.
	Note – diffraction and interference experiments (including Young's Slits, Newton's Rings, single slit) can be analysed quantitatively using Tracker. See guide mentioned in section on angular motion).	
Polarisation	Helium neon gas laser Semiconductor laser Light sensor One polaroid analyser plus scale – can be home made.	Compare the properties of each laser. Are both beams polarised? Plot graphs of I vs θ Also possible to record intensity over a period of ti me to see if there is any movement in the polarisation angle for each beam.
Malus Law	Laser + polariser if required. Check to see if laser output is plane polarised Analyser (plus angle scale) Light sensor (Photodiode plus meter).	Laser light should be polarised, so just analyser plus scale needed. Could use a white light source with polariser plus analyser.
Brewster's angle	Rotating platform, (protractor) Laser (can emits polarised light – check with analyser. If not plane polarised then use a polariser Some gas lasers polarisation plane rotates – something worth checking. Glass bock	Project the reflected beam from the glass block onto a wall. Record angle where the intensity is a minimum. Calculate the refractive index of the block, compare with theoretical value. **Search you tube for set up.** SSERC writing up

Optical Activity of certain solutions	Polarimeter (can be homemade) Light sensor Glucose, sucrose solutions. Measuring cylinder. Balance See http://www.sserc.org.uk/images/AH_Physics/Advanced_Higher_Physics_experiments.doc page 17	Plane of rotation dependent on concentration, length of solution. Nice experiment to attempt if you have the correct set up. See http://www.philipharris.co.uk/products/b8r05155_polarimeter Details from SSERC to follow on measuring optical rotation

Title	**Apparatus List / supplier**	**Support notes / tips /safety issues**
Interference	Sodium light source Diffraction grating, 300 lines mm^{-1} grating Spectrometer 300, 600 linesmm^{-1} gratings	$d\sin\theta = m\lambda$ Possible to use graphical approach to find λ. Plot $\sin\theta$ against m Given wavelength, could also try to calibrate different diffraction gratings
Wedge fringes	Flat glass plates Sodium source Travelling microscope Glass beam splitter	Although in the syllabus, this can be extended by finding the width of any thin object. (Paper, hair, card ..)
Newton's Rings	Sodium source Travelling microscope Glass beam splitter Newton's Rings apparatus Spherometer For this and wedge fringes, see: http://www.sserc.org.uk/images/AH_Physics/Advanced_Higher_Physics_experiments.doc (pages 1 and 7)	Fairly easy to do – good graphical approach required. Leads on nicely from wedge fringes http://www.philipharris.co.uk/products/b8a46229_newtons-rings-apparatus

Title	**Apparatus List / supplier**	**Support notes / tips /safety issues**
Speed of Sound	Comparison of methods Long resonance tube, closed at one end. Signal Generator Frequency meter Metre stick Speaker Retort stand to support speaker. Commercial set up available from Pasco	Exp1 Measure lengths for fundamental frequency and the first overtone. Subtract to find the wavelength x 2. Find λ, then use $v = f\lambda$ Exp 2 Vary the length of the tube and find the fundamental resonance frequency. Use a graphical approach to find v.
	Signal Generator Frequency meter Metre stick Speaker Reflector Microphone + oscilloscope	Set up a standing wave for sound. Use the microphone to detect distance between nodes or antinodes.
Variation with temperature	Any good models out there? Hair drier used to heat the air in an enclosed tube? Thermometers to record average temperature. Microphone at one end of tube speaker at the other?	Difficult to do – any suggestions? Closed tube - standing waves at different temperatures?
Speed of sound through solids and liquids.	See: http://www.sserc.org.uk/physics-home/national-3-4-5/3519-speed-of-sound	

Title	Apparatus List / supplier	Support notes / tips /safety issues
Young's Modulus (Popular with Engineering students)	Rod – metal, plastic or wood. G clamp to fix rod to end of bench Travelling microscope. Masses	Add masses to end and note deflection
	Vibrating bar and motion sensor G clamp to fix rod to end of bench.	Place motion sensor below bar Ensure motion sensor is at least 25 cm from bar.
	Rod – metal, plastic or wood. Blade supports for the end of each bar. Travelling microscope. Masses	Add masses to the centre and measure the deflection. Might be possible to use vernier callipers to measure the deflection.
	Elastic limit and breaking points of copper wire. Vernier scale required to measure the change in lengths. Commercial devices available.	Accuracy / precision can be a problem here due to the small change in lengths. http://www.philipharris.co.uk/products/f4h25213_youngs-modulus-apparatus

Title	Apparatus List / supplier	Support notes / tips /safety issues
Surface tension	Capillary tubes – 5 different bores if possible. Travelling microscope.	Ensure the tubes are degreased before using. Immerse in sodium hydroxide solution and thoroughly rinse and dry.
	Glass slide in contact with surface of liquid. Top pan balance Shallow container Jack to raise and lower the container.	Supporting the glass slide can be tricky, to ensuring that the bottom edge just comes into contact with the liquid.
	Jaeger's method Mainly glassware required Relatively easy set up. Refer to websites.	SSERC working on method that replaces U-tube manometer with pressure sensor from Pasco / Vernier etc NB More difficult to get graphs – more calculation based.
Viscosity Stoke's Law	Tall, large diameter measuring cylinder Metal ball bearing. Magnet to retrieve the ball. Timer	Normally done with glycerine – not nice to work with. Large quantity required. Better to dilute it with water.
Deflating soap bubble for viscosity of air	Details on website	SSERC has a method using video of a deflating soap bubble for viscosity of air. http://www.sserc.org.uk/physics-home/advanced-higher/3930-advanced-tracker. NB More difficult to get graphs – more calculation based.
Oswald Viscometer	chemists cupboard. It isn't suitable for very viscous liquids. https://education.scichem.com/Catalogue/ProductDetail/oswald-viscometer?productID=fcb97944-c893-46b0-9cd0-14bbe833677b&catalogueLevelItemID=c6dbf71a-31bf-4b17-b0d7-47ce833fe817	Used to determine the relative viscosities of liquids. Pretty easy to use. The hardest part is to clean it and then fill it. Use a pipette filler to suck up the liquid into the correct chamber, then let it fall back down through the capillary tube. Do this for water and then another liquid and can calculate the viscosity of the other liquid relative to water. Can use organic liquids from the chemists cupboard. It isn't suitable for very viscous liquids.

Title	Apparatus List / supplier	Support notes / tips /safety issues
Constants **Planck's Constant**	5 different (protected) LEDS Ammeter, voltmeter. Battery Means of measuring the wavelength of the light. – spectrometer / **local authority spectrophotometer should be available.** Possible evaluation of Philip Harris version – simplistic. See also tungsten lamp method – doable in most schools: http://www.sserc.org.uk/images/Physics/Planck's_Constant_Tungsten_Lamp.pdf	See SSERC info below http://www.sserc.org.uk/index.php/bulletins226/2003/208-spring-2003/1345-plancks-constant-finding-it-using-leds328 Theory a bit dodgy but good measurement procedures / graphical approach / evaluation potential. http://www.philipharris.co.uk/products/b8h29024_plancks-constant-experiment If you have the cash then Leybold has the following: https://www.ld-didactic.de/literatur/hb/e/p6/p6143_e.pdf
	Using the Photoelectric Effect	SSERC See http://www.sserc.org.uk/index.php/bulletins226/2001/201-spring-2001/1439-photoelectric-effect-kits-404 Prices will obviously have increased.
Permeability, μ_0	Make your own current balance using Helmholtz coils. Alternatively use a solenoid of known dimensions or a long wire plus calibrated Hall probe or search coil. Pasco supplies a calibrated Hall probe.	Details from SSERC to follow.

Permittivity, ε	Large parallel plate capacitor. Plastic spacers. (1) Coulomb meter, voltmeter (2) Vibrating switch method. Ammeter (3) Multimeter – capacitance meter reading in nF	Measure the effect on C of plate separation, area of overlap. Use graphical method to find ε_o for air. Find ε of glass, paper or any material that will fit between the plates Details from SSERC to follow.
e : m	Teltron deflection tube. Helmholtz coils Power supply Fine beam tube if you can borrow or gain access to one. Expensive https://www.3bscientific.co.uk/teltron,pg_675.html	Use screened connectors. e:m using electric field deflection e:m using magnetic deflection Many schools should have these tubes. Uncertainties can accumulate here, but still a good investigation to attempt.

Title	Apparatus List / supplier	Support notes / tips /safety issues
Speed of light	Use values of μ_0 **and** ε_0 to find c	Use values of μ_0 **and** ε_0 to find c. Good to combine uncertainties.
Capacitors in series and parallel	3 capacitors of similar size. Joulemeter. Voltmeter. Battery	Measure E stored in various arrangements of capacitors. (Series parallel) Plot a graph of E vs V^2 to give slope.
Resonance	See previous lists Air columns Sonometer Elastic thread, masses, pulley wheel Signal generator, vibration generator Various sizes of coils, variable capacitor. DC supply Storage oscilloscope. Ammeter	Resonance in air columns Relationship between resonant frequency and length of column. Relationship between resonant frequency and length of wire. Relationship between resonant frequency and length of thread. Measure resonant frequency of capacitor discharging through a coil (dc circuit)-analyse damped oscillation trace. Compare this value in ac circuit set up.
Damped Oscillations	Motion sensor 30 cm spring Masses, different sizes of card. Various values of L and variable capacitor	Aerodynamic damping – use of card. Ensure the motion sensor is at least 25 cm from the mass. Electromagnetic damping Damped oscillations in LCR circuits – see resonance above

Title	Apparatus List / supplier	Support notes / tips /safety issues
Magnetic Fields	Hall probe or search coil. Long wire. Power supply. Long Coil Slinky	Current carrying wire – B dependence on I and r. Coil – B dependence on number of turns, I, Slinky – B dependence on turns per metre.
LCR circuits	Various sizes of coils, variable capacitor. Signal Generator, frequency meter. Voltmeter, Ammeter	Find value of C and L graphically. Investigate series and parallel resonance. Standard project. (Inductor Quality factor could also be investigated as an extra).
Electromagnetic induction	Coil, trolley with neodymium magnets mounted, datalogger and voltage probe	http://www.sserc.org.uk/images/AH_Physics/The_Art_of_Induction.doc
Wind Tunnel Experiments	Different shaped aerofoils required. Anemometer. Means of measuring lift force.	Investigate Bernoulli Effect Vary angle of attack, aerofoil shape, wind speed, measure lift. Only attempt this if you have access to a wind tunnel.

SSERC Support
Contact:
gregor.steele@sserc.org.uk

See

http://www.sserc.org.uk/physics-home/advanced-higher

SSERC has guidance on data handling:

http://www.sserc.org.uk/physics-home/advanced-higher/3358-data-handling

This is due for review as some of the graphs used for illustration would be marked down by SQA for lack of minor grid lines etc

SSERC can occasionally lend equipment or host students requiring to use a piece of apparatus not available in their school. Students must be aware of what they will be doing and the measurements they need to take before coming to SSERC. In general, students should only be visiting SSERC to carry out one experiment to complete a project – the organisation does not have entire projects set up "ready to go" for students.

SSERC is also happy to be contacted by students to discuss aspects of project work, for example to suggest alternative experiments or to help troubleshoot those that are proving difficult. A teacher should make the initial contact and must agree to be cc'd or bcc'd into all replies to the student. SSERC staff are happy to discuss novel projects with teachers but ask that we are not contacted directly by students with queries along the lines of "I would like to do a project on… Do you have any ideas?"

Reminder of the apparatus available, held within your local authority, distributed by SSERC.
To see who has yours, log in to our site and go here:
http://www.sserc.org.uk/technicians (scroll down to Resources)

- Spectrovis Spectrophotometer, Labquest 2 Interface, Optical fibre probe.
- Thermal imaging camera.
- Cloud chamber.
- Sensors for Labquest 2 (some specifically chosen for AH): pressure sensor, magnetic field probe, GM tube, voltage probe, UV-A sensor.

University Support

PLEASE NOTE THE UNIVERSITY VISIT SHOULD BE USED AFTER RESEARCH / EXPERIMENTAL WORK AT SCHOOL.

St Andrews

Contact: Bruce Sinclair
bds2@st-andrews.ac.uk

"We are happy to consider requests for various things. We are keen to continue to collaborate with school teachers.
It is not unusual for us to host occasional AH project students for a morning or two using some of our kit as part of their project.
I am usually the point of contact".
"We have had staff members here contribute to the Fife Physics Teacher INSET days with short presentations and Q&A on topics suggested by school teachers. If any would be of interest to a wider audience I imagine my colleagues would be happy to consider".

University of Edinburgh

Contact: victoria.j.martin@gmail.com
Will respond to any requests made from teachers.
Victoria intends to repeat the course that covered the new content in AH – has funding already.

University of Dundee

Contact: n.m.taylor@dundee.ac.uk
Will respond to any requests made from teachers.

Heriot Watt University

Contact: Bill McMacPherson on W.N.MacPherson@hw.ac.uk

See

https://www.hw.ac.uk/schools/engineering-physical-sciences/teaching/physics-schools-laboratory.htm

Heriot Watt and the IOP (thanks to Nick Forwood) have put together a teacher and pupil guide **– available on GUZLED.**

Heriot Watt Support - Teacher's Handbook – list of titles

1. Period and length of a simple pendulum - Measurement of g 9
2. The Compound Pendulum 11
3. Determination of the gravitational constant *G* 14
4. Angular acceleration and torque 16
5. Mass on a spiral spring 17
6. Hooke's Law.. 19
7. Coulomb's Law 20
8. Force on a current-carrying conductor 22
9. A) Current and frequency in an inductive circuit 24
9. B) Self-inductance of a coil 26
10. Electrostatics 28
11. A) Thin Lenses 30
11. B) Reflection and Refraction 32
12. A) Optical polarization & Brewster's angle 34
12. B) Polarization – Malus' Law 35
13. A) Wavelength of red light using a helium-neon laser 37
13. B) Determining the track spacing on a CD using a laser 39
14. A) Ideal Gas Law 41
14. B) Determination of Absolute Zero 42
15. Viscosity 43
16. Refractive Index of Liquids 44
17. Experimental Aerodynamics 46
18. Resonance Tube 50
19. Speed of Sound 53

University of Glasgow

Arrangements for day visits
Contact: Peter Law on peter.law@glasgow.ac.uk

Pater has some excellent advice on preparation before a day visit.

AH Experiment Title	Description
'g' by Compound Pendulum	*Determination of 'g' by analysing the T- h and the hT^2 - h^2 graphs*
'g' by Owen's Bar Pendulum	*A special case of the compound pendulum where the radius of gyration, k can be determined from the dimensions of the pendulum*
'g' by Kater Pendulum	*Determination of 'g' by adjusting the reversible Kater pendulum until both periods are equal*
'g' by Rolling Sphere	*Determination of 'g' by timing the oscillations of a ball-bearing on a spherical mirror and determining the radius of the ball-bearing & the radius of curvature of the mirror*
Boltzmann's Constant, k_B	*Determination of k_B by obtaining the $V_{be} – i_c$ graph for the base-emitter junction of a collector grounded NPN transistor*
e/m by Electric Field Deflection	*Determination of e/m by plotting the parabolic electric field deflection and determining the electron velocity by crossed electric & magnetic fields*
e/m by Fine Beam Tube	*Determination of e/m by examining the circular path of electrons in a transverse magnetic field*
e/m by Magnetic Field Deflection	*Determination of e/m by altering the transverse magnetic field and the accelerating voltage to maintain the curvature of the electron trajectory constant*
Electro-magnetic Damping	*An investigation of the electro-magnetic damping of the coil of a ballistic galvanometer*
Electron de Broglie Wavelength	*Determination of electron de Broglie wavelengths and verification of de Broglie's hypothesis*
Hall Effect	*Investigation of the Hall effect using a two-dimensional electron gas and the determination of the 2-dimensional Hall coefficient, $R_{H,sq}$*
Magnetic Field Measurement by Ballistic Galvanometer	*Measurement of magnetic induction in a solenoid using a search coil and a charge-calibrated ballistic galvanometer*
Malus' Law	*Using LED laser light and polariser & analyser to verify Malus' Law*

AH Experiment Title	Description
Millikan’s Oil Drop Experiment (Assistant required)	*Determination of specific charge on an electron by direct timing of drop velocities (An assistant is required to record the times & reset the stopwatch)*
Mechanical Resonance	*An investigation of mechanical resonance of a ballistic galvanometer coil driven by low frequency ac voltage under different degrees of electro-magnetic damping*
Permeability of Free Space	*Determination of* μ_o *using a solenoid and search coil (Belham’s method)*
Permittivity of Free Space	*Determination of* ε_o *by charging and discharging an air-spaced parallel plate capacitor at high frequency*
Planck’s Constant by Electron Diffraction	*Determination of ‘h’ by measurements on the circular electron diffraction pattern produced by crystalline graphite*
Planck’s Constant by Stopping Potential	*Determination of ‘h’ by measuring the potential required to stop the photoelectric current from a photocathode exposed to a range of visible wavelengths*
Planck’s Constant by Tungsten Filament Lamp	*Determination of ‘h’ by measuring the photocurrent produced at different temperatures by a tungsten filament.*
Refractive index by Michelson Interferometer	*Determination of the refractive index of air and/or the refractive index of glass using a Michelson interferometer*
Refractive Index by Newton’s Rings	*Determination of the refractive index of water using Newton’s Rings*
Refractive index by Prism Spectrometer	*Determination of the refractive index of prism glass by minimum deviation and/or by determination of the polarising (Brewster) angle at the prism surface*
Speed of Light in Fibre Optic Cable	*Determination of the speed of light in fibre optic cable by measuring the time delay of LED light pulses travelling over different lengths of fibre optic cable.*
Speed of Microwaves	*Determination of the speed of microwaves in air by measuring the wavelength of microwaves from a standing wave pattern in a waveguide over a range of frequencies*
Speed of Voltage Waves on an Artificial Delay Line	*Determining the speed of waves on an artificial delay line by plotting the voltage standing wave pattern for a range of frequencies and by measuring the time voltage pulses take to travel along the line*
Speed of Sound by Kundt’s Tube	*Determination of the speed of sound in air by measuring the inter-nodal distance on the standing wave pattern produced in a Kundt’s tube*

AH Experiment Title	Description
Speed of Sound by Resonance Tube	*Determination of the speed of sound in air by measuring the resonant frequency over a range of air column lengths*
Speed of Sound by Lissajous' Figures	*Determination of the speed of sound in air by observing phase shifts between transmitted and received sound using Lissajous' figures*
Wavelength by Fabry-Perot interferometer	*Determination of the mean wavelength of the sodium doublet and the wavelength difference between the two lines of the sodium doublet using a Fabry-Perot interferometer*
Wavelength by Michelson Interferometer	*Determination of the mean wavelength of the sodium doublet and the wavelength difference between the two lines of the sodium doublet using a Michelson interferometer*
Wavelength by Newton's Rings	*Determination of the mean wavelength of the sodium doublet using Newton's Rings*
Young's Modulus by oscillating beam	*Determination of Young's Modulus for a clamped metre rule by timing the period of oscillation for a range of free lengths*

University of Strathclyde

Contact: shirley.wylie@strath.ac.uk
Labs are available are Wednesday afternoons from 1.00pm and Friday all day from 10.00am.
We do have most dates available from January onwards.

1. Young's Modulus by Searle's method, bending bar or vibrating bar.
2. Determination of acceleration due to gravity by use of simple pendulum, Kater's pendulum or oscillating ball.
3. Determination of speed of sound by either acoustic resonance or Kundt's tube.
4. Verification of relationship between length of string and frequency of vibration.
5. Measurement of magnetic induction in a solenoid.
6. Measurement of inductance / capacitance through LC resonance.
7. Measurement of charge to mass ratio by Magnetron effect.
8. Measurement of charge to mass ratio by fine beam tube method.
9. Measurement of surface tension by either Jaeger's method and drop method.
10. Measurement of wavelength of light by interference – thin film, Newton's rings and Michelson interferometry, spectroscopy.
11. Measurement of wavelength of light by diffraction.
12. Determination of refractive index by Snell's law, angular deviation, beam displacement or critical angle.
13. Determination of focal length of thin lenses and mirrors, verification of chromatic dispersion.
14. Determination of Planck's constant by LED turn-on and by atomic spectroscopy.
15. Determination of Rydberg constant by atomic spectroscopy.
16. Determination of charge on electron by Millikan's oil drop.
17. Determination of speed of light.
18. Verification of Fresnel reflection relationships.
19. Determination of coefficient of viscosity of castor oil.

University of Aberdeen

Contact: cpdservices@abdn.ac.uk

Continuing Professional Development (CPD) for Physics Teachers/Technicians

CfE Advanced Higher Physics

Friday 26th May 2017

Details; https://www.abdn.ac.uk/business-info/training/cpd/events/10572/

Fee: The course will cost £125.00 per person, this includes lunch and refreshments.

List of In-depth Experiments

If you wish to do an in-depth experiment please insert a '1' and a '2' in the choice column opposite your first and second choice of experiment. Every attempt will be made to give everyone their first choice.

No	Title/Description	Choice
1	Linear Kinematics and Dynamics* (Trolley experiments)	
2	Moment of Inertia of a Bicycle Wheel* (several methods used)	
3	Rotational Dynamics of a Simple Pendulum* (Tension and Damping)	
4	Multiple slit Interference and Diffraction* (using an optical laser)	
5a	Transverse Vibrations of a Wire* (Tension is variable)	
5b	Transverse Vibrations of a Wire (3 factors possible – l, T and μ)	
6a	Induced Voltage* (magnet free-falling through coil)	
6b	Induced Voltage (magnet free-falling through coil)	
7	Magnetic Field of a Circular Coil* (Axial and Transverse Fields)	
8	LCR Circuits*(Phase Relationships, Series Resonance & waveforms)	
9	Measurement of and Factors Affecting Capacitance* (A, d and ε_r)	
10	Photoelectricity – LEDs and Planck's Constant*	

* These experiments have been available on previous occasions.

Where the same title appears twice, the 'a' versions involve the use of a computer for data collection, whereas with the 'b' versions data collection is done by the experimenter.

List of Shorter Experiments

If you have opted for an in-depth experiment, choose a maximum of 4 of the following experiments by placing an 'X' in the corresponding choice boxes. If you have **not** chosen an in-depth experiment, choose a maximum of 7 of the following experiments by placing an 'X' in the corresponding choice boxes

	Topic	Experiments	Choice
A	Resistance	1. Variation with length 2. Variation with X section** 3. Variation with material** 4. Variation with temperature**	
B	Sound	1. Speed in air 2. Speed in steel 3. Speeds in different metals 4. Transducer characteristics 5. Interferometry	
C	E M Waves	1. Speed in air 2. Speed in cable 3. Polarization 4. Antenna radiation pattern	
D	Photoelectricity	1. Photovoltaic mode** 2. Photoconductive mode** 3. Photometry**	
E	Reactance	1. Capacitive with frequency 2. Capacitive with capacitance 3. Inductive with frequency 4. Inductive with inductance	

** These are new this year

List of Demonstrations

If you wish to see any of the following demonstrations please choose a maximum of 2 from the list.

Topic	Brief description of experiment	Choice
Centripetal Force and Acceleration	A variable speed turntable has bubble acceleromete of different sensitivities that can be positioned in different positions and orientations	
Fine Beam Tube	A beam of electrons forced into a circular path by a magnetic field	
Conservation of Angular Momentum	A spinning body in which the moment of inertia can be altered. The effect of torques on the system	