LADY LUMLEY'S SCHOOL

Advancing Physics AS 2000

Institute of Physics post-16 Initiative Shaping the future

OCR RECOGNISING ACHIEVEMENT

http://post16.iop.org/advphys

STUDENT GUIDE

SCHEMES OF WORK

These schemes of work show how the course activities fit together. Chapters 1-5 form the Unit "Physics in Action" (examined in January), Chapters 6-9 form the Unit "Understanding Processes" (examined in June).

EXAMPLE:

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
3-1	1.1 Seeing invisible things	b c d	pixel, resolution $v=f\lambda$ an application of image formation	20D Software based 'Electronic Image Capture' 10S 'Looking at Images'	Question 10S	C3.1b	IT3.3, C3.1a

Time (hours) The approximate length of time we will spend on this topic. In the above example 3-1 suggests that the work will take 3 hours but we may be able to finish this section in less time

Student Text The relevant section from the student textbook – you are expected to read this!

Specification type Refers to the text above each scheme. It tells you whether you are supposed to "understand" a concept or "give examples of" etc..

Specification content The part of the specification that is covered by the activity. Sometimes more than one activity or section is needed to cover a specification statement, or to gain practice and confidence. The complete Specification is available as a Microsoft Word document on your CD ROM - you may wish to print some of it (but probably not all – it's 110 pages long!). The Student Checklists in the textbook and on the CD ROM are much more useful!

Activities The activity reference from the Student CD ROM. This is useful so that you can track your progress through the work and read ahead. It is also useful if you miss a lesson and need to catch up.

Minimum student work These are the activities and questions that you will need to complete in your own time. These are in addition to questions from the student text. Remember that the CD ROM contains many questions and activities which you may wish to attempt to help you with any topics that you might find difficult. It also has a section entiltled "How to…"

Key Skills Covered These are the key skills covered in this section. You can use the activities to build up your Key Skills portfolio.

Key Skills Opportunity	Should you wish you can extend or adapt the activities to cover other Key Skills that you may need to complete your Key Skills Portfolio. These are only suggestions – there are many others! Throughout the course there is also opportunity to develop the additional Key Skills of 'Problem Solving', 'Improving own Learning and Performance' and 'Working with Others'.

Chapter 1 – Imaging

Specification Section 5.1.1.1 Imaging & Signalling (part)

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
3-1	1.1 Seeing invisible things	b c d	pixel, resolution v=fλ an application of image formation	20D Software based 'Electronic Image Capture' 10S 'Looking at Images'	Question 10S	C3.1b	IT3.3, C3.1a
3	1.2 Information in images	b c	bit,byte I bits of information can store 2^I different values	50S Software based 'Image processing: The surface of Mercury' OHTs 50O to 110O	At least one activity from: 60S, 70S, 80S, 90S, 100S. At least one question from: 10S, 40S, 60S, 80S Activity 110H	N3.1	N3.2
4	1.3 With your own eyes	a b c	formation of a real image by a thin converging lens (changing the curvature of the wavefront) focal length, power, magnification power of a converging lens P=1/f 1/v=(1/u)+(1/f) linear magnification	Visual illusions – OHTs 120O, 130O, 140O, 150O 130D 'Grey step: Edge enhancement in the retina' 60D Demonstration 'Image in mid-air' Activity 170E Experiment 'Converging lenses: power and focal length' Activity 190E Experiment 'A converging lens adds constant curvature 1 / f ' (OHTs 160O – 210O reqd)	140S 'Response of human eye to differences in brightness' Question 150S 'Cameras and eyes' Question 160C Comprehension 'Satellite imaging'	N3.3	

Chapter 2 – Sensing

Specification Section 5.1.1.2 Sensing

Types: Students should demonstrate:
(a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
3-1	2.1 Making very small things	a b c	current as a flow of charged particles; potential difference as energy per unit charge; emf, potential difference, current, charge $I = \Delta Q/\Delta t$	OHTs 10S 'Images of micromachined structures' 20D 'Current and charge in electron beams', 30D 'Spooning charge', 40D 'Shuttling ball and ions in a flame', 50D 'Conduction by 'coloured' ions', 60E 'Conduction by students' 20L Launchable File 'Moving charged particles'	10T 'Robots' or 10C 'Baby it's cold outside: The uses of sensors in the care of new-born babies' 30S 'Help with calculating current and power in an ion beam'	N3.2	

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
6-1	2.2 Miniature Circuits	a b c	resistance and conductance including series and parallel combinations; dissipation of power in electric circuits; the relation between potential difference and current in ohmic resistors ('Ohm's Law') resistance, conductance, series, parallel,simple circuit diagrams, graphs of current against potential difference; graphs of resistance or conductance against temperature $R = V/I$ $(G = I/V)$, $V = W/Q = P/I$, $P = IV = I^2R$, $W = VIt$,, $R = R_1 + R_2 + ...$ (series), $G = G_1 + G_2 + ...$ (parallel);	110E 'Using the digital multimeter to measure resistance' 120E 'Resistors in series and parallel', OHTs 31O – 35O 140E 'The filament lamp: The relationship between power and applied potential difference' 100S 'Some circuit problems' Software-based group activity & report back: 160S, 170S, 180S, 190S OHTs	80C 'Sensors and our senses' or 90C 'Sensors and Formula 1 racing' Help Activity 50S 'Dealing with variability in data: Data handling 5' 140S 'Combining resistors' 110S 'Power of appliances', 150S 'Electrical characteristics of resistors' Extension work: 40T, 50T	N3.2, N3.3, C3.1b, C3.3, IT3.3	
2	2.3 Controlling and Measuring Potential Differences	a b c	effect of internal resistance and the meaning of emf; action of a potential divider internal resistance, load $V = E - Ir_{internal;}$, simple cases of a potential divider in a circuit	200E 'Potential dividers' 170S 'Tapping off potential difference'	60S 'The potential divider in pictures', Activity 190D 'Lamp and resistor in series' Extension work: 70T 'When is a potential divider linear?'		

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
4	2.4 Sensors and our Senses	b	simple circuit diagrams, graphs of current against potential difference; graphs of resistance or conductance against temperature	Team Tasks and report back (preparation for Sensors coursework): 260E 'Monitoring rapid changes in light intensity', 270E 'Calibrating a position sensor', 280E 'Measuring rainfall', 290E 'Comparing a photodiode and a photoresistor', 300E 'Using temperature sensors', 310E 'Monitoring vibration', 320E 'The oscillations of a hacksaw blade', 330E 'Monitoring air flow'	260X 'Using a sensor in a potential divider' Choice and ordering of sensor and apparatus	C3.3, N3.1, N3.3,	IT3.2, IT3.3
5	2.5 Making Good Sensors	c	choice and use of a sensor for an application. This section also forms the Instrumentation Task for coursework module 5.3.1	340E 'Sensor projects briefing'	Use the how to Section of the CD ROM for hints	C3.3, N3.1, N3.3,	IT3.2, IT3.3

Chapter 3 – Signalling

Specification Section 5.1.1.1 Imaging and Signalling (part)

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
4-2	3.1 Digital Revolution and the Death of Distance	a b c d	digitising a signal; advantages and disadvantages of digital signals bit, byte, sampling, diagrams of waveforms amounts and rates of transmission of information an application of signal transmission	20D 'What do digital signals look like?' 50E 'Guess a waveform from a sample' 70S 'Looking less often' 100D 'The CD with the hole' OHTs 10O, 20O, 30O, 40O, 50O Case study fax v email: OHTs 60O, 70O	10S 'Data on the telecommunications explosion' or 10T 'Semaphore unites the new republic' 30T 'Digital recording error correction' or 40T 'Optics of a CD player' 50S 'Simple sampling'	C3.1a N3.2	C3.1b, C3.3, IT3.3

6-1	3.2 Signalling with electromagnetic waves	a b	the presence of a range of frequencies in a signal (its spectrum); evidence of the polarisation of electromagnetic waves spectrum, polarization, diagrams of waveforms, and their spectra	120D 'Polarisation of waves', 130E 'Polarisation by scattering' OHT: 90O 120S 'Longitudinal and transverse waves' 160S 'Filtering sounds' 180S 'Spectrum analysis: Going further', 190S 'Hearing impairment: Using a digital filter', 210S 'Cleaning up a sound', 240S 'Spectra of pulses' 250S 'Pulse length and bandwidth'	110H 'Home experiments with radio and television signals' 80X 'Charting the electromagnetic spectrum' Extension 110C ‘Maritime communications' 130S 'Polarisation in satellite communication' or 140S 'Polarisation in practice' 150H ‘Telling frequencies apart’ 50T 'Getting started with Cool Edit 96' 220S 'Building up a sound' 260S 'Bits per second and bandwidth'		C3.2, C3.3

Chapter 4 – Testing Materials

Specification Section 5.1.2 Designer Materials

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the terms needed to understand texts about properties and uses of materials
(c) ability to sketch and interpret
(d) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(e) initiative and independence in learning

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
3	4.1 Just the job	a b c	simple mechanical behaviour: types of deformation and fracture simple optical behaviour: reflection and refraction simple electrical behaviour: the broad distinction between metals, semiconductors and insulators stiff, elastic, plastic, ductile, hard, brittle, tough, reflection, refraction, resistivity, conductivity tables and diagrams comparing materials by properties	10S 'Exploring the range of materials' – brief intro. 10E, 20E, 30E, 40E, 50E, 60E, 70E, 80E as group activities and report back (with outcomes) 15O 'Material selection charts'/ 100T 'Introduction to materials selection charts' 5L 'Interactive materials selection charts'	at least one from 90H, 100H, 110H, 120H, 130H Use file 10D to answer teacher-set question.	C3.1a, C3.1b, IT3.1	N3.1

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
3-1	4.2 Better building materials	a b c d	simple mechanical behaviour: types of deformation and fracture stress, strain, Young Modulus, fracture stress, yield stress, stiff, elastic, plastic, ductile, hard, brittle, tough stress-strain graphs tensile/compressive stress, strain, Young modulus E=stress/strain	150E 'Measuring the stiffness of a material' 45S 'Calculations on stress, strain and the Young's Modulus' OHTs 20O, 30O, 40O, 50O, 60O	40S 'Hooke's Law and the Young's Modulus' 160S 'Bicycle frame design' or 150T 'Fantastic fibres' 50D 'Stress, strain and the Young's Modulus' Definitions of properties (using A-Z)	N3.2, N3.3	C3.1b
1			N.B. This forms part of coursework module 2862 'Physics in Practice'	Coursework - Making sense of data task: 'Bicycle Tyres'	Complete task – 3 hours	N3.2, N3.3, C3.3	
3	4.3 Crystal clear?	a b d	simple optical behaviour: reflection, refraction reflection, refraction, optical index total internal reflection, (sin i / sin r)=n	group activities and report back 170E, 180E, 190E, 200E, 210E 250E 'Measuring refractive index' 280E 'Retroreflectors and rainbows 300D – 'Disappearing glass'	290H 'Some home experiments in optics' 70S and 80S give useful help on refractive index and Snell's Law Explanation of 300D 75X 'The invisible man' 55D 'Materials for spectacle lenses'	C3.1a, C3.1b	

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
3	4.4 Conducting very well, conducting very badly	a b d	simple electrical behaviour: the broad distinction between metals, semiconductors and insulators resistivity, conductivity $R=\rho l/A$ $G=\sigma A/l$	demo: 310E ‘Measuring resistance of good conductors’; 330E ‘Measuring resistance of two insulators’ Either 340E ‘How the dimensions of a conductor affect resistance’ or 360E ‘Introduction to resistivity using conducting paper’ 100O ‘Range of values of conductivity’ 90O ‘Example calculation of resistivity’ 100O ‘Conductivity and resistivity’	70S ‘Electrical properties’ 80S ‘Resistivity and conductivity calculations’	N3.2	N3.3

Chapter 5 – Looking Inside Materials

Specification Section 5.1.2 Designer Materials

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the terms needed to understand texts about properties and uses of materials
(c) ability to sketch and interpret
(d) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(e) initiative and independence in learning

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
1		e	give and explain their own example of the relationship between uses, properties and structure of one material	Coursework briefing Texts to read: 20T-130T Coursework assessment sheet required for all students. N.B. This coursework forms part of Assessment Module 2862 'Physics in Practice'. Specification statement 5.3.2	3 hours research and writing before the submission date		
2	5.1 Materials under the microscope	a b c	direct evidence of the size of particles and their spacing hard, brittle, tough images showing structures of materials	Group observation and report back: 10E, 20E, 30E OHTs: 10S,20S Display materials 40S, 50S, 60S, 70S 30D 'The size of an atom' 80E 'Measuring the size of a molecule'	10C 'Visible structures' or 10T 'Biological tissues' 50H 'Home experiment: sweets and biscuits' 100H 'Spaghetti model of a polymer' Read article 'More than just seeing the surface' (Physics World, August 1998 – on student CD ROM)		
2	5.2 A clear view	a b	types of deformation and fracture Young Modulus, fracture stress, yield stress, stiff, brittle, tough	110E 'Glass thickness and colour' 120S 'Worldmaker model of absorption' 130D 'Photoelastic stress' 50C 'Tendon elasticity' OHTs: 90O, 100O, 110O ,120O	60D 'Springs connected to the Youngs Modulus		

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
2	5.3 Making more of materials	a b c	deformation and fracture stress, strain, Young Modulus, fracture stress and yield stress, stiff, elastic, plastic, ductile, hard, brittle, tough images showing structure of materials tables and diagrams comparing materials by properties stress-strain graphs up to fracture	choice: A-metals, B-polymers, C-composites, D-doping semiconductors	relevant questions for choice		
2-1	5.4 Controlling conductivity			OHTs: 220O, 230O, 250O 140D 'How resistivity changes with temperature'	180E 'Estimating with materials'		
1	Materials Presentations	e	give and explain their own example of the relationship between uses, properties and structure of one material	Materials Presentations. Only those students who have elected to do a talk need to present their report,			

Chapter 6 – Wave Behaviour

Specification Section 5.2.1 Waves and Quantum Behaviour (part)

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
6-1	6.1 Beautiful colours, wonderful sounds	a b c d	production of standing waves by waves travelling in opposite directions amplitude, phase, superposition wavelength of standing waves a superposition effect	20P 'Path difference and phase differences', 30E 'Hearing superposition' 40E 'Beats: Mixing waves in time' 10W 'Phase difference and superposition', 20W 'Superposition of waves: A drawing exercise' OHTs 2O,4O,6O,8O 10E 'Computer animation: Superposition and standing waves' 50P 'Slinky demonstration' 100E 'Standing waves on a rubber cord' 120P 'Standing waves in tubes: Kundt's experiment', 150D 'More complicated standing waves' 90S 'Standing waves on a string' OHTs/Posters 10P, 12O, 14O, 16O, 18O	80X 'Superposition outside the laboratory' – this is essential preparation for a Section C question. 100S 'Standing waves in pipes' 10T 'The Nautilus loudspeaker' or 20T 'Acoustics of rooms'	N3.1	IT3.3, N3.3
4	6.2 What is light?	d	a superposition effect	OHTs: 19O 'An estimate of the speed of light', 20O 'Huygens' candle', 30O 'Huygens' project' 40S 'Overlapping ripples', 50S 'Ripple tank images' 160S 'Why Snell's law?' 170P 'A focusing mirror with string' 180S 'Designing parabolic mirrors' 120X 'Checking out a mirror'	30T 'Historical attempts to measure the speed of light' 20E 'Ripple tank animation' 190D 'String model of a lens' 200S 'Trip times for a lens'	C3.1a, N3.1	

Time (hours)	Student Text	Specification		Activities	Minimum student work (2hours per week)	Key skills	
		type	content			Covered	Opportunity
6-1	6.3 Wave behaviour understood in detail	a b c d	interference of waves from two slits, diffraction of waves passing through a narrow aperture, diffraction by a grating superposition, coherence, diffraction, path difference, intensity path differences for double slits and diffraction grating, for constructive interference $n\lambda = d \sin\theta$ a superposition effect	210E 'Interference patterns in a soap film' 220E 'Diffraction by a slit' 230E 'Measuring wavelength with Young's slits', OHT: 55O 150S 'Questions on the two-slit experiment' 240E 'Measuring the wavelength of laser light' 200S 'Grating calculations'	140X 'Colours of thin films' 180S 'Two-source interference: Some calculations' 160S 'Using two-slit interference to measure exhaust velocity' 250H 'Using a CD as a reflection grating' 210S 'Using diffraction gratings' Extension: 50T 'Radio waves: Fading and interference'	N3.1, IT3.2	
4	6.4 Looking Forward	b d	phasor a superposition effect	260S 'Introducing phasors', 270S 'Amplitude and frequency of oscillations with phasors', 280S 'Two phasors at once', 290E 'Visualising phasors: Coloured threads', 300S 'Phasors across space' 340S 'Summing two phasors over time' 310S 'Beats: Seen and heard' 320S 'Young's slits by phasors', 330S 'Phasors to account for two slits'	350S 'Diffraction by phasors' Extension - Multiple slits: 360S 'Summing three phasors', 370S 'Phasors to account for four- and six-slit interference patterns' 380S 'Phasors to compare two, four and six slits'	IT3.1	IT3.2

Chapter 7 – Quantum Behaviour

Specification Section 5.2.1 Waves and Quantum Behaviour (part)
Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
4-1	7.1 Quantum Behaviour	a b c d	evidence that photons exchange energy in quanta *E = hf*, quantum behaviour: quanta have a certain probability of arrival; the probability is obtained by combining amplitude and phase for all possible paths. amplitude, probability, interference, superposition, path difference, intensity the energy carried by photons across the spectrum, *E = hf* a phenomenon in which quantum effects are significant	Display: 30T 'The range of quantum physics' Build up images (photograph only) from 20S 'Images with increasing exposure' 20D 'Listening to photons arriving' 10E 'Relating energy to frequency' 50S 'How exploring paths leads to arrows', 60S 'Curl up and line up', 70S 'A photon explores two holes' OHTs: 30O, 40O, 50O	30S 'Random arrival of photons' 30S 'Path lengths and arrow rotations'	C3.1a, N3.1, IT3.1	C3.1b, C3.2, IT3.2
4	7.2 'Try all paths' at work	b	phase, phasor, amplitude, probability, path difference, intensity	80E 'Calculating for a mirror on the bench' 40S 'Three paths on a mirror' OHTs 90O,100O 120S 'Many photons make a beam', 130S 'Photons propagating' 150P 'Reflection gratings: A selection' 170S 'Engineering a focusing mirror'	90S 'Calculating for a mirror on the screen' Extension: 100S, 110S 140S 'Checking the ends of the mirror' 160H 'CD – many paths at home'	N3.1	

2-1	7.3 Electrons do it too	a b c d	evidence from electron diffraction that electrons show quantum behaviour diffraction the energy carried by photons across the spectrum, $E = hf$ a phenomenon in which quantum effects are significant	160S 'Electrons through gratings'		N3.1, C3.1a	

Chapter 8 Mapping Space and Time

Specification Section 5.2.2 Sapce, Time and Motion (part)

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
3-1	8.1 Journeys	b c	displacement, speed, velocity; graphs of accelerated motion, including slope and area below the graph one and two dimensional motion under a constant force	60E 'Using a video camera to make speed–time graphs'	20S 'Exploring distance–time graphs' 30T ‘Gradients of Graphs’	N3.1	C3.2,N3.3
3	8.2 Maps and Vectors	a b c	the use of vectors to represent displacement, velocity and acceleration; the trajectory of a body moving under constant acceleration, in one or two dimensions vector, scalar graphical representation of addition of vectors and changes in vector magnitude and direction. the resolution of a vector into two components at right angles to each other; the addition of two vectors, graphically and algebraically	110E 'Displacement and vector addition' 120S 'Tip to tail addition of vectors' 30X 'Constructing a map of France' 140S 'Understanding vector components' 150E 'Using video to estimate components of velocity' 160E 'Vector components and coordinate systems'	50S 'The caretaker's phone'	N3.1	IT3.1, IT3.2

2	8.3 Velocity	a	the use of vectors to represent displacement, velocity and acceleration; the trajectory of a body moving under constant acceleration, in one or two dimensions; the independent effect of perpendicular components of a force	180S 'Getting a feel for velocity vectors' 190S 'Vector addition in one dimension' 70S 'Flying in a side wind'.	200S 'A boat crossing a river' 80S 'Using of the components of a vector'	N3.1	IT3.1, IT3.2

Chapter 9 : Computing The Next Move

Specification Section 5.2.2 Space, Time and Motion (part)

Types: Students should demonstrate: (a) knowledge and understanding of phenomena, concepts and relationships
(b) comprehension of the language and representations of physics
(c) quantitative and mathematical skills, knowledge and understanding by making calculations and estimates
(d) initiative and independence in learning by giving and explaining their own example

Time (hours)	**Student Text**	**Specification**		**Activities**	**Minimum student work (2hours per week)**	**Key skills**	
		type	content			Covered	Opportunity
2	9.1 What's the next move?	b d	displacement, speed, velocity, acceleration, vector, scalar a method of measuring the distance of a remote object	10S 'Reconstructing a flight' 20S 'Animating multiple exposure photographs' 30S 'Will the aircraft collide?' 40S 'Perspectives on relative velocity' OHT: 20O 'Relative velocity'	10M 'Displacement–time graph' 25P 'Remote measurements of distance' 50S 'Tracking aircraft paths by drawing' Case Study: 'RADAR'	C3.1a, IT3.2	IT3.3, C3.1b, C3.2
6-1	9.2 Speeding up, slowing down	a c	the trajectory of a body moving under constant acceleration, in one or two dimensions the kinematic equations $v = u + at$, $s = ut + {}^{1}/_{2}\,at^2$, $v^2 = u^2 + 2as$	80S 'Constant acceleration with graphs'. 90S 'Investigating acceleration with velocity' 100S 'Acceleration from graphs' OHTs: 30O, 40O 110E 'Predicting motion of falling card' (Use video camera) 120E 'Measuring the acceleration of free fall' 130D 'A thrown tennis ball follows a parabolic path' 140E 'Rolling a marble on a parabola' 150S 'Modelling parabolic motion' 390S 'What does a tennis ball know about parabolas' 170D 'Mid-air collisions' 172E 'Build and test a marble launcher'	30S 'Coping with graphs' 40M 'Acceleration–time graphs' 70S 'Braking distance and the Highway Code' 110S 'Accurate archery' Looking ahead (optional: 176S 'Why some things move in circles'	N3.1	N3.2

6-2	9.3 Forces Changing Velocities	a b c	the independent effect of perpendicular components of a force force, mass, acceleration the equation *F = ma* where the mass is constant	200E 'Acceleration and resultant force using a lightgate' 180M 'F = ma: Some tricky problems!'	120M 'Adding forces graphically' or 130M 'A loading problem' or 140M 'Landing an aircraft' 170X 'Inertia reel seat belt'	N3.1	
6-1	9.4 Energy describes motion	a b c	calculation of work done, including cases where the force is not parallel to the velocity; power as rate of transfer of energy power kinetic energy = $^1/_2 mv^2$; work done $\Delta E = F\Delta S$; force, energy and power: power = $\Delta E/t$, power = Fv	300P 'Free transport?' OHTs: 110O 'Gravity and free fall', 120O 'Working with gravity' 340E 'Stripping away kinetic energy' OHTs: 120O 'Working towards kinetic energy' 130O 'Energy flows to and from a train' 140O 'Power, force, velocity' 240W 'Along the flat and up the hill' 370E 'Effective ballistics'	200E 'A bouncing ball' 210E 'Landing heavily' 220S 'The skateboarder'	N3.1, N3.2	

Data, Formulae and Relationships

The information below is provided as a separate booklet for all *Advancing Physics* examinations.

Data

Values are given to three significant figures, except where more – or less – are useful.

Physical constants

speed of light	c	3.00×10^{8} ms^{-1}
permittivity of free space	ε_0	8.85×10^{-12} C^2 N^{-1} m^{-2} (or F m^{-1})
electric force constant	$k = \frac{1}{4\pi\varepsilon_0}$	8.98×10^{9} N m^2 C^{-2} ($\approx 9 \times 10^9$ N m^2 C^{-2})
permeability of free space	μ_0	$4\pi \times 10^{-7}$ N A^{-2} (or H m^{-1})
charge on electron	e	-1.60×10^{-19} C
mass of electron	m_e	9.11×10^{-31} kg = 0.000 55 u
mass of proton	m_p	1.673×10^{-27} kg = 1.007 3 u
mass of neutron	m_n	1.675×10^{-27} kg = 1.008 7 u
mass of alpha particle	m_α	6.646×10^{-27} kg = 4.001 5 u
Avogadro constant	L, N_A	6.02×10^{23} mol^{-1}
Planck constant	h	6.63×10^{-34} J s
Boltzmann constant	k	1.38×10^{-23} J K^{-1}
molar gas constant	R	8.31 J mol^{-1} K^{-1}
gravitational force constant	G	6.67×10^{-11} N m^2 kg^{-2}

Other data

standard temperature and pressure (stp)		273 K (0 °C), 1.01×10^{5} Pa (1 atmosphere)
molar volume of a gas at stp	V_m	2.24×10^{-2} m^3
gravitational field strength at the Earth's surface in the UK	g	9.81 N kg^{-1}

Conversion factors

unified atomic mass unit	1u	$= 1.661 \times 10^{-27}$ kg
	1 day	$= 8.64 \times 10^{4}$ s
	1 year	$\approx 3.16 \times 10^{7}$ s
	1 light year	$\approx 10^{16}$ m

Mathematical constants and equations

e = 2.72　　$\pi = 3.14$　　1 radian = 57.3°

arc = $r\theta$	*circumference of circle* = $2\pi r$
$\sin\theta \approx \tan\theta \approx \theta$ and $\cos\theta \approx 1$ for small θ	*area of circle* = πr^2
	surface area of cylinder = $2\pi rh$
$\ln(x^n) = n \ln x$	*volume of cylinder* = $\pi r^2 h$
$\ln(e^{kx}) = kx$	*surface area of sphere* = $4\pi r^2$
	volume of sphere = $\frac{4}{3}\pi r^3$

Prefixes

10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{3}	10^{6}	10^{9}
p	n	μ	m	k	M	G

Formulae and relationships

Optics

focal length	$\frac{1}{v} = \frac{1}{u} + \frac{1}{f}$	Cartesian convention (object distance u, image distance v, focal length f)
refractive index	$n = \frac{\sin i}{\sin r} = \frac{\text{speed of light in vacuo}}{\text{speed of light in medium}}$	(angle of incidence i, angle of refraction r)

Electricity

power	$P = IV = I^2R$	(power P, potential difference V, current I)
	$V_{\text{load}} = \varepsilon - Ir$	(emf ε, internal resistance r)
conductance	$G = \frac{I}{V}$	(conductance G)
	$G = G_1 + G_2 + ...$	(conductors in parallel)
resistance	$R = R_1 + R_2 + ...$	(resistors in series)
conductivity	$G = \frac{\sigma A}{l}$	(conductivity σ, cross section A, length l)
capacitance	energy stored $= \frac{1}{2}QV = \frac{1}{2}CV^2$	(charge Q, capacitance C)
discharge of capacitor	$Q = Q_0 e^{-t/RC}$	(initial charge Q_0, time constant RC)
	$\tau = RC$	(time constant τ)

Materials

for a material in tension

Hooke's law	$F = kx$	(tension F, spring constant k, extension x)

$$\text{stress} = \frac{\text{tension}}{\text{cross - sectional area}}$$

$$\text{strain} = \frac{\text{extension}}{\text{original length}}$$

$$\text{Young modulus} = \frac{\text{stress}}{\text{strain}}$$

$$\text{elastic strain energy} = \tfrac{1}{2}kx^2$$

Gases

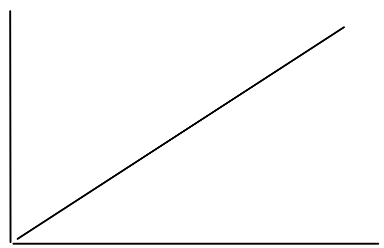
kinetic theory of gases	$pV = \frac{1}{3}Nm\overline{c^2}$	(pressure p, volume V, number of molecules N, mass of molecule m, mean square speed $\overline{c^2}$)

Motion and forces

force = rate of change of momentum

impulse = $F\Delta t$	(force F)
power = Fv	(velocity v)

components of a vector in two perpendicular directions



Fsinθ

F

θ

Fcosθ

equations for uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v = u + at$ $v^2 = u^2 + 2as$	(initial speed u, final speed v, time taken t, acceleration a, distance travelled s)
for circular motion	$a = \frac{v^2}{r}$	(radius of circle r)

Energy and thermal effects

efficiency	$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}}$	
energy	$\Delta E = mc\Delta\theta$	(change in energy ΔE, mass m, specific thermal capacity c, temperature change $\Delta\theta$)
Boltzmann factor	$e^{(-E/kT)}$	

Waves

$n\lambda = d\sin\theta$	(on a distant screen from a diffraction grating or double slit; order n, wavelength λ, angles of maxima θ)

Oscillations

	$\frac{d^2x}{dt^2} = a = -\left(\frac{k}{m}\right)x = -(2\pi f)^2 x$	(acceleration a, force per unit displacement k, mass m, displacement x frequency f)
	$x = A\cos 2\pi ft$	(amplitude A, time t)
	$x = A\sin 2\pi ft$	
	$T = 2\pi\sqrt{\frac{m}{k}}$	(periodic time T)
	$f = \frac{1}{T}$	
total energy	$E = \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$	

Atomic and nuclear physics

radioactive decay	$\frac{\Delta N}{\Delta t} = -\lambda N$	(number *N*, decay constant λ)
	$N = N_0 e^{-\lambda t}$	(initial number N_0)
	$T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$	(half-life $T_{\frac{1}{2}}$)

absorbed dose = energy deposited per unit mass

risk = probability $\times$ consequence

expected random variation in N random counts is of the order $\sqrt{N}$

mass-energy relationship	$E_{\text{rest}} = mc^2$	(energy *E*, mass *m*, speed of light *c*)
energy-frequency relationship for photons	$E = hf$	(photon energy *E*, Planck constant *h*, frequency *f*)
	$\lambda = \frac{h}{p}$	(wavelength λ, Planck constant *h*, momentum *p* (= *mv* for slow moving particles))

Field and potential

for all fields	$\text{field strength} = -\frac{dV}{dr} \approx -\frac{\Delta V}{\Delta r}$	(potential gradient d*V*/d*r*)
gravitational fields	$g = \frac{F}{m}$	(gravitational field strength *g*, gravitational force *F,* mass *m*)
	$V_{grav} = -\frac{GM}{r}$	(gravitational potential V_{grav}, gravitational constant *G*, mass *M*, distance *r)*
Electric fields	$V_{elec} = \frac{kQ}{r}$	(electric potential V_{elec}, electric force constant *k*, charge *Q*, distance *r)*

Electromagnetism

force on a current carrying conductor	$B = Il$	(flux density B, current I, length l)
force on a moving charge	$F = Bqv$	(charge Q, velocity perpendicular to field v)
	$\varepsilon = -\frac{d(N\Phi)}{dt}$	(induced emf ε, flux Φ, number of turns linked N)